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Quantifying Reductions in Vehicle Miles Traveled from New Bike Paths, Lanes, and Cycle Tracks: Technical Documentation

Authors

Volker, Jamey
Handy, Susan
Kendall, Alissa
et al.

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Quantifying Reductions in Vehicle Miles Traveled from New Bike Paths, Lanes, and Cycle Tracks

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A Technical Documentation Report from the National Center for Sustainable Transportation

Jamey Volker, University of California, Davis

Susan Handy, University of California, Davis

Alissa Kendall, University of California, Davis

Elisa Barbour, University of California, Davis

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16. Abstract
This report summarizes research outcomes in an effort to update the California Air Resources Board's (CARB) current methodology for estimating greenhouse gas (GHG) emission reductions from adding new bicycle paths, lanes, and cycle tracks. At least three programs offer Greenhouse Gas Reduction Fund (GGRF) funding for projects with new bicycle facilities. They include the California Strategic Growth Council's Affordable Housing and Sustainable Communities (AHSC) Program, the Natural Resources Agency's Urban Greening Grant Program (Urban Greening) and the California Department of Transportation's (Caltrans) Active Transportation Program (ATP). To measure GHG emission reductions from new bike paths and lanes, CARB currently relies on a method it published with Caltrans in 2005 for evaluating motor vehicle fee registration projects and congestion mitigation and air quality (CMAQ) improvement projects. The data on which the CMAQ method is based are even older, mostly from the 1990s (see section B of this report). This report reviews the more recent literature to determine whether and how the CMAQ method could be modified—or an alternative method developed—to better reflect emerging data and methods. It also assesses whether the CMAQ method could be expanded to Class III bike boulevards, or to distinguish between Class IV cycle tracks that replace auto travel lanes or parking from those that replace existing Class II bike lanes.

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Disclaimer

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A National Center for Sustainable Transportation Technical Documentation Report

April 2019

Jamey Volker, Institute of Transportation Studies, University of California, Davis

Susan Handy, Department of Environmental Science and Policy, University of California, Davis

Alissa Kendall, Department of Civil and Environmental Engineering, University of California, Davis

Elisa Barbour, Institute of Transportation Studies, University of California, Davis

Quantifying Reductions in Vehicle Miles Traveled from New Bike Paths, Lanes, and Cycle Tracks

Technical Documentation

California Climate Investments Quantification Methods Assessment
California Air Resources Board
Agreement #16TTD004

Prepared by:
Jamey Volker with Susan Handy, Alissa Kendall and Elisa Barbour
Institute of Transportation Studies, University of California, Davis

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Section A. Introduction

Under California's Cap-and-Trade program, the State's portion of the proceeds from Cap-and-Trade auctions is deposited in the Greenhouse Gas Reduction Fund (GGRF). The Legislature and Governor enact budget appropriations from the GGRF for State agencies to invest in projects that help achieve the State's climate goals. These investments are collectively called California Climate Investments.

Senate Bill (SB) 862 requires the California Air Resources Board (CARB) to develop guidance on reporting and quantification methods for all State agencies that receive appropriations from the GGRF. Guidance includes developing quantification methodologies for greenhouse gas (GHG) emission reductions and other social, economic, and environmental benefits of projects, referred to as "co-benefits." CARB develops quantification methodologies to provide project-level GHG emission or co-benefit estimates that are supported by empirical literature. This work relies on a review of the available science, coordination with the administering agencies, and outside experts and academic partners to obtain technical assistance and expertise, as needed. The quantification methodologies are developed to:

- Support calculating the estimated GHG emission reductions and applicable co-benefits for individual projects;
- Apply to the project types proposed for funding;
- Provide uniform methodologies that can be applied statewide and are accessible by all applicants;
- Use existing and proven tools or methodologies, where available;
- Include the expected period of time for when GHG emission reductions and co-benefits will be achieved; and
- Identify the appropriate data needed to calculate GHG emission reductions or co-benefits.

CARB may review and update GHG quantification methodologies and co-benefit assessment methodologies periodically based on: new or evolving project types; new legislation; available resources; new scientific developments or tools, or modifications in the analytical tools or approaches upon which the methodologies were based; or input from administering agencies or the public.

This report summarizes research outcomes in an effort to update CARB's current methodology for estimating GHG emission reductions adding new bicycle paths, lanes, and cycle tracks (also referred to as separated bikeways).[1] At least three programs offer GGRF funding for projects with new bicycle facilities. They include the Strategic

[1] The new bike paths and lanes category of projects includes "Bicycle paths (Class I), bicycle lanes (Class II)," or grade- or barrier-separated "bikeways (Class IV) that are targeted to reduce commute VMT and other auto travel," with emissions "reduced by replacing auto trips with bicycle trips" (California Air Resources Board, 2016).

Growth Council's Affordable Housing and Sustainable Communities (AHSC) Program, the Natural Resources Agency's Urban Greening Grant Program (Urban Greening) and the Department of Transportation's (Caltrans) Active Transportation Program (ATP) (CARB, 2016, 2018b, 2019).

To measure GHG emission reductions from new bike paths and lanes, CARB currently relies on a method it published with Caltrans in 2005 for evaluating motor vehicle fee registration projects and congestion mitigation and air quality (CMAQ) improvement projects (CARB, 2016, 2018b, 2019; CARB & Caltrans, 2005). The data on which the CMAQ method is based are even older, mostly from the 1990s (see section B of this report).

This report reviews the more recent literature to determine whether and how the CMAQ method could be modified—or an alternative method developed—to better reflect emerging data and methods. It also assesses whether the CMAQ method could be expanded to Class III bike boulevards, or to distinguish between Class IV cycle tracks that replace auto travel lanes or parking from those that replace existing Class II bike lanes. The report focuses on the first—and most difficult—step in the GHG emission reduction quantification method: estimating reductions in vehicle miles traveled (VMT) from new bike facilities.

The literature reviewed in this report indicates a need to update multiple factors in CARB's existing equation for estimating VMT reductions from new bicycle facilities. Recent research and data also allow estimating VMT reductions with a new method that uses bicycling counts instead of vehicular traffic. A case study of Davis' Fifth Street road diet is presented in section H to compare the existing and alternative quantification methods.

Section B. Existing Quantification Method

CARB published its current method for estimating GHG emission reductions from new Class I, II and IV bicycle facilities in its most recent GHG quantification methodologies for the AHSC, Urban Greening, and ATP programs (CARB, 2016, 2018b, 2019). CARB does not currently include Class III facilities (bicycle boulevards) in its GHG emission reduction quantification method, or distinguish Class IV facilities that replace existing Class II bike lanes.

For GGRF purposes, CARB defines Class I (bicycle paths), Class II (bicycle lanes), Class III (bicycle boulevards) and Class IV (cycle tracks) bicycle facilities as follows:

- Class I facilities: Bike paths or shared-use paths that "provide a completely separated right-of-way designated for the exclusive use of bicycles and pedestrians with crossflows by motorists minimized" (CARB, 2016 [2], 2017b [23], 2018a [4]).
- Class II facilities: Bike lanes that "provide a restricted right-of-way designated for the exclusive or semi-exclusive use of bicycles with through travel by motor vehicles or pedestrians prohibited, but with vehicle parking and crossflows by pedestrians and motorists permitted" (CARB, 2016 [2], 2017b [23], 2018a [4]).
- Class III facilities: Bike routes that "provide a right-of-way designated by signs or permanent markings and shared with pedestrians and motorists" (CARB, 2017b [23], 2018a [4]; National Association of City Transportation Officials, 2014).
- Class IV facilities: Separated bikeways that "provide a right-of-way designated exclusively for bicycle travel adjacent to a roadway and which are protected from vehicular traffic by features such as grade separation, physical barriers, or on-street parking" (CARB, 2016 [2], 2017b [23], 2018a [4]).

Figures 1 through 4 show an example of each facility type.

Figure 1. Class I Bicycle Path (Los Angeles Orange Line Bike Path)

Source: LADOT Bike Blog (2011)

Figure 2. Class II Bicycle Lane

Source: Fitch, Thigpen, Cruz, & Handy (2016)

Figure 3. Class III Bicycle Boulevard

Source: City of Berkeley (n.d.)

Figure 4. Class IV Cycle Track

Source: Fitch, Thigpen, Cruz, & Handy (2016)

CARB bases its current GHG emission reduction quantification method for new Class I, II and IV bicycle facilities on the premise that "emissions are reduced by replacing auto trips with bicycle trips" (CARB, 2016 [5], 2017b [23]). The two-step method first estimates the annual VMT the new bicycle facility would reduce. It then estimates the quantity of GHG emissions associated with that reduced VMT, based on auto vehicle emission factors for the first and last years in the expected useful life of the project. This report focuses on the first step: estimating reduced VMT.

CARB's current method estimates the annual VMT reductions from new bicycle facilities using Equation 1 (CARB, 2016 [B-1], 2018b [26], 2019 [16]):

Equation 1: Auto VMT Reductions (current method)

$$Auto\ VMT\ Reduced = (D) * (ADT) * (A + C) * (L)$$

Where,

			Units
D	=	days of use per year (default is 200 days)	Days
ADT	=	annual average two-way daily vehicular traffic on parallel road (project-specific data, with a maximum of 30,000)	Trips/day
A	=	adjustment factor (table lookup value)	-
C	=	activity center credit (table lookup value)	-
L	=	bike trip length (1.8 miles/trip in one direction)	Miles/trip

The adjustment factor and activity center credit tables from CARB's 2016 report are replicated below in Tables 1 and 2. The multi-component adjustment factor uses mode share and facility-level bicycle ridership change data and assumptions to estimate how much of the measured ADT would be converted to bicycle trips after bicycle facility installation. The activity center credit is an accessibility proxy that increases the adjustment factor for bike facilities that are closer to more "activity centers," like banks, churches, hospitals, light rail stations, office parks, post offices, public libraries, shopping areas, grocery stores, or schools and universities (CARB, 2016 [B-2], 2018b [28], 2019 [17]).

Table 1. Adjustment Factor (A) Lookup Table

Average Daily Traffic (ADT)	Bicycle Project Length (one-direction)	A (for cities with population >250,000 and non-university towns <250,000)	A (for university towns with population <250,000)
ADT ≤12,000 vehicles per day	≤1 mile	.0019	.0104
	>1 mile & ≤2 miles	.0029	.0155
	>2 miles	.0038	.0207
12,000<ADT ≤24,000 vehicles per day	≤1 mile	.0014	.0073
	>1 mile & ≤2 miles	.0020	.0109
	>2 miles	.0027	.0145
24,000<ADT≤30,000 vehicles per day (max is 30,000)	≤1 mile	.0010	.0052
	>1 mile & ≤2 miles	.0014	.0078
	>2 miles	.0019	.0104

Table 2. Activity Center Credit (C) Lookup Table

Count Your Activity Centers if There Are…	Within ½ Mile of the Project Area	Within ¼ Mile of the project Area
3	.0005	.001
>3 & <7	.0010	.002
≥7	.0015	.003

The adjustment factors in Table 1 “were derived from a limited set of bicycle commute mode split data for cities and university towns in the southern and western United States,”[2] then multiplied by 0.7[3] to “estimate potential auto travel diverted to bikes,” and again by a 0.65 “growth factor” to “estimate the growth in bicycle trips from construction of the bike facility”[4] (CARB & Caltrans, 2005, 31). However, it is unclear from the method documentation what portion of the cited mode split data was used to calculate the adjustment factors, and how it was used to create different factors by ADT and bicycle facility length.

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[2] As compiled by the Federal Highway Administration in its 1992 National Bicycling and Walking Study.

[3] 0.7 is reported as the 2000-2001 California statewide travel survey estimate of auto mode share of all trips in California.

[4] 0.65 “represents the average growth rate in bike trips from a new bike facility as observed in before and after data for bike projects in U.S. Department of Transportation’s (DOT) ‘A Compendium of Available Bicycle and Pedestrian Trip Generation Data in the United States’” (CARB & Caltrans, 2005, 31). After independently reviewing the DOT Compendium, it could still not be determined how the 0.65 number was calculated. Most of the bicycle count studies summarized in the Compendium did not measure *changes* in ridership following addition of a facility; rather, they primarily reported 1-time counts or multiple counts on existing facilities without any “before” counts (U.S. Department of Transportation, 1994). Indeed, DOT confirms in the Compendium that it “found few sources of before-and-after data” (U.S. Department of Transportation, 1994, 8-1).

It is also unclear how the activity center credits were derived, as there is no documentation for this component of the method.

Without knowing exactly how the adjustment factors and activity center credits were calculated, and because it was not within the scope of work for this report to further unpack their derivation, no specific modifications to the values listed in Tables 1 and 2 are suggested. However, recent research indicates that at least three of the inputs to the adjustment factors should be updated: auto mode share, bicycling mode share and the "growth rate" for bicycle trips following new facility construction.

