COUNTY OF SACRAMENTO
BICYCLE ADVISORY COMMITTEE
Meeting Agenda
Department of Transportation | Videoconference

Online: https://saccounty-net.zoomgov.com/j/1611517805?pwd=NHFxZjhhYjdzbnNNR1YzQmU1V3pNdz09

Dial-in: +1 669 254 5252 US,,1611517805#,,,,*486686#

WEDNESDAY May 18, 2022 - 6:00 p.m.

Members of the public wishing to address the committee on any item not on the agenda may do so at the beginning of the meeting. We ask that members of the public request to speak and keep their remarks brief. Testimony will be limited to a total of ten (10) minutes.

1. **Roll Call / Welcome and Introductions**
   Members: Thomas Cassera, Sue Schooley, Jack Wursten, Dave Comerchero, Pat Perez, Arlete Hodel

2. **Public Comment on Non-agenda Topics**

3. **Review and Approve Meeting Minutes of March 16, 2022** — **Action Item**
   See attached for draft meeting minutes.

4. **Arden Way Complete Streets Improvement Project – Phase 1** — **Review and Comment**
   Heather Yee, Senior Civil Engineer, (916) 874-9182, yeeh@SacCounty.NET
   See attached staff report, attachments and presentation.
   Estimated time: 10 min

5. **Active Transportation Program Cycle 6 Letters of Support** — **Review and Comment**
   Benjamin Rady, Associate Planner, SacDOT, (916) 874-7917, radyb@saccounty.net
   Mikki McDaniel, Senior Planner, SacDOT, (916) 875-4769, mcdanielm@saccounty.net
   See attached Letters of Support and Scopes of Work.
   Estimated time: 10 min

6. **Informational Items**
   - Final Meeting Minutes of January 19, 2022
   - Corps of Engineers 2024 Detour Plans

7. **Staff Updates and Reports Back**
   - Active Transportation Plan
   - Sacramento County Safe Routes to School Contract

8. **Future Agenda Items**
   - Watt Ave Complete Street Improvements Project I-80 to Roseville Rd - Phase 1
   - Go Slowly Campaign (Caltrans/OTS)
   - Folsom Blvd Complete Streets Improvements Phase 2

The meeting facilities are accessible to persons with disabilities. Requests for documents in accessible formats, interpreting services, assistive listening devices, or other accommodations should be made through the County Disability Compliance Office at (916) 874-7642 or (916) 874-7647 (TTY/TDD), no later than five working days prior to the meeting.

9. Set Next Meeting Dates

a) Next SacBAC meeting: July 20, 2022
   Online and Dial-in: TBD

b) Adjourn SacBAC

COUNTY OF SACRAMENTO
BICYCLE ADVISORY COMMITTEE
DRAFT Meeting Minutes
Department of Transportation | Videoconference

Online: https://zoom.us/j/98729158988?pwd=YkY1T3d3VXpjZ0EydlRabnZpTlYxdz09

Dial-in: +1 669 900 6833 US,,98729158988#,,,,*778340#

WEDNESDAY March 16, 2022 - 6:00 p.m.

Members of the public wishing to address the committee on any item not on the agenda may do so at the beginning of the meeting. We ask that members of the public request to speak and keep their remarks brief. Testimony will be limited to a total of ten (10) minutes.

1. **Roll Call / Welcome and Introductions**
   Members: Thomas Cassera, Sue Schooley, Jack Wursten, Dave Comerchero, Pat Perez, Arlete Hodel
   6:02 p.m.
   Present: Sue Schooley, Jack Wursten, Arlete Hodel, Dave Comerchero
   Excused: Thomas Cassera, Pat Perez
   Unexcused: None

2. **Public Comment on Non-agenda Topics**
   None

3. **Review and Approve Meeting Minutes of January 19, 2022** **Action Item**

   Motion: Approve meeting minutes of January 19, 2022 as is.

   Action: **Motion/Second:** Comerchero/Hodel
   Yes: Dave Comerchero, Arlete Hodel, Sue Schooley, Jack Wursten
   No: None
   Abstain: None

4. **Laguna Creek Inter-Regional Trail Master Plan (LCIRTMP)** **Review and Comment**
   Carrie Whitlock, AICP, Strategic Planning and Innovation Program Manager, City of Elk Grove,
   (916) 478-2238, cwhitlock@elkgrovecity.org
   6:07 p.m.
   - The plan is expected to be complete by December 2022/January 2023; grant funding should be secured by February 2023.
   - Committee wishes to be informed if consultant pushes through with in-person outreach events, to gather community input on designs.
   - This project will cover a 15-20 total miles.

