**08-8 Bicycle and Motorcycle Detection at New or Upgraded Signalized Intersections (Formerly known as "Traffic Actuated Signals for the Bicycles and Motorcyclists")**

**RECOMMENDATION:** The AB 1581 Subcommittee requests that the CTCDC recommends adoption of the language below into the CA MUTCD.

**AGENCY REQUESTING/SPONSORING:** Caltrans, at the direction of the Legislature

**BACKGROUND**:

AB 1581 (Fuller) was signed by the Governor on October 8, 2007, and became law on January 1, 2008. The legislation reads as follows:

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**Assembly Bill No. 1581**

CHAPTER 337

An act to add and repeal Section 21450.5 of the Vehicle Code, relating to vehicles.

[Approved by Governor October 8, 2007. Filed with Secretary of State October 8, 2007.]

LEGISLATIVE COUNSEL'S DIGEST

AB 1581, Fuller. Traffic-actuated signals: bicycles: motorcycles.

(1) Existing law provides for official traffic control devices.

This bill would include as an official traffic control device a traffic-actuated signal that displays one or more of its indications in response to the presence of traffic detected by mechanical, visual, electrical, or other means. Upon the first placement of a traffic-actuated signal or replacement of the loop detector of a traffic-actuated signal, the signal would have to be installed and maintained, to the extent feasible and in conformance with professional engineering practices, so as to detect lawful bicycle or motorcycle traffic on the roadway. Cities and counties would not be required to comply with those requirements until the Department of Transportation has established uniform standards, specifications, and guidelines for the detection of bicycles and motorcycles by traffic-actuated signals and related signal timing. The Commission on State Mandates would be required to consult with the Department of Transportation regarding mandate claims relating to these provisions. This bill would provide that its provisions would remain in effect until January 1, 2018, and would be repealed on that date. By imposing new duties on local government, this bill would impose a state-mandated local program upon local governments.

(2) The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement.

This bill would provide that, if the Commission on State Mandates determines that the bill contains costs mandated by the state, reimbursement for those costs shall be made pursuant to these statutory provisions.

*The people of the State of California do enact as follows:*

SECTION 1. (a) The Legislature hereby finds and declares the following:

(1) Bicyclists and motorcyclists are legitimate users of roadways in California.

(2) Traffic-actuated signals that do not detect bicycle or motorcycle traffic pose a danger to law-abiding bicyclists and motorcyclists.

(b) It is the intent of the Legislature in enacting this act to better protect law-abiding bicyclists and motorcyclists.

SEC. 2. Section 21450.5 is added to the Vehicle Code, to read:

21450.5. (a) A traffic-actuated signal is an official traffic control signal, as specified in Section 445, that displays one or more of its indications in response to the presence of traffic detected by mechanical, visual, electrical, or other means.

(b) Upon the first placement of a traffic-actuated signal or replacement of the loop detector of a traffic-actuated signal, the traffic-actuated signal shall, to the extent feasible and in conformance with professional traffic engineering practice, be installed and maintained so as to detect lawful bicycle or motorcycle traffic on the roadway.

(c) Cities, counties, and cities and counties shall not be required to comply with the provisions contained in subdivision (b) until the Department of Transportation, in consultation with these entities, has established uniform standards, specifications, and guidelines for the detection of bicycles and motorcycles by traffic-actuated signals and related signal timing.

(d) This section shall remain in effect only until January 1, 2018, and as of that date is repealed, unless a later enacted statute, that is enacted before January 1, 2018, deletes or extends that date.

SEC. 3. The Commission on State Mandates shall consult with the Department of Transportation when it develops parameters and guidelines for any mandate claim arising from the enactment of these provisions to ensure that eligible reimbursement is limited solely to the incremental costs of installing sensor wiring that can detect bicycle or motorcycle traffic.

SEC. 4. If the Commission on State Mandates determines that this act contains costs mandated by the state, reimbursement to local agencies and school districts for those costs shall be made pursuant to Part 7 (commencing with Section 17500) of Division 4 of Title 2 of the Government Code.

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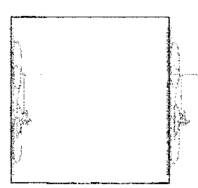
At its January 31, 2008, meeting, the CTCDC requested that Caltrans form an AB 1581 Subcommittee to advise the CTCDC on developing uniform standards, specifications and guidelines for the detection of bicycles and motorcycles by traffic-actuated signals and related signal timing. The members of the AB1581 Subcommittee are:

| | |
|---|---|
| Ahmad Rastegarpour, Chair | Caltrans |
| Kai Leung | Caltrans |
| Ken McGuire | Caltrans |
| Richard Haggstrom | Caltrans |
| Damon Curtis | SFMTA |
| David Roseman | City of Long Beach |
| Sean Skehan | LADOT |
| Robert Shanteau | Bicyclist representative |
| James Lombardo | Motorcyclist representative |

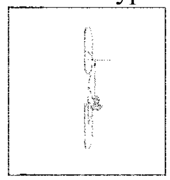
The AB 1581 Subcommittee met on March 4, April 2, July 9 and September 25, 2008. The rest of this background addresses the Subcommittee’s recommendations regarding detection of bicycles and motorcycles and related signal timing.