For example, the method would more fully and accurately measure the VMT and GHG emission reductions from bicycle facilities by using bicycling mode share numbers for *all* trips, not just *commute* trips, especially since the baseline VMT is based on *total* – not just *commute* – ADT (Matute, Huff, Lederman, Peza, & Johnson, 2016). While the current method does use an estimate of *auto* mode share (0.7) based on all trips, more recent data suggest the estimate may be low. The 2010-2012 California Household Travel Survey data show that 76.2% of all trips are made by auto (49.3% as an auto/van/truck driver, and 25.9% as a passenger), while 1.5% are bicycle trips (Caltrans, 2013, 4). More importantly, though, auto mode share is a poor and exaggerated proxy for modal substitution,[5] as detailed in section F (Modal Substitution).

Regarding the "growth rate" for cycling trips following new facility construction, the assumed 0.65 value appears to be understated, at least for Class I bike paths, Class II bike lanes, and Class IV cycle tracks that do not replace existing Class II facilities, as detailed in section F (Facility-Level Bicycle Ridership Change). Recent research indicates the growth rate may be closer to 1.0 for those facilities. However, the growth rates may be lower for Class IV facilities that replace existing bike lanes (possibly closer to 0.6) and Class III bike boulevards (possibly closer to 0.3 or 0.4). The current quantification method could be adjusted to use facility type-specific ridership growth rates as more before-and-after count data becomes available for each facility type.
In addition, recent studies also suggest that the bicycle trip length input to the VMT reduction equation should be updated. As discussed later in this report, much more recent average bicycle trip length data is available than the 1995 data used in the current method.

Given the amount and quality of bicycling-related research and data collection since Caltrans published the CMAQ method in 2005, it is also now possible to estimate VMT reductions from new bicycle facilities based on existing bicycle counts, without using ADT. A potential formula for this is presented at the end of the report. The formula could be used to estimate VMT reductions from new Class I, Class II and Class IV facilities (including those that replace existing bike lanes), as well as new Class III facilities.

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[5] As used in this review summary, the "substitution" rate is the percentage of bicyclists who would have otherwise, without the bicycle facility in question, made the same trip by auto.

Section C. Literature Review Methodology

This report focuses on estimating VMT reductions, the first step in CARB's method for quantifying GHG emission reductions from new bike facilities. This report does not examine the factors relevant to the second step in CARB's methodology (calculating the GHG emissions from the avoided VMT), which currently include vehicle fleet emissions factors (Matute et al., 2016).

The bicycling literature is reviewed to determine whether and how CARB's current VMT reduction estimation method could be modified to better reflect emerging data and methods, or expanded to apply to Class III facilities or to distinguish between Class IV facilities that replace auto travel lanes or parking from those that replace existing Class II bike lanes. This report only reviews those inputs—or components of inputs—whose values are clearly derived in the methodology documentation, specifically the facility use factor (section F, Seasonal Effects), bike trip length (section F, Bicycle Trip Length), and the mode share (sections B and F, Modal Substitution) and facility-level bicycle ridership change (section F, Facility-Level Bicycle Ridership Change) values used to calculate the adjustment factors. The report also reviews the merits of correcting for bike trip type—utilitarian versus recreational (section F, Bicycle Trip Type). The report does not probe the activity center credit values because it is unclear how they were derived.

Previous literature reviews on related issues were used to guide the initial literature selection and review, focusing on studies from 2005 (the CMAQ method publication date) onward (Buehler & Dill, 2016; S. Handy, Tal, & Boarnet, 2014, 2014; Handy, van Wee, & Kroesen, 2014; Muñoz, Monzon, & Daziano, 2016; Pucher, Dill, & Handy, 2010; Yang, Sahlqvist, McMinn, Griffin, & Ogilvie, 2010). That was augmented by reviewing the relevant studies cited in the first round of articles surveyed, along with additional relevant peer-reviewed journal articles, academic research reports and governmental or professional consultant reports identified through searches on Google, Google Scholar and the Transportation Research International Documentation (TRID) database, using search terms combining "bicycling" variously with "ridership," "substitution," "count," "intervention," "before-and-after," "trip length," and "seasonal." Only English-language literature was reviewed. All the literature that was both reviewed and cited herein is listed in section I.[6]

The literature review results are summarized next in sections D, E and F. To provide context, section D summarizes the state of the literature on what drives bicycling. Section E discusses the only two reviewed studies that attempted to measure changes in VMT or GHG emissions associated with bicycle path, lane or cycle track provision. Section F reviews the literature related to the components of CARB's current quantification method and the potential alternative method presented herein. The findings are then synthesized into a potential alternative VMT reduction quantification method in section G. The current and alternative quantification methods are compared using a case study of Davis' Fifth Street road diet in section H.

[6] A list of the reviewed but uncited literature is available upon request.

Section D. Drivers of Bicycling – An Overview

CARB's method for estimating GHG emission reductions from new bicycle facilities assumes that infrastructure can increase bicycling levels. The literature strongly supports that assumption, as discussed below. However, infrastructure is not the only factor influencing bicycle ridership. The range of factors and how they influence bicycling are summarized below. Providing this broader context can help the officials making decisions about funding or monitoring project outcomes better identify non-infrastructure factors (either of the project itself or its environment) that could hinder or enhance project success.

Many factors affect bicycle ridership levels and the decision to bicycle, including individual factors (e.g., attitudes, preferences, beliefs and biological factors), social environment factors (e.g., bicycle culture and supportive policies, and environmentalism), and built environment factors (e.g., distance to destination, topography, bicycle infrastructure like bike paths and lanes, and land uses) (Braun et al., 2016; Buehler & Pucher, 2012; Burk, 2017; Cole-Hunter et al., 2015; Dill & Carr, 2003; Handy & Xing, 2011).

For example, regarding individual factors, disaggregate studies consistently show that men are more likely than women to bicycle (Braun et al., 2016; Buehler, 2012; Cole-Hunter et al., 2015; Dill, Goddard, Monsere, & Mcneil, 2014; S. L. Handy & Xing, 2011; Nehme, Pérez, Ranjit, Amick, & Kohl, 2016), particularly younger men (Braun et al., 2016; Cole-Hunter et al., 2015; Monsere et al., 2014; Nehme et al., 2016). That, in turn, may be partly due to attitudinal differences. For example, men are more likely than women to agree with the statement "I like riding a bike" (Garrard et al, 2012). But analyses of six small U.S. cities, including four in California, show that liking to ride bikes is also strongly correlated with both bicycle commuting and recreational bicycling even after controlling for gender (Handy & Xing, 2011; Xing, Handy, & Mokhtarian, 2010). Conversely, those same studies found that the perceived need for a car (Handy & Xing, 2011) and the attitude of liking driving (Xing et al., 2010) are negatively correlated with bicycling.

With respect to social environment factors, both aggregate and disaggregate studies indicate that greater pro-bicycling culture (e.g., where bicycling is considered more normal) (Xing et al., 2010), local environmentalism (Burk, 2017) and organizational and citizen participation in bicycling-related policy (Harms, Bertolini, & Brömmelstroet, 2016) correlate with increased cycling (or a greater likelihood of cycling).

Among built environment characteristics, distance to work (a function of land use mix and density) and topography (e.g., hilliness) are consistently associated with a lower likelihood of commuting by bicycle (Braun et al., 2016; Cole-Hunter et al., 2015; Handy & Xing, 2011; Xing et al., 2010). By contrast, bicycling infrastructure (often measured as centerline miles of bicycling infrastructure, miles per area of interest, or distance to nearest bike facility) generally correlates with increased bicycling levels (usually measured as commute mode choice in individual-level studies and bicycling commute mode share, or number of bicycle commuters per 10,000 inhabitants, in aggregate studies) in both aggregate- and individual-level studies (Buehler & Dill, 2016; Handy, Tal, & Boarnet, 2014, 2014; Muñoz et al., 2016; Pucher et al., 2010; Schoner & Levinson, 2014).

For example, of the 23 bicycling mode choice studies Muñoz et al. (2016) reviewed that included a bicycling network measure (e.g., density of bicycle lanes and/or paths) in their models, 19 found a statistically significant positive relationship with bike mode choice (mostly measured for commute trips), while only one study found a statistically significant negative relationship. Of those 19 studies, nine (four aggregate and five disaggregate) used data from cities in the United States. All 23 studies used cross-sectional data.

Handy et al. (2014) likewise found that "infrastructure investments significantly increase bicycling," based on a review of four cross-sectional studies from the United States that quantified the impact of bicycling strategies on commute bicycling mode share (or propensity) and controlled for sociodemographic characteristics (Handy, Tal, & Boarnet, 2014, 3).

That accords with Buehler and Dill's (2016) review of 67 mostly cross-sectional, peer-reviewed studies on the impact of "links" in the bikeway network on cycling levels or propensity (for both commute trips and otherwise). They concluded that "[m]ost studies suggest a positive relationship between bikeway networks or aspects of the network and cycling levels," though they found some mixed results, particularly in areas with "adequate" bike lane supply and already-high bicycling levels (Buehler & Dill, 2016, 21).

But not all bike infrastructure is created equal. Different types of facilities have different effects. Buehler and Dill (2016, 21) conclude from their comprehensive literature review that both stated- and revealed-preference studies suggest two hierarchies: (1) that cyclists and non-cyclists alike may prefer "separate paths and/or lanes over cycling in roadways with motorized traffic;" and (2) that "cyclists and non-cyclists seem to prefer physically separated bike paths or cycle tracks to bike lanes or wide shoulders on roadways," though some experienced cyclists have reported a preference for bicycling in traffic than on separate facilities. However, neither cross-sectional multi-location studies (Buehler & Pucher, 2012) nor before-and-after facility-level studies demonstrate a clear difference in magnitude of the effect of bike lanes, bike paths or cycle tracks on ridership or modal substitution (see sections F, Facility-Level Bicycle Ridership Change, and F, Modal Substitution).

Facility type is not the only infrastructure component that matters. Researchers are increasingly studying aspects of bikeway networks beyond individual bikeway "links" or the density of those links within a given area of interest, including overall network connectivity, comfort, accessibility, and overall "level of service" (Buehler & Dill, 2016 [reviewing the literature]; Lowry & Loh, 2017; Schoner & Levinson, 2014). Research in that area is "still emerging," and thus not examined in depth in this report (Buehler & Dill, 2016, 23). But it is an area to watch for future developments that could suggest new approaches to quantifying VMT and GHG emission reductions from new bicycle facilities.

The remaining literature review focuses on the studies that report results most readily usable to calculate, at the facility level, VMT reductions associated with new bike lanes, paths and cycle tracks. Those more applicable results include bicycle counts before and after a bicycle facility installation (the bicycle ridership “growth rate”), and information relevant to contextualizing those counts, specifically modal substitution, trip length, seasonal adjustment and trip type share estimates (Matute et al., 2016). All five are at least partially factored into CARB’s current VMT reduction equation, as discussed above. All five are also relevant to the potential alternative VMT reduction equation examined at the end of this report (Matute et al., 2016). The next section examines the two studies reviewed for this report that attempted to measure changes in VMT or GHG emissions associated with bicycle path, lane or cycle track provision.

This report does not separately detail the limitations of and difficulties in using results from other types of bicycling study results, but they include the four listed in Figure 5, among others.

Figure 5. Common Limitations of Bicycling Studies

1. Most studies focus exclusively on some measure of bicycle commuting as the dependent variable, and as a result do not capture the full VMT-reducing effect that bicycling infrastructure additions could have on both other utilitarian trips and recreational trips (Matute et al., 2016, 40).

2. Using probability-based sampling and statistical modeling to identify and determine the strength of bicycling predictors, as most studies do, can produce statistically significant inferences with large sample sizes or changes in cycling levels, but is not well-suited for determining behavioral changes or changes in nonmotorized travel from individual infrastructure projects (Krizek, Handy, & Forsyth, 2009, 725, 736; Götschi, Krizek, McGinnis, Lucke, & Barbeau, 2011, 14).

3. Surveying residents near new infrastructure projects (rather than using intercept surveys and bike counts), as many before-and-after studies do, likely excludes actual facility users who live further away and thereby underestimates the facilities' impacts on bicycling, VMT and GHG emissions, especially where the surveyed neighborhoods have low baseline cycling rates (e.g., Brown et al., 2016; Burbidge & Goulias, 2009).

4. For the studies that employ statistical modeling to detect differences in bicycling levels or propensities, it is impossible to directly compare the magnitude of the model outputs between the studies because of the different methodologies used, which can lead to very different results (Handy, Tal, & Boarnet, 2014, 2014). For example, in their analysis of aggregate cross-sectional data from 23 U.S. cities, Dill and Carr (2003) found that one additional mile of Class II bike lanes per square mile was associated with a one percentage point higher bicycle commute mode share. But using repeated cross-sectional data from those same 42 cities (plus 19 others) that included measures of local "environmentalism," Burk (2017) found an effect size about 1/10 as large as that found by Dill and Carr (2003).

Section E. Studies Estimating GHG Emission Reductions Associated with New Bicycle Facilities

Only two of the studies reviewed for this report attempted to measure changes in VMT or GHG emissions associated with bicycle path, lane or cycle track provision (Matute et al., 2016; Brand et al., 2014). Neither of the studies' results are easily applicable to proposed real-world projects.

Matute et al. (2016, 7) use a "life-cycle assessment (LCA) approach" to compare the GHG emissions from the "construction, operation, and use of" Class I, Class II and Class IV "bikeway facilities versus other transportation modes that would be used in place of the bikeway." As part of their consequential LCA analysis, they "forecast[] ridership" on new bicycle facilities using before-and-after bicycle count data from 44 Class I, Class II, Class III and Class IV facilities across eight U.S. cities (Los Angeles, San Francisco, Portland, Austin, Honolulu, Denver, Chicago and Washington, D.C.) (p. 17). They also estimate "what share of bicycle ridership on a facility represents a reduction in vehicle and transit travel," using original survey data from cyclists (n=618) intercepted on 20 facilities in Los Angeles County (p. 17).

With that data they produce a sensitivity analysis of the net change in life-cycle GHG emissions due to the construction of hypothetical 2.3-mile Class I, Class II and Class IV facilities in California, using different values for annual bicycle ridership increases on the facility route and modal substitution rates (from autos to bikes) (Matute et al., 2016, 54-56). But their GHG emission reduction estimates are difficult to apply to proposed real-world projects because the report does not explain a few key intermediate steps. They do not explain (1) how to estimate the change in annual cycling volumes on a new facility route, (2) how a different facility length would impact the results, (3) how to calculate annual ridership increases from shorter-duration counts (like those on which their study is based), (4) why they decided to use a 3.1-mile trip length and how well that reflects average bicycle trip lengths in California, and (5) how they calculate from their data the baseline auto-to-bike substitution rate used in the sensitivity analysis.[7]

Apart from their sensitivity analysis, however, Matute et al. (2016) do report applicable bike count, modal substitution and trip rate results from multiple bicycle facility interventions summarized below in the literature review sections on those factors.

Brand et al. (2014) used a longitudinal cohort research design to examine the effects on carbon dioxide (CO_2) emissions of new walking and cycling routes (two traffic-free bridges, and one riverside footpath) in three locations in England. They surveyed residents living within a five-km road network distance of one of the three facilities three separate times, once prior to facility construction (n=3,516), once a year later post-construction (n=1,849) and once a year after that (n=1,510), all in the same month

[7] The authors of that report did not respond to requests for answers to these questions.

(April). The surveys included a seven-day recall instrument to measure travel activity, and the authors estimated CO_2 emissions from the auto travel reported therein. The authors then estimated linear regression models to predict change in CO_2 emissions, using proximity to the new facilities, use of the facilities (yes/no) and many sociodemographic variables as predictors. They found "no significant change in transport CO_2 emissions despite the new routes being well used by walkers and cyclists," and that neither "living near the infrastructure nor using it predicted changes in CO_2 emissions from motorized travel" (Brand et al., 2014, 284).

However, Brand et al.'s (2014) results should not be used to estimate GHG emission reductions from new bicycle facilities elsewhere for at least four reasons. First, the reported regression models used a pooled data set of survey responses from both cyclists and non-cyclists, and they did not isolate the effects of the facilities on bicycling. Instead, the models estimated the effect on CO_2 emissions across the entire sample – cyclists and non-cyclists alike – living near or using the facilities, adjusting for sex, age, site and other baseline characteristics.[8] Second, as the authors note, because the "CO_2 emissions outcomes still had high standard deviations," which "reduced statistical power," the study "lacked the power to detect smaller [CO_2 emission] changes" of the type that you would expect at the individual level (Brand et al., 2014, 293). Third, the participants included a much lower percentage of young adults (7% for the two-year cohort) than in the general population (26% locally), which is important because studies suggest younger adults are more likely to bicycle in general (e.g., Braun et al., 2016; Cole-Hunter et al., 2015; Nehme et al., 2016), and also more likely to substitute bicycle trips for auto trips (Piatkowski, Krizek, & Handy, 2015). Fourth and finally, by surveying only nearby residents, the study likely excludes actual users who live further away and thereby underestimates the facilities' impacts on bicycling and GHG emission reductions (e.g., Burbidge & Goulias, 2009, 78 [finding that the residents of the neighborhood next to a new multi-use trail did not use the trail after it was built, and that "users of the trail came from elsewhere"]; Brown et al., 2016).

[8] The only cycling-related predictor variable included in the models was household bicycle access ("Any adult bicycle in household," with yes or no answer choices) (Brand et al. (2014, 287).

Section F. Review of Method Components

This section reviews the literature related to the components of CARB's current quantification method and the potential alternative method presented in section G, including facility-level bicycle ridership change, seasonal effects, bicycle trip length, modal substitution, and trip type.

Facility-Level Bicycle Ridership Change

Bicycle counts provide an essential empirical measure of bicycling trips along a given route, and the change in ridership on that route after installation of a new bicycle facility (Götschi, Krizek, McGinnis, Lucke, & Barbeau, 2011; Matute et al., 2016).[9] CARB's current method for estimating VMT reductions from the addition of bike facilities uses a before-and-after ridership "growth rate" estimate (0.65). But the count data available when CARB and Caltrans published the CMAQ method was limited (U.S. Department of Transportation, 1994; see footnote 4 above). The more recent before-and-after bike counts reviewed are presented by facility type in Tables 3 (Class I bike paths), 4 (Class II bike lanes), 5 (Class III bike boulevards), and 6 (Class IV cycle tracks).

Matute et al. (2016, 50) analyzed before-and-after count data for the most facilities – 34 bike lanes, six cycle tracks, two bike paths and two bike boulevards, all in the United States – and found a mean 110% ridership change across all facility types. Interestingly, the mean ridership change across the 44 total facilities of all types studied by Matute et al. (2016) is quite close to the average ridership change for new Class I, Class II and Class IV facilities calculated separately (across all studies reviewed). But the average change for new bicycle boulevards, as well as Class IV facilities that replaced existing Class II facilities, were both lower.

For the two Class I facilities for which the reported counts distinguished between bicyclists and pedestrians, the average change was 86%, though that average was calculated across the two Class I facilities along with two bicycle boulevards and six cycle tracks (Table 3).[10] The mean ridership change was 119% across the 37 individual Class II facilities for which before-and-after counts were reported (Table 4).[11] And the average change was 107% for all 16 Class IV cycle tracks (including those that replaced existing Class II facilities) (Table 6).

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[9] This report focuses on the impact of *new* bicycle facilities, not improved or replaced facilities. However, it does report the before-and-after bike counts and modal substitution estimates for the five (out of eight total) cycle track facilities analyzed in Monsere et al. (2014) that replaced existing Class II bike lanes. It is also unclear whether any of the facilities analyzed in Matute et al. (2016) replaced existing facilities.

[10] Adding in the combined ridership and walking change estimates for the two facilities for which bicyclist-only counts were not reported would raise the average ridership change for all four facilities to 100%.

[11] This excludes the ridership change estimates from the City of Toronto (23%) because it is not clear how many facilities were studied there. If it was just a single facility, adding it to the 37 other individual Class II facilities would lower the average ridership change for all 38 facilities to 116%.

At least five of the 16 Class IV cycle tracks for which before-and-after counts were reported replaced existing Class II bike lanes. The average ridership change for those five facilities was 61% (Table 6). The average for the other 11 facilities was 128%, though it is unclear whether six of those Class IV projects replaced existing bike facilities or not (Table 6).[12] Removing the facility with by far the highest estimated ridership increase percentage – a 1.5-mile cycle track in Washington, D.C. with an estimated 500% ridership increase – reduces the average for the remaining 10 projects down to 91% (Table 6).

Bicycle boulevards showed the lowest percentage increase in ridership. The average was 36% across the nine new Class III bicycle boulevards for which (aggregate) ridership change percentages were reported (Table 5).

The low number of individual new facilities for which bicycling-specific before-and-after counts were reported, particularly amongst Class I bike paths, Class III bike boulevards and Class IV cycle tracks, makes statistical inference about the impact of facility type or length difficult.[13] But the results do indicate that sizeable percentage increases in ridership can be expected along the routes of new Class I, Class II and Class IV facilities. The results also indicate that the 0.65 "growth rate" used in the current methodology may be too low for new Class I and Class II facilities, as well as those Class IV facilities that do not replace existing Class II bike lanes. The implications are less clear for Class III facilities and Class IV facilities that replace Class II facilities.

While ridership increased by 36% on average across the nine Class III facilities for which (aggregate) ridership change percentages were reported, ridership actually decreased on some facilities (Dill, McNeil, Broach, & Ma, 2014, 578). In addition, some of the "after" counts may have been taken too soon after facility installation (including, in at least two cases, before installation was fully complete) to observe full ridership changes (Dill, McNeil, Broach, & Ma, 2014, 577).

Also uncertain is the difference in impact on ridership of Class IV facilities that replaced existing bicycle facilities versus those that did not. The average percentage change in ridership was 61% for the five facilities known to have replaced existing Class II facilities (Table 6). That is substantially lower than the average across all 16 Class IV facilities (107%), as well as the average across the 11 facilities not known to have replaced existing bike facilities (128%) (Table 6). However, it is unclear whether six of those Class IV projects replaced existing bike facilities or not (see footnote 12).

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[12] Matute et al. (2016) did not report whether the six cycle tracks they studied replaced existing Class II facilities.

[13] It is especially difficult to make inferences related to bike paths, bike boulevards and cycle tracks and facility lengths because the report analyzing the most facilities of all types – Matute et al. (2016) – did not provide facility length data or separate out the ridership change estimates for bike paths, cycle tracks and bike boulevards.

Relationship between Ridership Change and Facility Length

Analysis of the cycle track data for the facilities whose lengths were reported indicates at least some correlation between facility length and percent ridership change (Table 6). The seven facilities less than one mile long (including the five that replaced existing bike lanes) averaged a 65% ridership increase. Excluding the aforementioned 1.5-mile Washington, D.C. cycle track with an estimated 500% ridership increase, the two facilities at least one mile long averaged a 118% ridership increase. The Pearson correlation between length and percent ridership change for those nine facilities is 0.305. Adding in the 1.5-mile Washington, D.C. cycle track increases the Pearson correlation to 0.691.

The Pearson correlation between facility length and ridership change percentage increases further, to 0.754, among just the five facilities that did not replace existing bicycle facilities (including the Washington, D.C. cycle track). Among the five cycle track facilities that replaced Class II bike lanes, the correlation is counterintuitively negative, at -0.445. However, the sample sizes are so small that definitive conclusions cannot be drawn from these results.

Facility lengths were not reported for most Class I and Class II facilities, making it impossible to analyze the relationship between ridership change and facility length for those facilities. It was also impossible to analyze the facility length-ridership change relationship for Class III facilities because bike counts were not reported by facility for the nine bike boulevards studied in Dill, McNeil, Broach and Ma (2014) and Matute et al. (2016), and facility lengths were not provided by Matute et al (2016).

Relationship between Ridership Change and Pre-Installation Cyclist Volumes

Matute et al. (2016, 50) found “no relationship” between cyclist volumes before facility installation and percent ridership change – the percent change was similar regardless of the “before” counts. Similarly, Goodno, McNeil, Parks, & Dock (2013) found almost identical percent ridership increases at the three count locations along a new cycle track route in Washington, D.C. despite very different original bike traffic volumes.

Even studies showing minimal to no increases in bicycling following an infrastructure improvement tend to confirm this finding – because those studies generally involved areas (or at least surveyed samples) with such “low base rates of cycling” that statistically significant changes one way or another could not be detected (Brown et al., 2016, 358). For example, Burbidge and Goulias (2009) found no effect on cycling levels of a new suburban bike trail for a sample of 144 nearby residents who collectively, over 386 travel diary days prior to bike trail construction, had only taken two bicycle trips. Similarly, where only two of the 366 sampled nearby residents made any bicycling trips prior to the conversion of a rail line to a multi-use trail, Evenson, Herring, & Huston

(2005) found no statistically significant change in cycling time (minutes per week) for those who had used the trail.[14]

As Matute et al. (2016, 50) conclude, the fact that observed percentage changes in ridership are similar regardless of “before” bicycle volumes “implies that ridership change can be predicted reasonably reliably by volumes observed before facility installation.” That, in turn, makes more tractable a VMT reduction estimation calculation based on pre-facility bike counts, like the alternative quantification method discussed at the end of this report.

How this data could be used in a potential alternative method for quantifying the VMT reductions is examined in section G.

[14] Note also that neither Evenson et al. (2005) nor Burbidge and Goulias (2009) collected trip counts on the facilities themselves, nor reported the total counts of bicycle trips made by the survey respondents (nearby residents). As a result, they had to use statistical tests, rather than simply comparing counts, to assess the presence and magnitude of a change in bicycling levels (see footnote 6, supra, for a discussion of that and other limitations of non-count-based studies). With such low preexisting cycling levels, only a very large increase would lead to a statistically significant change (see, e.g., Krizek et al., 2009, 725, 736; Götschi et al., 2011, 14).