The AB 1581 Subcommittee found that motorcycles are difficult to detect because of their small size and that bicycles are often not detected at all because most loops are designed to detect horizontal sheets of metal, such as the bottom of a car or truck, while the rims on bicycle wheels, although typically metal, are vertical. For instance, the common Type A (square) loop can only detect a bicycle that is located over the loop conductors, as shown in this figure:



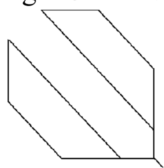
**“Sweet” spots**

But a bicycle cannot be detected over the center of a Type A loop, as shown here:

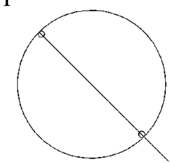


“Dead” spot

To detect a bicycle across its entire width, an inductive loop needs to be a diagonal quadrupole, examples of which are shown here, including a Caltrans Type D and a quadracircle loop:



Type D loop



Quadracircle

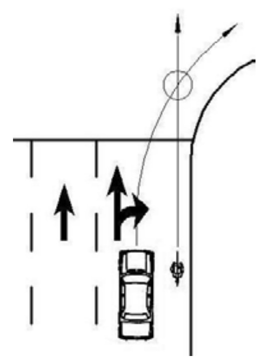
The Type D loop was invented and was introduced into the Caltrans Standard Plans in the 1980’s but deployment has been limited. Winding and sawcut details are shown in Caltrans Standard Plan ES-5B.

The quadracircle was invented in about 1990 in Palo Alto. Several local agencies in California have reported success using it, although Caltrans has not experimented with it. Winding and sawcut details are shown in Cupertino’s Standard Detail 5-19.

Even if the loop is not a diagonal quadrupole, a bicyclist who knows to stop on top of the conductors may still be detected. But many loops are covered by the final lift of pavement. The CA MUTCD provides for a Bicycle Detector Symbol, shown at right, that can be used to show bicyclists where to stop.

Limit line loops are normally 6’ wide by at least 6’ long and centered in the lane, or about 3’ from the left lane line of a wide right lane. Wider loops would have a hard time rejecting vehicles in the adjacent lane and narrower loops would not be able to detect motorcycles. Motorcyclists are taught to ride in either the right or left wheel track, and since the wheel track of a typical car is about 5’ wide, motorcyclists will generally stop about 2½-3’ from the center of a lane. This places the motorcycle over the edge of a 6’ loop, which is an ideal position for it to be detected.

A limit line loop in a wide right lane may be located some distance from the right hand curb or edge of pavement. That brings up the question of where a bicyclist would be expected to stop. CVC Section 21202(a) requires a bicyclist traveling “at a speed less than the normal speed of traffic” to ride “as close as practicable to the right-hand curb or edge of the roadway” but gives an exception when the bicyclist is “approaching a place where a right turn is authorized.” This exception was intended to provide the bicyclist the flexibility to avoid having to stop against the right hand curb or edge of the road where a potential “right hook” conflict would be created with a right turning motorist. By stopping in the center of the travel lane, a bicyclist is in a position to be seen by following motorists while not creating a conflict with right turning drivers.



Right hook conflict

Where there is a bike lane on an approach, bicyclists may also need to be detected in a travel lane. CVC 21208 requires a bicyclist traveling “at a speed less than the normal speed of traffic moving in the same direction at that time shall ride within the bicycle lane” but gives the same exception as CVC 21202(a) when the bicyclist is “approaching a place where a right turn is authorized.”

The AB 1581 Subcommittee recommends that all new limit line detectors shall provide an approximate

6’x6’ Limit Line Detection Zone located in the center of every travel lane, or about 3’ from the left lane line of a wide right lane, and that such Limit Line Detection Zones detect motorcycles and bicycles. A narrower limit line detection zone may be necessary for a bike lane. The Subcommittee also recommends that if more than half of the limit line detectors have been or are being replaced, then the entire intersection should be upgraded to provide Limit Line Detection Zones in every lane. Although the Subcommittee established this performance standard based on its members’ knowledge that inductive loops can meet it, the standard can potentially be met by other detection technologies. **Therefore the AB 1581 Subcommittee recommends that the performance standard be made technology-neutral in order to accommodate current as well as future detection technologies.**

The next step was for the Subcommittee to determine the bicycle-rider combination that would need to be detected. (The Subcommittee found that if a bicycle and its rider can be detected, then so can a motorcycle and its rider, regardless of the detection technology being used.)