Table 3. Before/After Bike Counts – Class I Bike Paths

Study	Location	Facility Description	Facility Length	Before/After Bike Counts (Period)	Percent Change	Notes
Matute et al. (2016)	Washington, D.C.; Portland, OR; Los Angeles, CA; San Francisco, CA; Austin, TX; Chicago, IL; Denver, CO; Honolulu, HI	Two bike paths total across the eight study locations. Additional details, including the specific city location of the two paths, not reported.	Not reported	Not reported	Mean = 86% Median = 48%	Percent change numbers reflect combined data for 10 facilities: the two bike paths, six cycle tracks and two bicycle boulevards
Fitzhugh, Bassett, & Evans (2010)	Knoxville, TN	Urban greenway retrofitted with an eight-foot-wide pedestrian and bike path	2.9 miles	Median = 4.5/13 (median of peak two-hour morning, midday and afternoon counts)	Median = 189%	Counts did not distinguish between bicyclists and pedestrians. Before and after counts taken in the affected neighborhood at a "location that provided distinct views of physical activity," during two-hour periods in the morning, midday and afternoon over two days in March 2005 (pre-intervention) and March 2007 (post-intervention)

Table 3 (cont.). Before/After Bike Counts – Class I Bike Paths

Study	Location	Facility Description	Facility Length	Before/After Bike Counts (Period)	Percent Change	Notes
Cohen, Sehgal, Williamson, Golinelli, & Lurie (2008)	Los Angeles, CA	Bike path (mostly – a couple miles of the bikeway is a bike lane) along the 14-mile Orange Line bus rapid transit busway	~14 miles total (including bike path and lane)	Total = 890/1,229 (sum of morning and afternoon peak hour counts for seven consecutive days at three separate locations along route)	38%	Counts did not distinguish between bicyclists and pedestrians, though the authors did confirm that the increase in at least one of the count locations "was among bikers."
Average for All Facilities (n=2) = **86%**			Facilities analyzed in Cohen et al. (2008) and Fitzhugh et al. (2010) are excluded from average because their reported counts included pedestrians and bicyclists. Average including all four facilities would be 100%.			

Table 4. Before/After Bike Counts – Class II Bike Lanes

Study	Location	Facility Description	Facility Length	Before/After Bike Counts (Period)	Percent Change	Notes
Matute et al. (2016)	Washington, D.C.; Portland, OR; Los Angeles, CA; San Francisco, CA; Austin, TX; Chicago, IL; Denver, CO; Honolulu, HI	34 bike lanes total across the eight study locations. Additional details, including the number of facilities in each city, not reported.	Not reported	Not reported	Mean = 113% Median = 73%	Found “no relationship” between pre-facility cyclist volumes and percent ridership change. The mean percentage change reported appears to be an average of the percent changes calculated for each facility individually.

Table 4 (cont.). Before/After Bike Counts – Class II Bike Lanes

Study	Location	Facility Description	Facility Length	Before/After Bike Counts (Period)	Percent Change	Notes
Gudz et al. (2016)	Davis, CA	5-to-7-foot bike lanes added along both sides of a segment of Fifth Street as part of a road diet project that reduced the four-vehicle-lane segment to three traffic lanes	0.8 miles	175.5/457 (each an average of four peak morning and four peak evening 1.5-hour counts on Wednesdays and Thursdays)	160%	Before counts taken in May. After counts taken in October. Counts reported to the left are an average of the morning and evening counts for east-west traffic (same direction as Fifth Street) at the intersection (A Street) on segment closest to the biggest trip attractor on the corridor – the University of California, Davis. Counts were also taken at six other intersections. But because they almost certainly include some bicycle trips captured in the A Street counts, to avoid double-counting they were not included in the percent change calculation. In any event, the percentage change is not much different (193%) if you sum the after counts at all the count locations and divide by the sum of all before counts at those locations.

Table 4 (cont.). Before/After Bike Counts – Class II Bike Lanes

Study	Location	Facility Description	Facility Length	Before/After Bike Counts (Period)	Percent Change	Notes
Goodno et al. (2013)	Washington, D.C.	Buffered center-median two-way bike lane on Pennsylvania Avenue	~1 mile	Exact counts not reported, but appear to be about 25 for the before counts at both locations, and between 175 and 190 for the after counts (at the afternoon peak hour)	>250% (at both count locations)	Counts taken during the morning and afternoon peak hours at two locations along the corridor in April before facility installation and three times in the two years following installation
City of Toronto (2001)	Toronto, Ontario	Unspecified bike lanes within the city	Not reported	Not reported	Mean = 23%	Date of counts not reported
Sallaberry (2000)	San Francisco, CA	Bike lanes added in both directions along Valencia Street	~2 miles	88/215 (PM peak hour)	144%	Counts taken on Bike-to-Work Day in May 1997, and during a "typical" weekday in March 2000
Average for All Facilities (n=37) = **119%**			The 34 cycle track facilities analyzed in Matute et al. (2016) are all assumed to have shown the same ridership increase (113%). City of Toronto data not included because it is not clear how many facilities were studied there. No weighting done by facility length or other attribute.			

Table 5. Before/After Bike Counts – Class III Bike Boulevards

Study	Location	Facility Description	Facility Length	Before/After Bike Counts (Period)	Percent Change	Notes
Matute et al. (2016)	Washington, D.C.; Portland, OR; Los Angeles, CA; San Francisco, CA; Austin, TX; Chicago, IL; Denver, CO; Honolulu, HI	Two bike boulevards total across the eight study locations. Additional details, including the specific city location of the two paths, not reported.	Not reported	Not reported	Mean = 86% Median = 48%	Percent change numbers reflect combined data for 10 facilities: the two bike boulevards, six cycle tracks and two bicycle paths

Table 5 (cont). Before/After Bike Counts – Class III Bike Boulevards

Study	Location	Facility Description	Facility Length	Before/After Bike Counts (Period)	Percent Change	Notes
Dill, McNeil, Broach & Ma (2014)	Portland, OR	Eight bike boulevards	0.9 to 4.2 miles (not reported for each facility individually)	Not reported	22%	Percent change reflects combined data for the seven facilities for which before-and-after count data were available. Counts were taken at 10 locations across the seven facilities, with six locations showing increased ridership, and four showing reduced ridership. The after counts were mostly taken less than a year after facility installation, and for at least two facilities were taken before some elements of the facility were completed.
Average for All Facilities (n=9) = **36%**			Average excludes the one facility for which Dill, McNeil, Broach and Ma (2014) did not report before-and-after counts.			

Table 6. Before/After Bike Counts – Class IV Cycle Tracks

Study	Location	Facility Description	Facility Length	Bike Count (Before/After)	Percent Change	Notes
Matute et al. (2016)	Washington, D.C.; Portland, OR; Los Angeles, CA; San Francisco, CA; Austin, TX; Chicago, IL; Denver, CO; Honolulu, HI	Six cycle tracks total across the eight study locations. Additional details, including the specific city location of the six cycle tracks, not reported.	Not reported	Not reported	Mean = 86% Median = 48%	Percent change numbers reflect combined data for 10 facilities: the two bike paths, six cycle tracks and two bicycle boulevards
McClain & Peterson (2016)	Oakland, CA	Road diet replaced one vehicle travel lane in each direction with parking-protected cycle tracks across nine city blocks on Telegraph Avenue (from 20th to 29th Streets)	~0.5 miles	Total = 687/1,283 (sum of peak one-hour morning and afternoon counts of traffic in all directions at four intersections along route)	87%	Before counts taken on October 17, 2013. After counts taken on September 29, 2016.

Table 6 (cont.). Before/After Bike Counts – Class IV Cycle Tracks

Study	Location	Facility Description	Facility Length	Bike Count (Before/After)	Percent Change	Notes
Monsere et al. (2014)	Austin, TX	One-way cycle track on Barton Springs Road protected by flexposts and a 1.5-foot buffer (there is a shared-use path on the other side of the street)	0.5 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	58%	
	Austin, TX	Two-way cycle track replaced standard bike lanes, Bluebonnet Lane protected by flexposts and a two-foot buffer	0.7 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	46%	Replaced existing bike lanes.
	Austin, TX	Two-way cycle track replaced a one-way standard bike lane on one-way Rio Grande Street protected by flexposts and a four-foot buffer	0.4 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	126%	Replaced existing bike lane (one direction).

Table 6 (cont.). Before/After Bike Counts – Class IV Cycle Tracks

Study	Location	Facility Description	Facility Length	Bike Count (Before/After)	Percent Change	Notes
	Chicago, IL	Two-way cycle track on Dearborn Street protected by flexposts, parking and a three-foot buffer	1.2 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	171%	
	Chicago, IL	Cycle tracks replaced standard bike lanes on both sides of N. Milwaukee Street protected by a mix of painted 2-3-foot buffers with posts and parking areas	0.8 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	21%	Replaced existing bike lanes.
	Portland, OR	Road diet replaced one travel lane and standard bike lanes on each side of NE Multnomah Street with cycle tracks protected by a mix of parking, painted buffers, flexible bollards and/or planters	0.8 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	68%	Replaced existing bike lanes.

Table 6 (cont.). Before/After Bike Counts – Class IV Cycle Tracks

Study	Location	Facility Description	Facility Length	Bike Count (Before/After)	Percent Change	Notes
	San Francisco, CA	Cycle tracks along a one-way street couplet (Fell and Oak Streets), protected by flexposts. Replaced parking on one street and an existing bike lane on the other.	0.3 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	46%	One of the two cycle tracks replaced an existing bike lane.
	Washington, D.C.	Road diet on one-way street replaced one vehicle lane with a one-way cycle track protected by plastic flexposts	1.12 miles	Complete raw data not provided. See report for explanation of adjustments and averaging, and ultimate count change numbers.	65%	

Table 6 (cont.). Before/After Bike Counts – Class IV Cycle Tracks

Study	Location	Facility Description	Facility Length	Bike Count (Before/After)	Percent Change	Notes
Goodno et al. (2013)	Washington, D.C.	Two-way cycle track on 15th Street, NW.	~1.5 miles	Exact counts not reported, but appear to range from 25 to 75 for before counts, and 225 to 375 for after counts (at the afternoon peak hour)	>500%	Counts taken during the afternoon peak hour at two locations along the corridor in April and/or October before facility installation and at three locations in each of the three years following initial installation (and for approximately 1.5 years after the original one-way facility was modified into a two-way facility)
Average for All Facilities (n=16) = 107% (80% if facility with reported 500% increase excluded)			The six cycle track facilities analyzed in Matute et al. (2016) are all assumed to have shown the same ridership increase (86%) as the average for the 10 combined bike path, cycle track and bike boulevard facilities for which the mean 86% figure was reported. No weighting done by facility length or other attribute.			
Average for All Facilities Known to Have Replaced Existing Bike Lanes (n=5) = 61%			Calculated by summing the percentage change for each facility known to have replaced existing bike lanes (see Monsere et al., 2014)), and dividing by the number of facilities.			
Average for Facilities Not Known to Have Replaced Existing Bike Lanes (n=11) = 128%			Calculated by summing the percentage change for each facility not known to have replaced existing bike lanes, and dividing by the number of facilities. Five facilities did not replace existing bike lanes. It is unclear whether the other six facilities replaced existing bike lanes (Matute et al. (2016)).			
Average for Facilities < 1 Mile Long (n=7) = 65%						
Average for Facilities >= 1 Mile Long (n=2; facility with reported 500% increase excluded) = 118%						

Seasonal Effects

An estimate of annual bicycle ridership change is essential for estimating annual VMT reductions from a new bicycle facility. However, it can be difficult to translate hourly or daily counts into annual volumes. Bicycling volumes vary substantially by hour, day and season (Jones et al., 2010; Matute et al., 2016; Monsere et al., 2014; Nordback & Sellinger, 2014; Skov-Petersen, Jacobsen, Vedel, Thomas Alexander, & Rask, 2017). CARB's current quantification method attempts to account for the seasonal (mostly weather-related) variation by assuming the new bicycle facility would only be used 200 days out of the year. But more sensitive adjustment factors are now available, and will become increasingly accurate with the more widespread use of continuous automated bike counters.[15]

No comprehensive survey of local and regional governments was done to determine which California jurisdictions have continuous bike count data with which locally specific adjustment factors could be (or have been) calculated, but at least some do. San Francisco and San Diego both have dozens of continuous bike counters (see section H). And others, like Long Beach and Oakland, have at least one continuous bike counter. A year's worth of continuous bike count data from even a single counter can be enough to calculate seasonal adjustment factors in the same fashion as Nordback and Sellinger (2014) did in Seattle.

Nordback and Sellinger (2014) detail how to use continuous automatic count data to calculate daily/hourly and monthly adjustment factors to apply to short-duration (e.g., peak-hour) bike counts to estimate annual average daily bicycle trips. They developed daily/hourly and monthly adjustment factors using automatic count data collected continuously from October 2, 2012 to September 30, 2013 on the bikeways on both sides of Seattle's Fremont Bridge. To calculate annual average daily bicycle trips (AADBTs) from a one-hour count during one of the peak-hour time periods for which they created daily/hourly adjustment factors ($AF_{D,H}$), one would use Equation 2.

Equation 2:

$$ADBT = (hourly\ count) * AF_{D,H} * AF_M$$

Where,

Hourly count	=	a one-hour count during one of the listed peak-hour time periods
$AF_{D,H}$	=	the applicable daily/hourly adjustment factor
AF_M	=	the applicable monthly adjustment factor

[15] Automated bike counters use a range of technologies – infrared, inductive loops, etc. – to digitally record bike trips along a corridor without on-site human counting or monitoring (Ryus et al., 2014; San Francisco Municipal Transportation Agency, 2016). Jurisdictions are increasingly embedding these devices more permanently into their street and path infrastructure to obtain continuous counts over longer periods of time than an average manual count.

While the authors caution that it “is not appropriate to apply these factors” outside of Seattle, or even to all locations within Seattle, they are illustrative of how seasonal adjustment factors can be developed and applied using local continuous bike counts (Nordback & Sellinger, 2014, 40). In areas without sufficient local continuous bike counts, planners can use a generic set of seasonal adjustment factors developed from project-level data across the United States.

Based on continuous counts from across the nation, the National Bicycle and Pedestrian Documentation Project developed a set of “count adjustment factors” to convert hourly bicyclist and pedestrian counts to annual (and average annual daily) volumes (National Bicycle and Pedestrian Documentation Project, 2009). The authors caution that “more year-long automatic count data is needed from different parts of the country” for pedestrian and on-street bicyclist counts outside of “multi-use paths” (like many Class I facilities) and “pedestrian and entertainment areas” (like most downtowns) (National Bicycle and Pedestrian Documentation Project, 2009, 1). But they conclude that “enough data now exists to allow us to adjust counts done [during] almost any period on multi-use paths and pedestrian districts to an annual figure” (National Bicycle and Pedestrian Documentation Project, 2009, 1).

The National Bicycle and Pedestrian Documentation Project seasonal adjustment steps are summarized as follows, with reference to Tables 7, 8, and 9 below:

- Start with an hourly count. To improve count estimation accuracy, the National Bicycle and Pedestrian Documentation Project “strongly encourage[s] that all estimates be based on the average of at least two… and preferably three… counts during the same time period and week” (National Bicycle and Pedestrian Documentation Project, 2009, 1).
- Multiply the hourly count by 1.05 (to reflect bicyclists who travel between 11 p.m. and 6 a.m.).
- Identify the weekday hour (and season and area/facility type) of your count, then divide your hourly count by the appropriate factor listed in Table 7 below (Table 1 of the National Bicycle and Pedestrian Documentation Project’s report) to get a daily user estimate.
- Divide the daily user estimate by the weekly adjustment factor in Table 8 below (Table 2 of the report) for the day of the week on which your counts were taken to obtain a weekly user estimate (holidays use weekend rates).
- Multiply the weekly user estimate by 4.33 to obtain a monthly user estimate for the month in which the counts were taken.
- Divide the monthly user estimate by the appropriate monthly adjustment factor from Table 9 below (table 3 of the report) to get the annual user estimate.
- Divide by 365 to produce an average annual daily trip estimate.

Equation 3 represents these steps in mathematical form.

Equation 3:

$$AADBT = \frac{(hourly\ count) * 1.05 * 4.33}{(hourly\ adjustment\ factor) * (daily\ adjustment\ factor) * (monthly\ adjustmnet\ factor) * 365}$$

Where,

Hourly adjustment factor = appropriate value from Table 7 based on month, day and time during which the count was taken

Daily adjustment factor = appropriate value from Table 8 based on day of the week during which the count was taken

Monthly adjustment factor = appropriate value from Table 9 based on month of the year during which the count was taken

Table 7. Hourly Adjustment Factors

	April - September					**October-March**			
	Multi-Use Path		Pedestrian & Entertainment Area			Multi-Use Path		Pedestrian & Entertainment Area	
	Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun		Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun
0600	2%	1%	1%	1%	0600	2%	0%	0%	0%
0700	4%	3%	2%	1%	0700	4%	2%	1%	1%
0800	7%	6%	4%	3%	0800	6%	6%	2%	2%
0900	9%	9%	5%	3%	0900	7%	10%	4%	4%
1000	9%	9%	6%	5%	1000	9%	10%	5%	5%
1100	9%	11%	7%	6%	1100	9%	11%	8%	8%
1200	8%	10%	9%	7%	1200	9%	11%	10%	10%
1300	7%	9%	9%	7%	1300	9%	10%	13%	13%
1400	7%	8%	8%	9%	1400	9%	10%	11%	11%
1500	7%	8%	8%	9%	1500	8%	10%	8%	8%
1600	7%	7%	7%	9%	1600	8%	8%	7%	7%
1700	7%	6%	7%	8%	1700	7%	5%	6%	6%
1800	7%	5%	7%	8%	1800	6%	3%	6%	6%
1900	5%	4%	7%	8%	1900	4%	2%	6%	6%
2000	4%	3%	7%	8%	2000	2%	1%	6%	6%
2100	2%	2%	6%	8%	2100	2%	1%	5%	5%

Source: National Bicycle and Pedestrian Documentation Project (2009, Table 1)

Table 8. Daily Adjustment Factors

Day	Factor
Monday	14%
Tuesday	13%
Wednesday	12%
Thursday	12%
Friday	14%
Saturday	18%
Sunday	18%

Source: National Bicycle and Pedestrian Documentation Project (2009, Table 2)

Table 9. Monthly Adjustment Factors by Climate Area

Month	Long Winter & Short Summer	Moderate Climate	Very Hot Summer & Mild Winter
January	3%	7%	10%
February	3%	7%	12%
March	7%	8%	10%
April	11%	8%	9%
May	11%	8%	8%
June	12%	8%	8%
July	13%	12%	7%
August	14%	16%	7%
September	11%	8%	6%
October	6%	6%	7%
November	6%	6%	8%
December	3%	6%	8%

Source: National Bicycle and Pedestrian Documentation Project (2009, Table 3)

In the absence of locally specific continuous count data, or until California-wide seasonal adjustment factors are developed, AHSC, Urban Greening, and ATP fund applicants could follow the steps and factors provided by the National Bicycle and Pedestrian Documentation Project to extrapolate AADBT from hourly bike count data, at least for projects near multi-use paths or denser pedestrian and entertainment areas.

Bicycle Trip Length

CARB's current quantification method uses a default one-way bicycle trip length of 1.8 miles, which is based on the 1995 National Personal Transportation Survey (NPTS). But much more recent data is available (see Table 10).

The 2009 National Household Transportation Survey (NHTS)[16] shows a 2.3-mile average one-way bicycle trip length across all trip purposes (Kuzmyak & Dill, 2012). And more recent data from intercept surveys and Global Positioning System (GPS) tracking show even longer average trips.

For example, Matute et al. (2016) calculated one-way trip distances for the over 100 cyclists they intercepted riding on newly constructed Class I, Class II or Class IV bicycle facilities in Los Angeles County who provided sufficient origin and destination information. They reported a mean seven-mile one-way trip distance.

However, the 2010-2012 California Household Travel Survey shows a shorter, 1.5-mile average bicycle trip length across all trip purposes (Caltrans, 2013, 119). Because this is the most recent California-wide estimate, CARB may want to use this 1.5-mile average as the default bike trip length in its quantification methodology going forward.

More locally specific trip length estimates lack standardization and may therefore not be ideal for use in a statewide VMT reduction quantification method.

Table 10. Recent One-Way Bicycle Trip Length Estimates

Study	Location	Data Source	Mean One-Way Trip Length
Matute et al. (2016)	Los Angeles County	Intercept survey of cyclists (2016)	7.0 miles
Caltrans (2013)	California	California Household Travel Survey (2010-2012)	1.5 miles
Kuzmyak & Dill (2012)	United States	National Household Travel Survey (2009)	2.3 miles

Modal Substitution

Estimating VMT reductions from new bicycle facilities requires assumptions not only about changes in facility usage and about average trip lengths, but also about modal substitution – the percentage of the new bike trips[17] that would have otherwise been made by automobile absent the new facility. The current quantification method uses a 0.7 substitution rate, which is based on an old California auto mode share figure for all trips and assumes that modal substitution rates are equivalent to existing mode shares. But more recent, stated substitution data from intercept surveys of cyclists indicate that the actual substitution rate is much lower, as summarized in Table 11.

The *total* substitution percentage averaged across all seven facilities analyzed by Monsere et al. (2014) is 25.3%, which is just shy of the 27.7% total substitution

[16] The NPTS was renamed the NHTS beginning with the 2001 NHTS. The most recent NHTS was completed in 2017, but relevant summaries of the data were not yet publicly available at the time this report was written, nor were they prepared separately for this report.
[17] This excludes trips made by cyclists who biked the same route even before the facility addition.

percentage averaged across all 20 Los Angeles County facilities analyzed by Matute et al. (2016).[18] That includes *all* substitution from auto trips (driver or passenger), transit trips, walking trips and any other mode. Monsere et al. (2014) did not separately calculate the auto-only substitution rate, but it was calculated that 10.9% of the new cyclists on the 20 facilities analyzed by Matute et al. (2016) would have made their trips by automobile. That aligns with the 11% figure reported by Thakuriah, Metaxatos, Lin, and Jensen (2012) for a bike path and two bike lanes in a Chicago suburb, though it is unclear if their respondent pool included any people who cycled the same route before facility installation anyway. If it did, the true auto substitution rate (using as the denominator just those cyclists who started using the route *after* facility installation) would be higher.

The primary reason the auto and total substitution rates are so much lower than the 0.7 rate used in the current quantification method appears to be that many of the additional cyclists on new bicycle facilities are not new cyclists; instead, these are cyclists who switched routes to take advantage of the better infrastructure. Route switching percentages were calculated for the data reported in Monsere et al. (2014) and Matute et al. (2016) ranging from 35.3% to 84.4% (Table 11). In addition, as the bus substitution rate (10.9%) calculated from the data reported in Matute et al. (2016) indicates, cyclists are more likely to have taken transit previously than the general California public is to make trips by transit on a day-to-day basis (4.4% of all trips, according to the 2010-2012 California Household Travel Survey [Caltrans, 2013, 4]).

Piatkowski et al. (2015) report much higher auto substitution percentages, ranging from 23.7% to 72.4%. But they are not directly comparable to the other substitution percentages shown in Table 11 for at least three reasons. First, they did not survey cyclists on new facilities, and thus did not measure route shift. Second, they only reported substitution rates for non-recreational cyclists, which likely increased their reported auto substitution rate results vis-à-vis rates calculated for recreational and utilitarian cyclists combined. Third, their survey results combined cyclists and pedestrians.

In sum, the available data indicate an overall stated substitution rate between 0.2 and 0.3 (for cyclists who did not bike on the same route prior to bicycle facility installation), with an auto substitution rate of about 0.1. However, because almost all of the data come from intercept surveys on Class IV cycle track facilities, it is impossible to determine whether and how the substitution rates vary by facility type.[19] More intercept surveys on bike paths and bike lanes would be useful.

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[18] Note that the averages were calculated independently by the authors of this review summary using the data reported by Monsere et al. (2014) and Matute et al. (2016) because the percentages they reported included respondents who cycled on the same route prior to installation of the analyzed facilities. Cyclists who continue to ride on the same route pre- and post-facility are irrelevant for VMT – and GHG emission – reduction quantification purposes. What matters is the percentage of *increased* bicycle trips on the route that would have otherwise (without the new bicycle facility) been made by automobile.

[19] All seven facilities for which Monsere et al. (2014) reported substitution rates are Class IV cycle tracks. And over half of Matute et al.'s (2016, 37) survey respondents were intercepted on cycle tracks.

Table 11. Modal Substitution Estimates

Study	Location	Facility Description	Survey Method	Auto-to-Bike Substitution %	Other-to-Bike Substitution %	Route Shift %	New Trip %
Matute et al. (2016)	Los Angeles County	One Class I bike path, five Class IV cycle tracks and 14 Class II bike lanes	Intercept survey (463 poster/non-dismount responses; 155 long-form/dismount responses)	10.9%	10.9% (bus) 5.9% (other)	50.4%	21.8%
Piatkowski et al. (2015)	Denver, CO	Multiple intercept survey locations. See source paper for details.	Intercept survey (utilitarian cyclists and pedestrians only; results combined for cyclists and pedestrians; n= 56)	23.7 %	32.2% (bus or light rail) 20.5% (walked or biked, whichever not currently doing) 5% (other)	Not measured	18.6%

Table 11 (cont.). Modal Substitution Estimates

Study	Location	Facility Description	Survey Method	Auto-to-Bike Substitution %	Other-to-Bike Substitution %	Route Shift %	New Trip %
	Boulder, CO	Multiple intercept survey locations. See source paper for details.	Intercept survey (utilitarian cyclists and pedestrians only; results combined for cyclists and pedestrians; n= 59)	57.1%	30.3% (bus or light rail) 9% (walked or biked, whichever not currently doing) 0% (other)	Not measured	3.6%
	Littleton, CO	Multiple intercept survey locations. See source paper for details.	Intercept survey (utilitarian cyclists and pedestrians only; results combined for cyclists and pedestrians; n= 29)	72.4%	17.3% (bus or light rail) 0% (walked or biked, whichever not currently doing) 3.5% (other)	Not measured	0%
	Sacramento, CA	Multiple intercept survey locations. See source paper for details.	Intercept survey (utilitarian cyclists and pedestrians only; results combined for cyclists and pedestrians; n= 11)	27.3%	45.4% (bus or light rail) 9.1% (walked or biked, whichever not currently doing) 9.1% (other)	Not measured	0%