In selecting the reference bicycle-rider, the Subcommittee’s objectives were to make sure that (1) most bicycles and riders were included and (2) its selection allowed for a wide variety of existing or future detection technologies. Therefore it selected a 90 pound 4’ tall person riding a small adult bicycle with a non-ferromagnetic frame, aluminum rims, stainless steel spokes and headlight, such as the folding bicycle shown at right. The reason a 90 pound 4’ tall person was selected was that a small person is the most difficult for technologies such as video detection systems to detect. The reason a folding bicycle was selected was that its small rims are the most difficult for technology such as inductive loops to detect. The reason that a non-ferromagnetic frame was selected was that a large number of modern bicycles are built with aluminum or carbon-fiber frames. And the reason that aluminum rims and stainless spokes were selected was that most modern bicycle wheels are made with those materials.

Currently, Figure 4D-111(CA) shows a bicyclist pushbutton and an R62C(CA) sign at an intersection and states that a pushbutton may be used to activate a traffic signal, in which case it should be located so it is convenient to use by bicyclists. This provision appears to be based on the expectation that bicyclists will stop near the curb or edge of pavement. There are three operational issues with using a bicyclist pushbutton, however: (1) A pushbutton does not serve bicyclists who are not required to ride as far to the right as practicable because they are riding at the normal speed of traffic, preparing for a left turn, avoiding hazards or at a location where a right turn is authorized (see CVC 21202(a)); (2) A bicyclist who stops to push the button is positioned to the right of right turning vehicles, inviting a right hook conflict as described above; and (3) If the lane is "too narrow for a vehicle and a bicycle to travel safely side by side within the lane" (see CVC21202(a)(3)), then a bicyclist who pushes the button is in a position that invites in-lane passing by motorists. Furthermore, CVC 21450.5(b) refers to “the first placement of a traffic-actuated signal or replacement of the loop detector” and to “lawful bicycle or motorcycle traffic on the roadway.” The intent of the law is that if it is feasible to detect bicycles and motorcycles in the roadway, then such detection shall be primary and a pushbutton, if used, shall be secondary. As described above, detection of bicycles and motorcycles in the roadway is feasible, so the Subcommittee recommends that a bicyclist pushbutton be allowed only as a supplement to the required limit line detection, and even then only in a lane that is wide enough for a bicycle and a vehicle to travel safely side by side within the lane and where vehicular right turns are either prohibited or not authorized. An example of such a location is a short bike lane to the left of a channelizing right-turn island (pork chop island).

R62C (CA)

On the other hand, a pushbutton may be helpful for bicycle detection on a shared-use path or bike path, but only if the bicyclist pushbutton is located on the right side of the path. (See Section 9A.03 for definitions of “shared-use path” and “bike path”.)

Although AB 1581 addresses both motorcycle and bicycle detection, the proposed language below only addresses bicycle detection. The reason is that a motorcycle will be detected wherever a bicycle is detected.

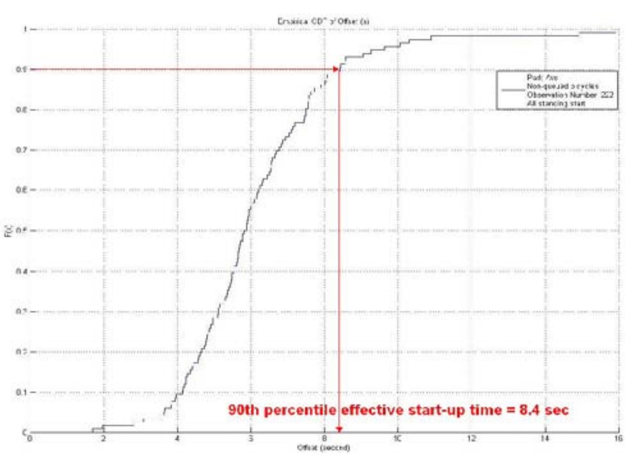
In developing its signal timing recommendation, the AB 1581 Subcommittee basically followed the pedestrian signal timing guidance in Section 4E.10 of the CA MUTCD. The Subcommittee used several sources in determining a formula for the time that will allow most bicyclists to cross an intersection of a given width.

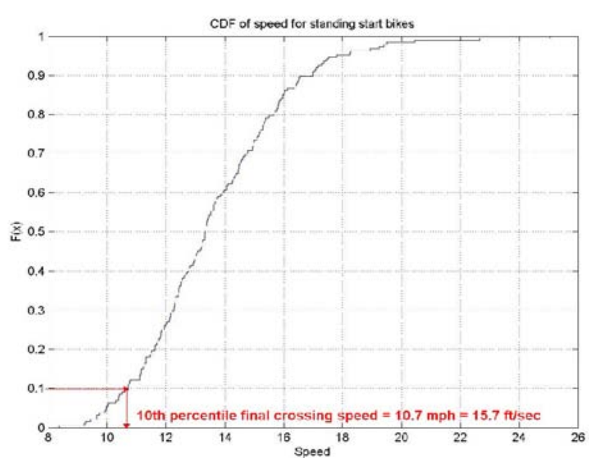
The oldest source was the 1983 edition of the *Traffic Control Devices Handbook,* which states, “The clearance time required for bicycles should be evaluated as standard practice for each signalized intersection along a heavily used bikeway. A bicyclist’s speed of 10 mph (14.7 ft/sec) and a perception/reaction time of 2.5 seconds is generally used in the calculation to determine the number of seconds required to ride across a given street.”