Table 11 (cont.). Modal Substitution Estimates

Study	Location	Facility Description	Survey Method	Auto-to-Bike Substitution %	Other-to-Bike Substitution %	Route Shift %	New Trip %
	Davis, CA	Multiple intercept survey locations. See source paper for details.	Intercept survey (utilitarian cyclists and pedestrians only; results combined for cyclists and pedestrians; n= 37)	25.0%	8.3% (bus or light rail) 47.2% (walked or biked, whichever not currently doing) 8.3% (other)	Not measured	11.2%
Monsere et al. (2014)	Austin, TX	One-way cycle track on Barton Springs Road protected by flexposts and a 1.5-foot buffer (there is a shared-use path on the other side of the street)	Intercept survey (invited at intercept, and survey filled out electronically later; n = 18)	Not separately calculated	17.1% (auto and all other modes)	82.9%	0%
	Austin, TX	Two-way cycle track replaced a one-way standard bike lane on one-way Rio Grande Street protected by flexposts and a four-foot buffer	Intercept survey (invited at intercept, and survey filled out electronically later; n = 43)	Not separately calculated	15.6% (auto and all other modes)	84.4%	0%

Table 11 (cont.). Modal Substitution Estimates

Study	Location	Facility Description	Survey Method	Auto-to-Bike Substitution %	Other-to-Bike Substitution %	Route Shift %	New Trip %
	Chicago, IL	Two-way cycle track on Dearborn Street protected by flexposts, parking and a three-foot buffer	Intercept survey (invited at intercept, and survey filled out electronically later; n = 124)	Not separately calculated	25.3% (auto and all other modes)	72.3%	2.4%
	Chicago, IL	Cycle tracks replaced standard bike lanes on both sides of N. Milwaukee Street protected by a mix of painted 2-3-foot buffers with posts and parking areas	Intercept survey (invited at intercept, and survey filled out electronically later; n = 236)	Not separately calculated	58.8% (autos and all other modes)	35.3%	5.9%
	Portland, OR	Road diet replaced one travel lane and standard bike lanes on each side of NE Multnomah Street with cycle tracks protected by a mix of parking, painted buffers, flexible bollards and/or planters	Intercept survey (invited at intercept, and survey filled out electronically later; n = 112)	Not separately calculated	22.7% (autos and all other modes)	77.3%	0%

Table 11 (cont.). Modal Substitution Estimates

Study	Location	Facility Description	Survey Method	Auto-to-Bike Substitution %	Other-to-Bike Substitution %	Route Shift %	New Trip %
	San Francisco, CA	Cycle tracks along a one-way street couplet (Fell and Oak Streets), protected by flexposts. Replaced parking on one street and an existing bike lane on the other.	Intercept survey (invited at intercept, and survey filled out electronically later; n = 278)	Not separately calculated	29.5%	63.5%	7.0%
	Washington, D.C.	Road diet on one-way street replaced one vehicle lane with a one-way cycle track protected by plastic flexposts	Intercept survey (invited at intercept, and survey filled out electronically later; n = 300)	Not separately calculated	22.7%	72.7%	4.6%
Thakuriah et al. (2012)	Chicago, IL	Three bicycle facilities in the Chicago suburbs, including a 0.5-mile bike path, a 1,260-foot bike lane and a 7,197-foot bike lane	Intercept survey (71 total respondents across the three sites)	11% (denominator includes those who biked via same route previously)	Not reported	Not reported	Not reported

Bicycle Trip Type

As discussed, the current quantification method does not fully exclude recreational trips from its VMT reduction calculus. Its default 1.8-mile average trip length figure from the 1995 National Personal Transportation Survey is based on all trips, as is the 0.7 automobile substitution rate underpinning the adjustment factor "A" in the current method. In addition, at least one recent study indicates that bike facilities do influence people's choice to bicycle instead of drive for recreational purposes (Matute et al., 2016).

Nonetheless, if desired, decrementing the VMT reduction estimate by the percentage of recreational trips provides a more conservative estimate.

Data from the 2009 NHTS provide one estimate of recreational trip share. They show that 49.4 percent of bicycle trips were made for "vacation" (2.1%) or "other social or recreational" (47.3%) purposes[20] (Kuzmyak & Dill, 2012). The estimate is likely conservative, however, because some of the trip purposes categorized as "other social or recreational" are arguably more similar to utilitarian trips than purely recreational trips.

[20] "Vacation" bicycle trips include those made for rest, relaxation or vacation. "Other social or recreational" trips include those made for exercise, playing sports, going out for entertainment, visiting a public place, eating a meal or getting coffee or snacks, and social events (Kuzmyak & Dill, 2012).

Section G. Alternative Quantification Method

Given the amount and quality of bicycling-related research and data collection since Caltrans published the CMAQ method in 2005, it is now possible to estimate VMT reductions from new bicycle facilities based on existing bicycle counts, without using ADT. Projecting VMT reductions from new bicycle facilities without vehicular ADT begins with obtaining bike counts on the route for the proposed facility (or an adjacent route, if no road or path currently exists where the facility is proposed to run). The short-duration ridership counts must then be converted to average annual daily bike trips using a temporal and seasonal adjustment factor. The growth factor can be adjusted based on facility type and length, though more facility-specific data is needed. Multiplying that new ridership estimate by an average trip length yields new bicycle miles traveled from adding a bike facility. Not all of those new bicycle trips replace vehicle trips, however. Further adjustment is needed, including an auto-bicycle substitution rate, a carpool factor (not every vehicle trip has just one occupant) and, to be conservative, a trip type factor (recreational bike trips may be less likely than utilitarian bike trips to replace auto trips).

One reason to rely on bicycling count data rather than vehicular ADT is that using vehicular ADT assumes that higher auto volumes correlate to higher bicycling volumes. That is often not the case.

For example, a high-volume arterial running from suburban residential developments in a hilly area to a freeway accessing the metropolitan job center 10 miles away could easily have high vehicular volume but low bicycling volume, due to the topography and distance to the major regional job center. On the other hand, a high-volume arterial in a flat area with high accessibility to residential, commercial and retail uses could have substantial bicycle traffic, just as the stretch of Telegraph Avenue in the Uptown neighborhood of Oakland, California did even before the city installed Class IV cycle tracks on both sides of the street (McClain & Peterson, 2016).

Existing bicycling counts inherently account for factors like topography and distance that will limit bicycle ridership with or without bicycle facilities. By contrast, using vehicular ADT requires applying adjustment factors like the proximity to "activity centers" proxy used in CARB's current method.

Likely in part because they account for limiting factors beyond infrastructure, pre-facility-installation bicycle counts also appear to be a reasonably reliable predictor of post-installation counts. For example, as discussed above, Matute et al. (2016, 50) found that there was "no relationship" between cyclist volumes before facility installation and percent ridership change across the 44 facilities they analyzed – the percent change was similar regardless of the "before" counts. As Matute et al. (2016, 50) conclude, this "implies that ridership change can be predicted reasonably reliably by volumes observed before facility installation."

In addition, as discussed in the preceding sections, there is a growing body of literature on the auto substitution rate for cyclists using a new facility and route, as well as average bicycle trip lengths.

Based on this expanding literature, VMT reductions can now be estimated from new bicycle facilities without using vehicular ADT. Equation 4 is one potential bicycle-count-based method.

Equation 4: Auto VMT Reductions (alternative method)

$$Auto\ VMT\ Reduced = (D) * (BC) * (S) * (GF) * (AS) * (C) * (T) * (L)$$

Where,

			Units
D	=	days of use per year (default is 365 days, since counts can be adjusted seasonally)	Days/year
BC	=	average hourly (or daily) bicycle count (counts taken on the street to be improved with the bike facility, or, in the case of a facility not on an existing street, a parallel street)	Trips/day
S	=	seasonal adjustment factor (adjusts bicycle count to annual average daily bicycle trips)	-
GF	=	growth factor (expected rate of increase in bicycle count, e.g. 1.0 for a 100% increase in trips on the route)	-
AS	=	automobile substitution rate (expected rate at which cyclists who did not bike on the same route prior to bicycle facility installation switched from driving, or being driven in, an automobile to cycling)	-
C	=	carpool factor (default is 1/1.15, to reflect the California average number of vehicle trips per person trips by personal auto)	-
T	=	trip type factor (optional inclusion for conservative estimates; default is 0.506)	-
L	=	bike trip length (default is 1.5 miles/trip in one direction)	Miles/trip

Values for the first two variables, *D* and *BC*, would be provided by the funding applicant. *D* would have a default of 365, but it could be changed based on local conditions and the type of seasonal adjustment factor used. Where possible bicycle counts should be taken in similar fashion across sites, for example by following the National Bicycle and Pedestrian Documentation Project methodology, as discussed in section F, Seasonal Effects.

The seasonal adjustment factor, *S*, could use local data where available. But to ensure continuity in application across California, the National Bicycle and Pedestrian Documentation Project's adjustment factors can be used in the interim, as discussed above in section F, Seasonal Effects, and as applied in the case study at the end of this report.

The growth factor, *GF*, could be approximated based on the findings from the count-based studies discussed in section F, Facility-Level Bicycle Ridership Change, either by facility type or as an approximate average value for all of them. It appears from the literature that a uniform, facility-agnostic growth rate around 1.0 could be appropriate. A facility-specific factor around 1.0 might also be appropriate for Class I bike paths, Class II bike lanes, and Class IV cycle tracks that do not replace existing Class II facilities. However, the growth rates may be lower for Class IV facilities that replace existing bike lanes (possibly closer to 0.6) and Class III bike boulevards (possibly closer to 0.3 or 0.4). The literature also indicates at least some correlation between facility length and ridership increases (at least for Class IV cycle tracks). However, more research is needed to clarify the facility length-ridership relationship, particularly for Class I and Class II facilities.

The auto substitution factor, *AS*, could be based on the available data discussed above in section F, Modal Substitution, which indicate an auto substitution rate of about 0.1. However, the auto substitution factor should be adjusted to account for carpooling (not all bicyclists who would have made the same trip by car would have done it alone). The carpool factor, *C*, corrects for that, by dividing the total number of substituted trips by the average vehicle occupancy rate (average number of people per auto) used by Caltrans (1.15) (Caltrans, 2016).

The (optional) trip type factor, *T*, is included to correct for the fact that bike trips that are purely for exercise, sport, or recreation are not as likely to substitute for auto trips as utilitarian bike trips. The default value for *T* is based on the combined share (49.4%) of bicycle trips made for "vacation" (2.1%) or "other social or recreational" (47.3%) purposes, taken from the 2009 NHTS. The default value is the percentage of all other (non-vacation, social, or recreational) trips, calculated as 1-0.494 (=0.506). This approximation of commute and utilitarian trip share is likely conservative, however, because some of the trip purposes categorized as "other social or recreational" are arguably more similar to utilitarian trips than purely recreational trips. In addition, as discussed above, at least one recent study indicates that bike facilities influence people's choice to bicycle instead of drive for recreational purposes as well as for commute and utilitarian purposes (Matute et al., 2016). Furthermore, the auto substitution factor already accounts for recreational ridership, as it is based on the substitution rates of all surveyed cyclists combined, regardless of trip purpose (Matute et al., 2016; Monsere et al., 2014; Thakuriah et al., 2012). If the substitution factor, *AS*, were calculated based on only utilitarian trips, it would be quite a bit higher. Including this optional factor thus produces a conservative estimate of VMT reductions from bicycle facility installation.

The trip length factor, *L*, is based on the average length of bicycle trips taken for any purpose. Currently, CARB uses a 1.8-mile default, based on the 1995 NPTS. But more recent estimates exist. The 2009 NHTS data show an increased average bike trip length of 2.3 miles, as discussed in section F, Bicycle Trip Length. And the most recent California Household Travel Survey data show a 1.5-mile average bicycle trip length. Because this is the most recent California-wide bike trip length estimate, it may be the safest – and certainly most conservative – default value to use in this alternative quantification method. In any event, using the average bike trip length would produce a conservative estimate of vehicle miles if the new bicycle trips are shorter than the driving trips they replace, as would be the case if the bicyclist chooses a closer destination for that trip given the slower speed of bicycling.

As bicycling research progresses, the above factors should be re-examined and updated, replaced or added to as needed. For example, the ridership growth rate factors should be adjusted as more facility-level before-and-after count studies are done. Additionally, as more data becomes available on the differences between recreational and utilitarian bicycling (e.g., as to trip length and auto substitution rates), the bike counts could be split by estimated (or surveyed) trip purpose proportions, with trip-purpose-specific factors applied to each. That would provide a more holistic estimate of bicycling-related VMT reduction than the current approach of decrementing the ridership counts by the percentage of recreational trips. Emerging research on the importance of the connectivity, comfort, accessibility and overall “level of service” of bikeway networks may also warrant adding network-based factors to the equation in the future.

Section H. Comparing Methods – Case Study of Fifth Street Road Diet in Davis, CA

To illustrate how the alternative quantification method could be applied, and to compare the process and results to those of CARB's existing method, a case study was conducted of the 2014 Fifth Street road diet project in Davis, California.

Project Setting and Description

The project chosen for this case study is a road diet completed in August 2014 on a 0.8-mile segment of Fifth Street in Davis, California. The project added Class II bike lanes on both sides of the street. Both the setting and project are described in more detail below.

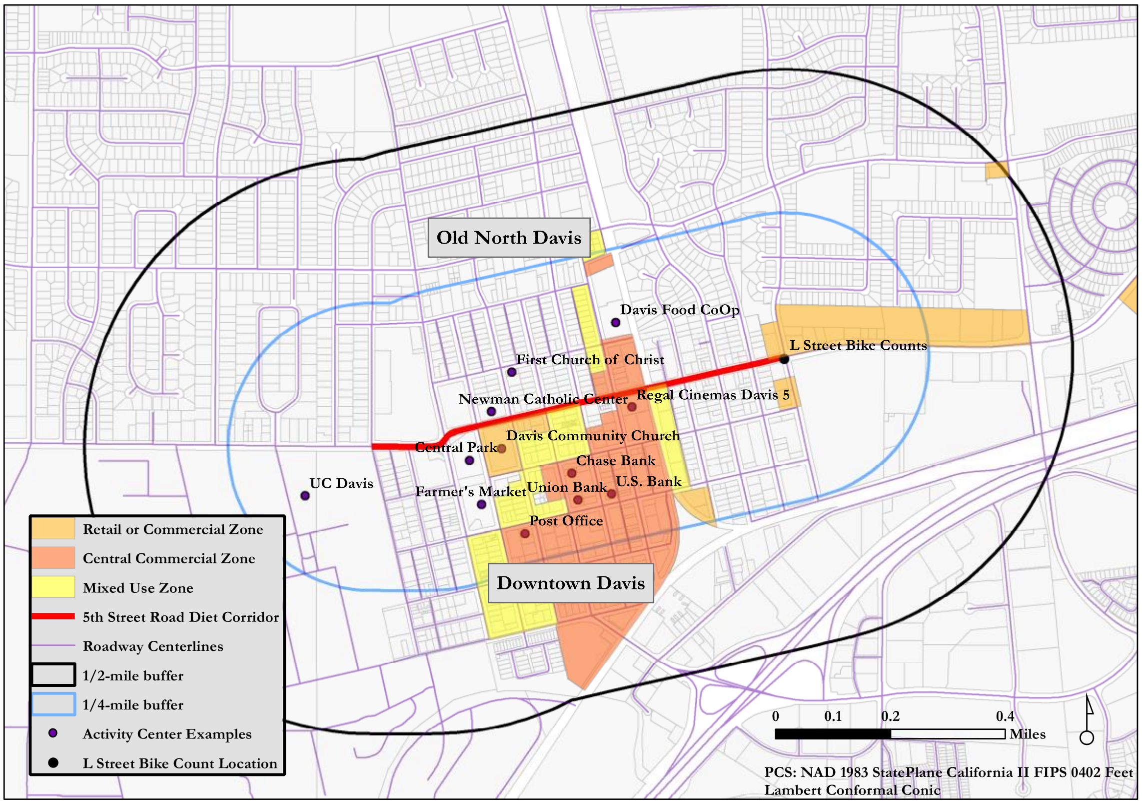
The City of Davis has a population of about 68,000. Many of its residents either study or work at the University of California, Davis (UC Davis). UC Davis' 9-month academic year runs from September to June, with a multi-week winter break from mid-December to early January, and a one-week spring break in March.

Davis has a mild Mediterranean climate with dry, hot summers and cool, rainy winters. These conditions, along with its relatively small area (~10 square miles), proximity to a major university, and "flat terrain throughout the city, are conducive to active transportation" (Gudz, Fang, & Handy, 2016, 62).

The studied segment of Fifth Street runs from A Street on the west to L Street on the east. See Figure 5, below. The stretch of Fifth Street from A Street to just east of G Street constitutes the northern border of Downtown Davis and separates it from Old North Davis. It accesses a wide diversity and density of land uses, including UC Davis (Figure 5). "Several modes of transportation travel this corridor, including but not limited to light-duty cars and trucks, small freight, delivery vehicles, buses, city service vehicles, bicycles, pedestrians, and skateboarders" (Gudz et al., 2016, 62).

Before the road diet, the studied segment of Fifth Street "had four vehicle lanes (i.e., two lanes in each direction that measured approximately 12 ft each), with traffic signals at the A, B, F, G, and L Street intersections" (Gudz et al., 2016, 62). "Most of the right-of-way was dedicated to these four traffic lanes and on-street parking along the north side of the roadway on some blocks. The entire segment had 3- to 4-ft sidewalks with landscaped buffers on both sides but no marked bicycle lanes" (Gudz et al., 2016, 62).

Figure 5. Davis Fifth Street Road Diet Corridor with Nearby Land Uses and Activity Centers



GIS Layer Sources: City of Davis (zoning); Yolo County (parcels and streets)

The August 2014 road diet "reduced" this 0.8-mile "segment of Fifth Street to three traffic lanes, with one lane dedicated for each direction of travel and a shared left-turn lane for both directions, and added a 5- to 7-ft" Class II "bicycle lane on each side" (Gudz et al., 2016, 62). The project also added modified Americans with Disabilities Act-compliant pedestrian amenities at all intersections, added left-turn signals and bicycle boxes at two intersections, installed new traffic signals at two intersections, and left some on-street parking spaces (Gudz et al., 2016).

Bicycle Trip, Vehicular Trip and Activity Center Data

Gudz et al. (2016) studied the impact of the Fifth Street road diet on bicycle and pedestrian use and vehicular travel times. Both before and after the road diet was completed, the researchers counted bicyclists and pedestrians at the intersections of Fifth Street with A, B, D, E, F, J and L streets. They collected counts twice daily (morning and evening) on Wednesdays and Thursdays, from 8:45 to 10:15 a.m. and from 4:30 to 6:00 p.m. The before counts included four observation days (eight observation periods), while the after counts were done over two days (four observation periods). Both the before (May 2013) and after (October 2014) counts were conducted while UC Davis was in session. Gudz et al. (2016) present the mean before and after counts by intersection and time period (morning and evening) in table 1 of their article. The counts aggregate all east-west and west-east trips observed during the relevant time period.

Gudz et al. (2016) did not report total corridor ridership counts for the studied segment of Fifth Street. But it can conservatively be concluded that the corridor count would be at least as much as the highest intersection-specific count.[21] The highest mean counts for the morning (121.3 person-trips) and evening (155.5 person-trips) periods both occurred at the intersection of L Street and Fifth Street. Those counts are used in the below estimation of facility-induced VMT reduction using the alternative quantification method.

The researchers did not also count vehicular traffic. But they note that the "studied segment of Fifth Street is a relatively busy east-west arterial, with annual daily traffic of 14,998 vehicles" (Gudz et al., 2016, 62). That figure is used as the average annual daily vehicular traffic in the below estimation of facility-induced VMT reduction using the current quantification method.

In addition to average annual daily vehicular trips, CARB's current method requires quantification of the number of "activity centers" within ¼-mile and ½-mile buffers of the project (or parallel) corridor.[22] To count the activity centers near the Fifth Street corridor, a parcel and land use map was created in ArcMap with ¼-mile and ½-mile buffers around the corridor. A non-exhaustive list of activity centers was created using openstreetmap.org, Yolo County land use data, and walking the corridor. The example activity centers and generalized commercial- or retail-related zoning blocks[23] were then tagged in the map (Figure 5).

VMT Reduction Estimation – Current Method

CARB's current method estimates the annual VMT reductions from new bicycle facilities using Equation 1 (CARB, 2016 [B-1], 2018b [26], 2019 [16]):

[21] To calculate the total corridor count, you would start with the east-west bike trip counts at the easternmost intersection and west-east bike trip counts at the westernmost intersection, then add to those counts the number of bicyclists that turned onto Fifth Street (going either east or west) at the intervening intersections during the same count period.
[22] "Activity centers" include banks, churches, hospitals, light rail stations (park and ride), office parks, post offices, public libraries, shopping areas or grocery stores, universities, junior colleges, primary schools and secondary schools (CARB, 2016) [B-2], 2018b [28], 2019 [17]).
[23] The central commercial and mixed-use zones shown in the map are the actual zoning designations for those areas, while the "retail or commercial zone" combines a sample of parcels in the area otherwise zoned for commercial or retail use.

Equation 1: Auto VMT Reductions (current method)

$$Auto\ VMT\ Reduced = (D) * (ADT) * (A + C) * (L)$$

Where,

			Units
D	=	days of use per year (default is 200 days)	Days
ADT	=	annual average two-way daily vehicular traffic on parallel road (project-specific data, with a maximum of 30,000)	Trips/day
A	=	adjustment factor (table lookup value)	-
C	=	activity center credit (table lookup value)	-
L	=	bike trip length (1.8 miles/trip in one direction)	Miles/trip

Applying Equation 1 to the Fifth Street road diet project, the default values were retained for *D* (200 days) and *L* (1.8 miles/trip). For *ADT*, the annual daily two-way vehicular traffic reported by Gudz et al. (2016) was used (14,998). Referencing Table 1, the value used for *A* was 0.0073 (university town with population less than 250,000, ADT between 12,000 and 24,000, and bicycle project length less than 1 mile).

The value for *C* was more time-consuming to obtain, since it requires fieldwork or detailed mapping to determine the number of activity centers within ¼-mile and ½-mile radii of the bicycle facility (or parallel corridor) (Table 2). In this case, it was determined that there are more than seven activity centers within a ¼-mile radius of the road-dieted segment of Fifth Street. For example, as shown in Figure 5, there is a post office, a university (UC Davis), at least three churches (or other religious centers), at least three banks, a grocery store, a farmer's market, a centrally-located park, a movie theater, and multiple shopping and/or office areas (as shown by the blocked mixed-use, central commercial, and commercial or retail zones). As a result, the value used for *C* was 0.003 (Table 2).

Applying those values in Equation 1 yields an annual reduction of 55,613 vehicle miles traveled:

$$Annual\ VMT\ Reduced = \left(200\ \frac{days}{year}\right) * \left(14{,}998\ \frac{vehicle\ trips}{day}\right) * (0.0073 + 0.003) * \left(1.8\ \frac{miles}{vehicle\ trip}\right)$$

$$Annual\ VMT\ Reduced = \mathbf{55{,}613}$$

Applying CARB's auto vehicle emission factors (AVEF) for Yolo County in 2017 (522 grams of CO_2 equivalents per mile)[24] and 2029 (356 grams CO_2e/mile)[25] yields a yearly

[24] The earliest year for which emissions factors are available in CARB's most recent guidance.

[25] The last year the Fifth Street bike lanes would be operational, using CARB's default 15-year lifetime for Class II facilities and the actual project completion date of August 2014 (CARB, 2016).

average of 24.4 metric tons of avoided CO_2 equivalents ($MTCO_2e$), per Equation 5 (CARB, 2016):

Equation 5:

$$GHG\ Emission\ Reductions = \frac{(VMT\ Reduced * AVEF_{2017}) + (VMT\ Reduced * AVEF_{2029})}{1{,}000{,}000} / 2$$

Where,

$AVEF_{2017}$	=	CARB's auto vehicle emission factor for Yolo County in 2017 (the year closest to 2014, when Fifth Street road diet project was completed, for which an emission factor was available)
$AVEF_{2029}$	=	CARB's auto vehicle emission factor for Yolo County in 2029 (the 15th and final year of assumed project operation, according to CARB's current quantification method)

The result for the Fifth Street road diet project is:

$$\boldsymbol{GHG\ Emission\ Reductions = 24.4\ MTCO_2e}$$

VMT Reduction Estimation – Alternative Method

The alternative quantification method proposed in this report estimates the annual VMT reductions from new bicycle facilities using Equation 4.

Equation 4: Auto VMT Reductions (alternative method)

$$Auto\ VMT\ Reduced = (D) * (BC) * (S) * (GF) * (AS) * (C) * (T) * (L)$$

Where,

			Units
D	=	days of use per year (default is 365 days, since counts can be adjusted seasonally)	Days/year
BC	=	average hourly (or daily) bicycle count (counts taken on the street to be improved with the bike facility, or, in the case of a facility not on an existing street, a parallel street)	Trips/day
S	=	seasonal adjustment factor (adjusts bicycle count to annual average daily bicycle trips)	-
GF	=	growth factor (expected rate of increase in bicycle count, e.g. 1.0 for a 100% increase in trips on the route)	-
AS	=	automobile substitution rate (expected rate at which cyclists who did not bike on the same route prior to bicycle facility installation switched from driving, or being driven in, an automobile to cycling)	-
C	=	carpool factor (default is 1/1.15, to reflect the California average number of vehicle trips per person trips by personal auto)	-
T	=	trip type factor (optional inclusion for conservative estimates; default is 0.506)	-
L	=	bike trip length (default is 1.5 miles/trip in one direction)	Miles/trip

Applying Equation 4 to the Fifth Street road diet project, the default values for *D* (365 days/year), *C* (1/1.15 vehicle trips/person trips), and *L* (1.5 miles/trip) were used. The default value for *T* (0.506) was also used, but for comparison purposes VMT reduction was also estimated without using *T*, since as discussed above, using *T* produces a more conservative estimate.