The 1995 ITE Journal article *Signal Clearance Timing for Bicycles* reports, “The speed of bicyclists ranges from less than 10 mph for schoolchildren to 25 mph for fit adults. In June 1985, the Palo Alto Transportation Division timed bicyclists at six intersections where clearance-time accidents had occurred or were considered likely to occur. The Palo Alto observations show rolling-start speeds ranging from 12 mph to 17 mph (except on Bryant crossing Oregon, where the cyclists for the most part are elementary school students). The difference in average crossing times on new green and old green at the six intersections is (in seconds) 4.8, 6.1, 5.3, 3.7, 4.8 and 4.6. This difference represents the time lost in reacting to the green light and then accelerating to full speed. In general, to avoid clearance-time conflicts on a new green, yellow and red clearance must equal or exceed the crossing time from a standing start: $g + y + r_{clear} \geq t_{cross}$.”

The current *San Francisco Bicycle Plan* states, “Where possible, the City should consider timing the signals along bike routes for bicycle speeds approximately 12 to 15 mph. Minimum green times at actuated signals should take bicyclists into account. Bicyclists need more start-up time than motor vehicles. Actuated signals should be timed so that the minimum green time is at least 8 seconds where grades are flat. On routes with an upgrade, bicyclists need even more time.”

An ongoing research project is being performed for Caltrans by PATH at UC Berkeley. The Committee has received reports on this study at previous meetings. The key preliminary results of this study are contained in the graphs below, which show cumulative distribution functions of the effective start-up (offset) time and final crossing speed, respectively, for bicyclists crossing El Camino Real at Park Boulevard in Palo Alto. Note that the 90th percentile effective start-up time observed at Park Boulevard was 8.4 sec while the 10th percentile final crossing speed was 10.7 mph or 15.7 ft/sec. The PATH research team notes that their start-up time comprises both the bicyclist’s perception/reaction time (PRT) and the additional time that the bicyclist needs to accelerate from a standing start to final crossing speed,

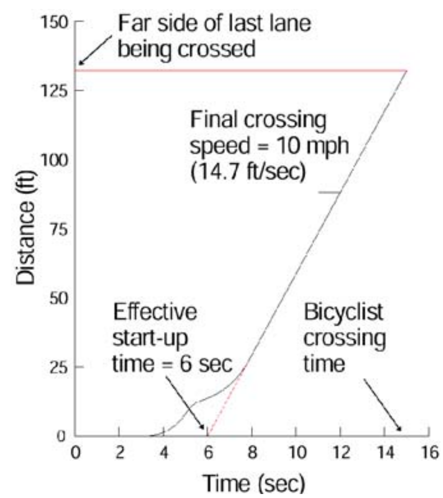


which is why it is significantly longer than traditional estimates of PRT such as the one in the *1983 Traffic Control Devices Handbook*.

The Subcommittee recommends that the CA MUTCD provide guidance that the length of the minimum green plus the yellow interval plus the all-red interval should be at least long enough to allow a design bicyclist to cross the intersection from a standing start before a conflicting green is shown. This crossing time is the time necessary to cross the intersection from a rolling start plus the additional time needed for a standing start.

Based on the above research, the rolling start speeds range from 10 to 12 mph and the additional time needed for a standing start ranges from 3.7 to 8.4 sec. The Subcommittee recommends that the final crossing speed for the design bicyclist be 10 mph (14.7 ft/sec) and the effective start-up time needed for a standing start be 6 sec. This effective start-up time represents the time lost in reacting to the green light and then accelerating to full speed.




Thus the recommended formula for the bicyclist crossing time is

*Crossing time (sec) = 6 sec + (w+6 ft)/14.7 ft/sec*

where *w* = distance (in feet) that the bicyclist must travel to cross the intersection and a typical bicycle is about 6 ft long.

For El Camino Real at Park Boulevard, for instance, *w* = 125 ft, so the crossing time is 15 sec, as illustrated in the figure at right. The current minimum green, yellow and all-red intervals are 7, 3 and 1 sec, respectively. Thus the new minimum green time would need to be increased by 4 sec. It should be noted that El Camino Real at Park Boulevard has a pronounced crown, accounting for the extra time needed for bicyclists to get started there.

Using this formula results in longer minimum green times than are commonly used now, but the PATH research team found that the increased minimum green times would have a minimal effect on traffic congestion because during periods of congestion the side street green times are usually longer than the minimum green times anyway. Also, the time needed to serve pedestrian calls has a much bigger impact on congestion.