For *GF*, a conservative value of 1.0 was used (as discussed in the section G). The resulting VMT reduction estimate would be even higher using a value of 1.19 (based on the average 119 percent increase shown in Table 4 for Class II facilities). No adjustment was made for facility length. Because facility lengths were not reported for most Class II facilities in the reviewed studies, it was impossible to analyze the relationship between ridership change and facility length for those facilities, as discussed above in section F.

For *AS*, a value of 0.1 (vehicle trips/bicycle trip) was used, based on the data analyzed and figures reported by Matute et al. (2016) and Thakuriah et al. (2016), as discussed above in section F. Modal Substitution.

The two remaining factors, *BC* and *S*, are intertwined. As discussed above, the two bicycle counts used for *BC* are 121.3 (trips/morning observation period) and 155.5 (trips/evening observation period). To estimate a seasonally adjusted *BC*, those morning and evening counts were each divided by 1.5 (to obtain hourly counts amenable to seasonal adjustment), seasonally adjusted using the *S* factors (and adjustment methodology) published by the National Bicycle and Pedestrian Documentation Project, then averaged, as shown below. The result is a combined value for *BC* and *S* of 2,011 (bicycle trips/day).

<u>Morning-period adjustment</u>:
The National Bicycle and Pedestrian Documentation Project seasonal adjustment methodology is summarized in more detail above in section F, Seasonal Effects (see also National Bicycle and Pedestrian Documentation Project (2009)). In short, however, the method proceeds as follows:

- Start with an hourly count.
- Multiply the hourly count by 1.05 (to reflect bicyclists who travel between 11 p.m. and 6 a.m.).
- Identify the weekday hour (and season and area/facility type) of your count, then divide your hourly count by the appropriate factor listed in Table 7 (table 1 of the National Bicycle and Pedestrian Documentation Project's report) to get a daily user estimate. Here, the factor for counts taken between April and September in high-density pedestrian areas during the 9-10 a.m. hour (representing the bulk of the 8:45-10:15 a.m. count period) is 0.05.
- Divide the daily user estimate by the weekly adjustment factor in Table 8 (table 2 of the report) for the day of the week on which your counts were taken to obtain a weekly user estimate. Here, the counts were taken on Wednesday and Thursday, both of which have a 0.12 adjustment factor.

- Multiply the weekly user estimate by 4.33 to obtain a monthly user estimate for the month in which the counts were taken (May here).
- Divide the monthly user estimate by the appropriate monthly adjustment factor from Table 9 (table 3 of the report). Here, the factor for May in moderate climates (as well as in climates with very hot summers and mild winters) is 0.08.
- Divide by 365 to produce an average annual daily trip estimate.

Applying that method here to the morning-period mean count yields the following average annual daily bicycle trips:

$$AADBT\ (AM) = \frac{121.3\ trips}{1.5} * 1.05 * \frac{1}{0.05} * \frac{1}{0.12} * 4.33 * \frac{1}{0.08} * \frac{1}{365} = 2{,}099\ trips/day$$

<u>Evening-period adjustment</u>:
Applying the same method (albeit with a different daily adjustment factors) to calculate average annual daily bicycle trips from the evening-period mean count yields:

$$AADBT\ (PM) = \frac{155.5\ trips}{1.5} * 1.05 * \frac{1}{0.07} * \frac{1}{0.12} * 4.33 * \frac{1}{0.08} * \frac{1}{365} = 1{,}922\ trips/day$$

<u>Averaging</u>:
To improve count estimation accuracy, the National Bicycle and Pedestrian Documentation Project "strongly encourage[s] that all estimates be based on the average of at least two… and preferably three… counts during the same time period and week" (National Bicycle and Pedestrian Documentation Project, 2009, 1). The bike count data used here satisfies that suggestion, as both the morning- and evening-period counts are averages of four counts taken at the same time on Wednesday and Thursday of two consecutive weeks (Gudz et al., 2016, 63).

To further improve the estimation accuracy, the average annual daily bicycle counts estimated from the morning- and evening-period L Street counts were then averaged. The result, which was used for *BC* in Equation 4:

$$Average\ (seasonally\ adjusted)\ \mathrm{BC} = (2{,}099\frac{trips}{day} + 1{,}922\frac{trips}{day})/2 = 2{,}011\ trips/day$$

Applying those values in Equation 4 yields an annual reduction of 95,740 vehicle miles traveled:

$$Annual\ VMT\ Reduced = \left(365\ \frac{days}{year}\right) * \left(2{,}011\ \frac{bicycle\ trips}{day}\right) * 1 * \left(0.1\ \frac{person\ trips\ by\ auto}{bicycle\ trip}\right) * \left(\frac{1}{1.15}\frac{vehicle\ trips}{person\ trips\ by\ auto}\right) * \left(1.5\ \frac{miles}{trip}\right) * 1$$

$$Annual\ VMT\ Reduced = \mathbf{95{,}740}$$

Applying the conservative trip type adjustment factor, *T*, reduces that VMT reduction estimate to roughly **48,445**.

Applying CARB's auto vehicle emission factors (AVEF, in grams of CO_2 equivalents per mile) for Yolo County in 2017 (522 g CO_2e/mile) and 2029[26] (356 g CO_2e/mile) yields a yearly average of 42.0 metric tons of avoided CO_2 equivalents (MTCO$_2$e), per Equation 5 (CARB, 2016):

$$GHG\ Emission\ Reductions = \frac{(VMT\ Reduced * AVEF_{2017}) + (VMT\ Reduced * AVEF_{2029})}{1{,}000{,}000} / 2$$

$$GHG\ Emission\ Reductions = \mathbf{42.0\ MTCO_2e}$$

Applying the conservative trip type adjustment factor, *T*, reduces that GHG emissions reduction estimate to **21.3 MTCO$_2$e**.

Comparison of Results

Using CARB's existing quantification method results in an estimated reduced annual VMT of 55,613 and an annual reduction in emitted CO_2e of 24.4 metric tons. Using the alternative quantification method nearly doubles both estimates to 95,740 avoided VMT and 42.0 avoided MTCO$_2$e, if the trip type factor is excluded. Applying the trip type factor, the alternative quantification method produces VMT and GHG emission reduction estimates similar to those from the existing quantification method, 48,445 VMT and 21.3 MTCO$_2$e, respectively.

Table 12. Summary of Differences in Case Study Outcomes

	Annual VMT Reductions	**GHG Emissions Reductions**
Current Method	55,613 vehicle-miles	24.4 MTCO$_2$e
Alternative Method (no *T*)	95,740,315 vehicle-miles	42.0 MTCO$_2$e
Alternative Method (applying *T*)	48,445 vehicle-miles	21.3 MTCO$_2$e
Difference (no *T*)	**+40,127 vehicle-miles**	**+17.6 MTCO$_2$e**
Difference (applying *T*)	**-7,168 vehicle-miles**	**-3.1 MTCO$_2$e**

This result would be even more disparate if the actual bicycle growth factor observed by Gudz et al. (2016) from the Fifth Street road diet (~1.6) were used in the alternative quantification, or even the average growth factor (1.19) for Class II facilities derived

[26] The last year the Fifth Street bike lanes would be operational, using CARB's default 15-year lifetime for Class II facilities and the actual project completion date of August 2014 (CARB, 2016).

from the broader literature (Table 3). Using a growth factor of 1.6 would yield 153,185 or 77,510 in estimated VMT avoided, depending on whether the trip type factor is applied. While a growth factor of 1.19 would yield approximate VMT reduction estimates of 113,930 or 57,650.

It is also instructive to work backwards from the alternative method's higher estimate and try to obtain the same result using the current method.[27] To achieve 95,740 in estimated VMT reductions using the existing quantification method, the Fifth Street corridor would need an ADT of 25,820. Such a high ADT approaches the existing quantification method's 30,000 ADT cap (Table 1).[28] Furthermore, an ADT of 25,820 is not only close to practically infeasible on the existing roadway, it might dissuade erstwhile bicyclists attracted by the bike lanes from riding along Fifth Street (or at all) (Fagnant & Kockelman, 2016). And that illustrates the logical incongruity of using existing ADT to estimate bike ridership and VMT reduction potential. Bicyclists prefer routes with *low* vehicular traffic volumes – there is a *negative*, not positive, correlation between vehicular ADT and bicyclist route preference and choice (Broach, Dill, & Gliebe, 2012). The alternative quantification method removes this logical incongruity by basing VMT reduction estimates on existing *bicycle* traffic volumes, rather than vehicular ADT.

Could the existing method be tweaked to achieve a similar result as the alternative quantification method despite its reliance on ADT? Not without fundamentally changing the adjustment factor and activity center credit calculations. Simply updating the known factor components based on recent studies of California and other United States bike facilities might actually exacerbate the difference in the two methods' estimates. For example, replacing the growth factor (0.65) and automobile substitution rate (0.70) used to derive the adjustment factors in the current method[29] with the Class II facility growth factor (1.0), substitution rate (0.1) and carpool factor (1/1.15) used in the alternative quantification method would *reduce* the annual VMT reduction estimate for the Fifth Street bike lane additions to 10,625, more than 85,000 VMT less than the alternative method estimate.

These results further reflect the fact that vehicle ADT does not always correlate to higher bicycling volumes, and that a quantification method based on AADBT rather than vehicle ADT might improve estimation of VMT and GHG emission reductions from bike facility installation, as discussed above in section G.

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[27] It is more instructive for comparison purposes to use the alternative method estimate without the trip type factor since, as discussed in section F, Bicycle Trip Type, since the current quantification method does not fully exclude recreational trips from its VMT reduction calculus either.

[28] The ADTs required to meet the higher VMT reduction estimates using growth rates of 1.19 or 1.6 would exceed the 30,000 ADT cap.

[29] See Table 1, and footnotes 3 and 4 above.

Ease of Method Application

The case study process also provided insight on the ease of applying the current and alternative quantification methods. That assessment was aided by communications with and review of available data from jurisdictions' housing projects that received AHSC or ATP funding. Jurisdictions – via their bicycle coordinators or other staff member(s) with knowledge of bicycle facilities and counts – were asked about the type (e.g., continuous, less-than-continuous automatic, or manual), timing and location of their bicycle and vehicular counts, and who conducted the counts (e.g., the jurisdiction itself, consultants for proposed developments, etc.).[30] The information from those communications was augmented by reviewing the bicycle and vehicular count information available online for the jurisdictions. The information gleaned, along with the insights from the case study process, indicates that the alternative quantification method would not be more onerous to use than the existing method, in at least two respects.

First, once a GGRF funding applicant has the requisite hourly (or daily) bicycle count data or vehicular ADT, the alternative quantification method can be applied more quickly than the existing method. Default values are available for all other factors in the alternative method besides the bike count, including the seasonal adjustment factor (following the steps and factors provided by the National Bicycle and Pedestrian Documentation Project in the absence of a more locally specific seasonal adjustment factors). The existing method, on the other hand, requires the potentially time-consuming identification and documentation of all the "activity centers" within ½-mile and ¼-mile buffers of the planned bicycle facility. The process undertaken for this case study is described above.

Second, in many jurisdictions it may be just as easy for a funding applicant to obtain the requisite hourly bicycle count data as the necessary vehicular ADT. Most of the jurisdictions for which information was obtained about their bike and auto traffic data collect bike counts at dozens of locations (San Francisco, Oakland, Los Angeles, Long Beach, San Diego, West Sacramento and Davis), most updated at least annually. And those jurisdictions collectively house more than a third of the AHSC- and ATP-funded projects. Only one of the jurisdictions for which traffic count information was obtained does not yet conduct bike counts, though other smaller jurisdictions that have not yet responded to requests for information may also not collect bike counts.

San Francisco, Oakland, Los Angeles, Long Beach and San Diego also collect at least some bike count data using continuous counters. San Francisco currently collects continuous bike counts in dozens of locations, while San Diego is moving this year from dozens to thousands of continuous counter locations. Other jurisdictions are planning

[30] Jurisdictions that responded to requests for information on their bicycle and automobile traffic counts include San Francisco, Oakland, Hayward, West Sacramento, Long Beach and San Diego. Davis and Caltrans, while not housing projects funded by the AHSC or ATP programs, also provided information about local and statewide bicycle and automobile traffic counts.

to either expand or initiate continuous bike count programs, including Long Beach, Oakland and West Sacramento. As the Alameda County Transportation Commission explains for why it pairs its manual count program with an automated count program, continuous data can “provide valuable insights into variation in the levels of bicycling and walking by time of day, day of week, season and over time,” enabling development of local seasonal adjustment factors (Alameda County Transportation Commission, 2012).

As a result of the increased – and increasing – focus on bicycle and multi-modal planning over the last few years, many of the surveyed jurisdictions have bike count data for nearly as many locations as automobile counts, including in San Diego, West Sacramento and Davis. Indeed, in both San Diego and Oakland, traffic counts are typically multi-modal, collecting bike and automobile counts simultaneously.

For projects proposed in areas without bike or auto counts, the project applicant would likely have to pay for them regardless of whether the GGRF funding application requires vehicle or bicycle ADT to estimate VMT reductions. Cash-strapped local governments usually do not fund studies required for development projects by local ordinances and state environmental review laws (Fulton & Shigley, 2012; Rothman, 2011; Thomas, 1993). Some jurisdictions, like Long Beach, actually obtain most of their automobile counts from project applicant-funded consultants through the development and environmental review process.

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