As with the pedestrian crossing time guidance already contained in the CA MUTCD, the recommendation of the AB 1581 Subcommittee is for the bicyclist crossing time to be a guidance statement and not a standard.

**PROPOSAL:**

Following are the AB 1581 Subcommittee's proposed changes to the CA MUTCD:

Section 4A.02 Definitions Relating to Highway Traffic Signals

15. Detector – a device used for determining the presence or passage of vehicles (including motorcycles), bicycles or pedestrians.

50A. Reference Bicycle-Rider – a minimum 4' tall person, weighing minimum 90 lb, riding on an unmodified minimum 16" wheel bicycle with non-ferromagnetic frame, aluminum rims, stainless steel spokes, and head light.

29A. Limit Line Detection Zone – an approximate 6'x6' area immediately behind the limit line, either centered in a normal width lane or approximately 3' from the left lane line if a right lane is more than 12' wide.

~~Section 4D.105(CA) Bicycle Detectors~~

~~Option:~~

~~Bicycle detectors may be required at traffic-actuated signal installations.~~

~~The loop detector logo shown on Department of Transportation's Standard Plan A24C may be used to show a bicyclist where to stop in a bike lane or traffic lane to be detected.~~

~~Support:~~

~~See Figure 4D-111(CA) for suggested locations of bicycle detectors and Department of Transportation's Standard Plans for typical bike lane pavement markings.~~

~~Efforts need to be made to ensure that signal detection devices are capable of detecting a bicycle. Detectors for traffic-actuated signals need to be located in the bicyclist's expected path, including left-turn lanes and shoulders. Marking the road surface to indicate the optimum location for bicycle detection is helpful to the bicyclist. Video detection is an effective alternate technique to loop detection.~~

**Section 4D.105(CA) Bicycle/Motorcycle Detection**

**Standard:**

**All new limit line detector installations and modifications to the existing limit line detection on a public or private road or driveway intersecting a public road (see Section 1A.13 for definitions) shall either provide a Limit Line Detection Zone in which the Reference Bicycle-Rider is detected or be placed on permanent recall or fixed time operation. Refer to CVC 21450.5.**

**All new and modified bike path approaches to a signalized intersection shall be equipped with either a Limit Line Detection Zone or a bicyclist pushbutton, or else the phase serving the bike path shall be placed on permanent recall or fixed time operation. A bicyclist pushbutton, if used, shall be located on the right side of the bike path and where it can be reached from the bike path. See Section 9B-10 for bicycle regulatory signs.**

**At new signalized intersections or when the advance detection is being replaced at existing signalized intersections, phases with advance detection only shall be placed on permanent recall.**

Support:

The requirement to detect the Reference Bicycle-Rider in the Limit Line Detection Zone is technology-neutral.

Option:

The detection zone in a bike lane may be narrower than 6'. See Figure 4D-111(CA).

A Bicycle Detector Symbol may be used. See Sections 9B-12 and 9C.05.

A bicyclist pushbutton may be used to supplement the required limit line detection only where all of the following conditions exist:

A. Some bicyclists might stop next to the curb or edge of pavement;
B. The lane is wide enough for a bicycle and a vehicle to travel safely side by side within the lane; and
C. Vehicular right turns are either prohibited or not authorized.

See Section 9B.10 for bicycle regulatory signs.

Guidance:

If more than 50% of the limit line detectors have been or need to be replaced at a signalized intersection, then the entire intersection should be upgraded so that every lane has a Limit Line Detection Zone.

The Reference Bicycle-Rider or the equivalent should be used to confirm bicycle detection under the following situations:

A. A new detection system has been installed;
B. The detection configuration has been modified; or
C. A complaint has been made about lack of detection by bicyclists/motorcyclists.

Support:

CVC Section 21202(a) requires bicyclists traveling “at a speed less than the normal speed of traffic” to ride “as close as practicable to the right-hand curb or edge of the roadway” with exceptions, including when the bicyclist is “approaching a place where a right turn is authorized.” This exception was intended to provide the bicyclist the flexibility to avoid having to ride against the right hand curb or edge of the road where a potential conflict would be created with a right turning motorist. Accordingly, the Limit Line Detection Zone need not extend all the way to the curb or edge of pavement. See Figure 4D-111(CA).

A bicyclist pushbutton is only allowed as a supplement to the required limit line detection and then only in limited circumstances because:

A. A bicyclist pushbutton does not benefit those bicyclists who are not required to ride as far to the right as practicable because they are riding at the normal speed of traffic, preparing for left turn, avoiding hazards or at a location where a right turn is authorized. Refer to CVC 21202(a);
B. A bicyclist who stops to push the button is positioned against the right hand curb or edge of roadway where a potential conflict would be created with a right turning motorist; and
C. If the lane is too narrow for a vehicle and a bicycle to share safely side by side, then a bicyclist who pushes the button is in a position that invites unsafe in-lane passing by motorists.

A Limit Line Detection Zone provides for the detection of both bicycles and vehicles, including motorcycles.

Guidance:

Signal timing: For all phases, the sum of the minimum green, plus the yellow change interval, plus any red clearance interval should be sufficient to allow a bicyclist riding a bicycle 6’ long to clear the last conflicting lane at a speed of 14.7 ft/sec plus an additional effective start-up time of 6 seconds, according the formula $G_{min} + Y + R_{clear} \geq 6 \text{ sec} + (w+6 \text{ ft})/14.7 \text{ ft/sec}$.

Support:

The speed of 14.7 ft/sec represents the final crossing speed and the effective start-up time of 6 seconds represents the time lost in reacting to the green light and then accelerating to full speed.

Option:

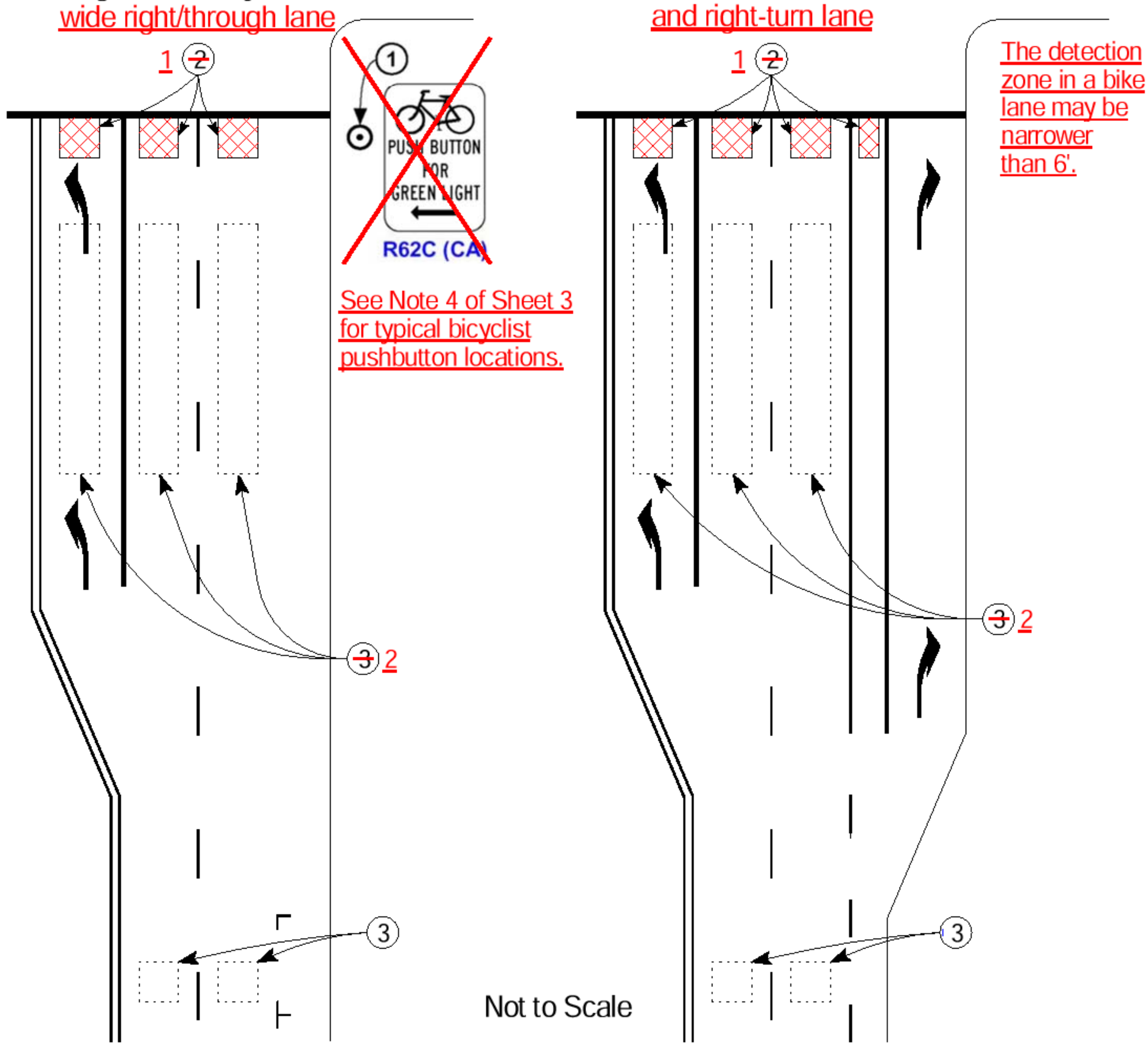
A limit line detection system that can discriminate between bicyclists and vehicles may be used to extend the length of the minimum green.

Revise Figure 4D-111(CA) as shown on the following pages.

## Examples of
## Figure 4D-111(CA) ~~Bicycle~~ Detection Systems
## (Sheet 1 of 3)

a - Intersection with a ~~Right Turn Only Lane~~ wide right/through lane

b - Intersection with a Bike Lane and right-turn lane




~~1. Bike/Push Button for Green Light (R62C (CA)) Sign or a Type D Loop Detector may be used to activate a traffic signal. A push button should be located so it is convenient to use by bicyclists.~~

1 ~~2~~. Typical ~~Type D Loop Detector Locations.~~ technology-neutral limit line detection locations. See Section 4D.105(CA).

2 ~~3~~. Typical ~~Loop Detector locations. See Section 4D.105 (CA).~~ presence detection locations See Section 4D.103(CA).

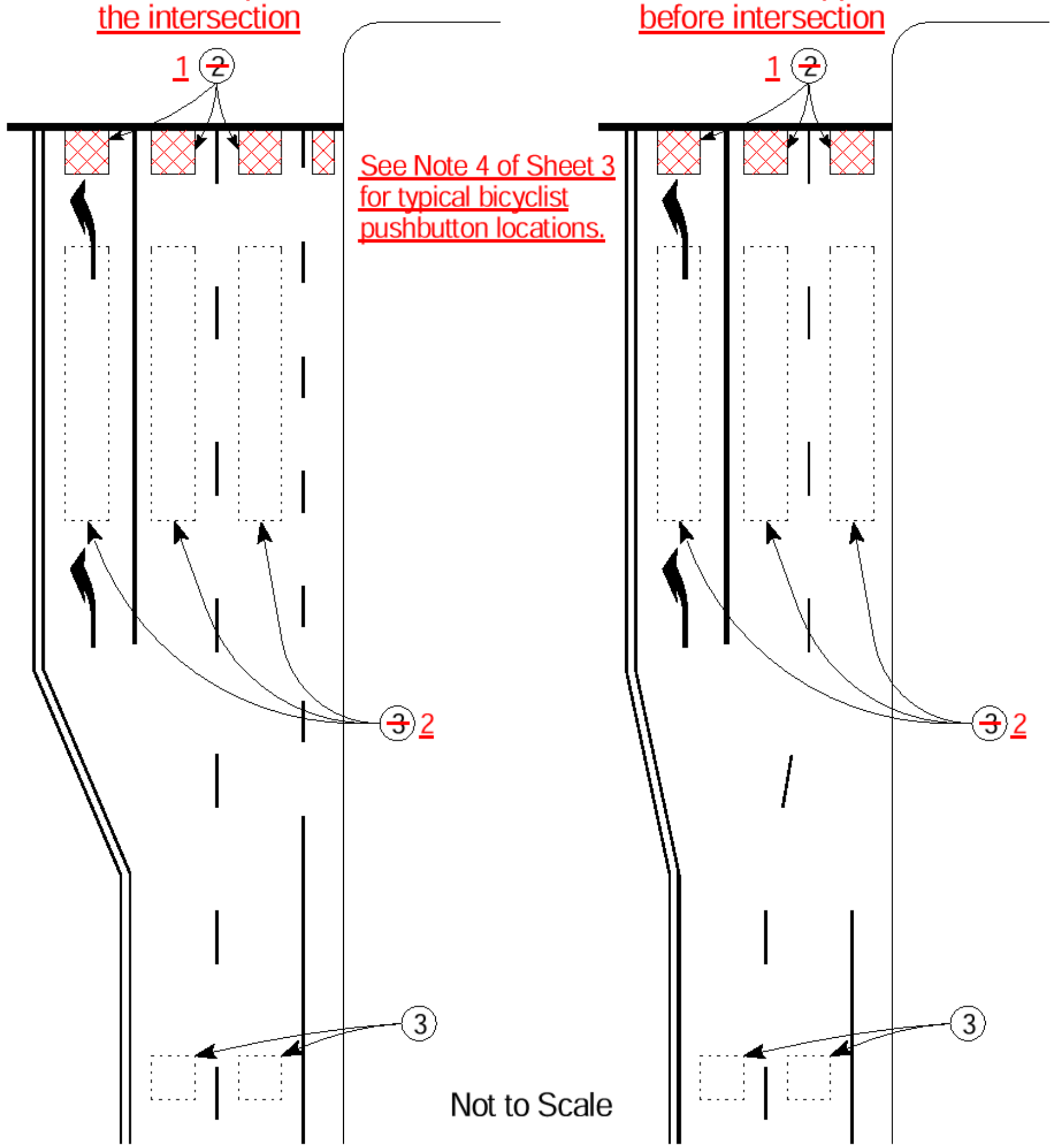
~~4. See Standard Plan A24C for Bicycle Loop Detector pavement marking details.~~

3. Typical advance detection locations.

Examples of
Figure 4D-111(CA) ~~Bicycle~~ Detection Systems
(Sheet 2 of 3)

c -Intersection with a Bike Lane striped to the intersection

d -Intersection with a Bike Lane dropped before intersection




1 Typical technology-neutral limit line detection locations. See Section 4D.105(CA).

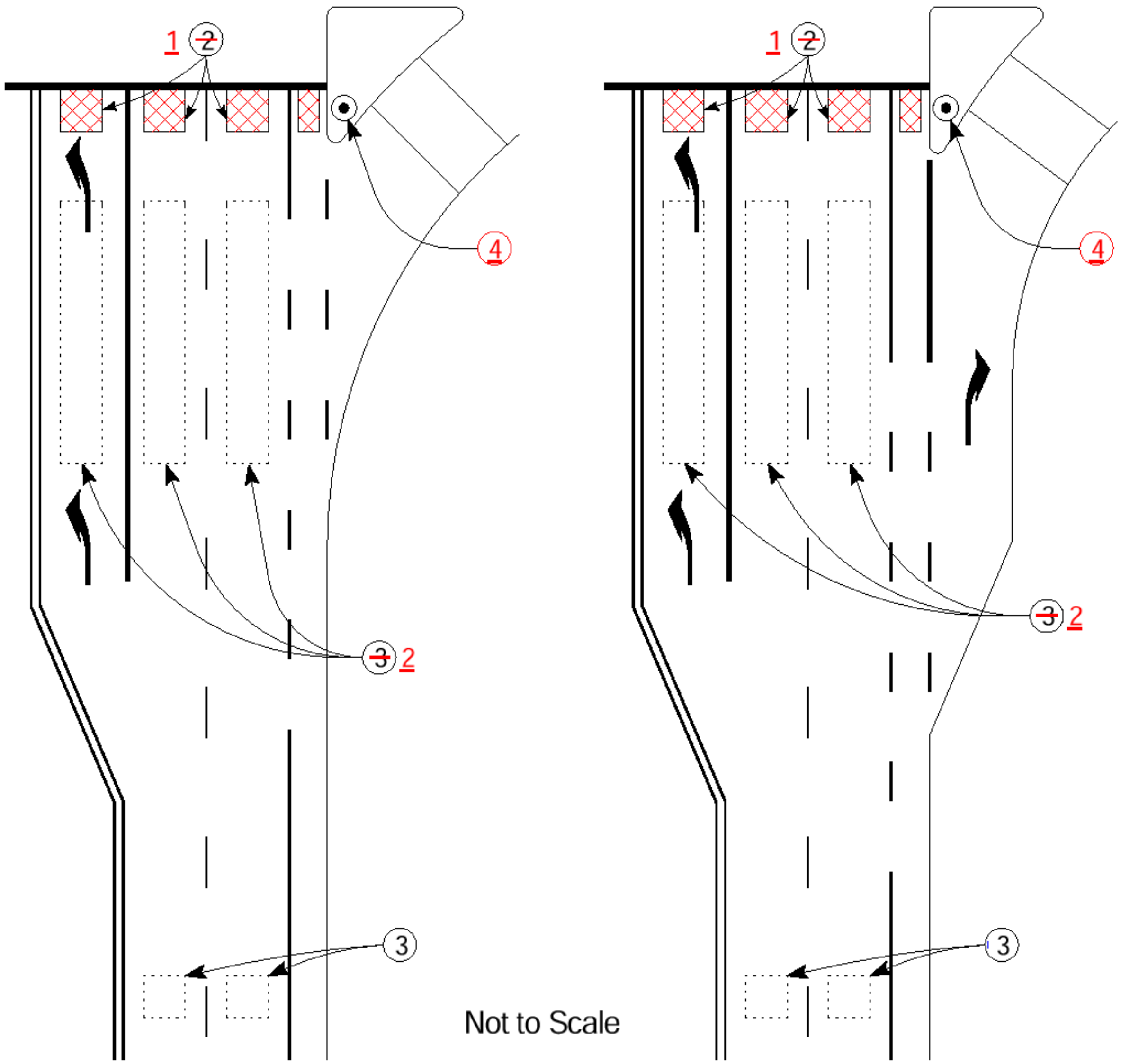
2 Typical presence detection locations. See Section 4D.103(CA).

3. Typical advance detection locations.

Examples of
Figure 4D-111(CA) ~~Bicycle~~ Detection Systems
(Sheet 3 of 3)

e - Intersection with a bike lane, a shared right/through lane and channelizing island

f - Intersection with a channelized right-turn lane




1 Typical technology-neutral limit line detection locations. See Section 4D.105(CA).

2 Typical presence detection locations. See Section 4D.103(CA).

3. Typical advance detection locations.

4. Typical bicyclist pushbutton locations. A bicyclist pushbutton may be used to supplement the required limit line detection where (1) some bicyclists might stop next to the curb or edge of pavement, (2) the lane is wide enough for a bicycle and a vehicle to travel safely side by side within the lane, and (3) vehicular right turns are either prohibited or not authorized. See Section 9B.10 for bicycle regulatory signs.