5. **Active Transportation Program Cycle 6 Project Candidates** **Review and Comment**
   Ben Rady, Associate Planner, SacDOT, (916) 874-7917, radyb@saccounty.net
   6:20 p.m.

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- Committee member encouraged more Class IV projects be implemented.
- Member suggested to prioritize commonly used commuter routes instead of trails.
- Committee suggested it would be best to spread out the projects chosen, to broaden impact.
- Member observed that the Low Stress Bikeway Network to American River Parkway is lacking in mileage covered.
- Three projects were identified by a member to be their lowest priority—those on American River Parkway, Fruitridge Road, and Mayhew Drain Trail.
- In general, support was expressed for all candidates in Arden-Arcade. However, Committee requests that County staff review how community and REWAA ranked the projects.
- While one member expressed that Cottage Way should be a low priority, another suggested to consider it due to the low volume of vehicles along this route.
- The majority prefers projects closer to schools, e.g. Bell Street (for Dyer-Kelly Elementary) and Hurley Way (for Thomas Edison Elementary).

6. Revised Annual Report from SacBAC to Board of Supervisors **Review and Comment**

Mikki McDaniel, Senior Planner, SacDOT, (916) 875-4769, mcdanielm@saccounty.net
Kiara Movido, Student Intern, SacDOT, (916) 874-3926, movidok@saccounty.net
6:55 p.m.

Motion: Approve and forward the 2021 Annual Report to the Board of Supervisors.

Action: **Motion/Second:** Wursten/Comerchero
Yes: Jack Wursten, Dave Comerchero, Sue Schooley, Arlete Hodel
No: None
Abstain: None

7. Informational Items

- Final Meeting Minutes of December 15, 2021

8. Staff Updates and Reports Back

- SacBAC presentations

9. Future Agenda Items

- Arden Way Phase 2
- Watt Ave Complete Street Improvements Project I-80 to Roseville Rd - Phase 1
- Go Slowly Campaign (Caltrans/OTS)

10. Set Next Meeting Dates

a) Next SacBAC meeting: May 18, 2022
Online: https://zoom.us/j/98729158988?pwd=YkY1T3d3VXpjZ0EydlRabnZpTlYxdz09
Dial-in: +1 669 900 6833 US,,98729158988#,,,,*778340#

b) Adjourn SacBAC

Action: **Motion/Second:** Hodel/Comerchero
Yes: Arlete Hodel, Dave Comerchero, Sue Schooley, Jack Wursten
No: None
Abstain: None
7:14 p.m.

To: Members of the County Bicycle Advisory Committee

Subject: Arden Way Complete Streets Improvement Project – Phase 1, Update of Design Change

Location/District: Arden Way between Morse Avenue and Watt Avenue

Recommendation: Review and Comment

Contact: Heather Yee, Senior Civil Engineer, Sacramento County Department of Transportation (SACDOT), (916) 874-9182, yeeh@SacCounty.NET

Summary: The first phase of this project will construct approximately 0.5 miles of bicycle lanes, sidewalks, and landscaped buffers and medians along Arden Way between Watt Avenue and Morse Avenue, as well as improve signalized crossings with new curb ramps, expanded bus turnouts and enlarged loading areas, detection for bicycles, audible and countdown pedestrian signals, and crosswalk striping. Later phases will extend these improvements westward, towards Ethan Way. This is in an effort to encourage bicycle, pedestrian and transit use along Arden Way.

There is also a planning related efforts related to this project with the development of the Arden Way Complete Streets Master Plan (CSMP). The Sacramento County Department of Transportation, with the assistance of a consultant, is leading a community driven process to envision a roadway that would serve and encourage additional modes to utilize the corridor.

The Phase 1 project has been brought to the SacBAC in the past, but outreach efforts for the CSMP have led to a design change with the bicycle facility. Today's presentation will provide an update to the SacBAC.

Funding Source(s): SACOG Community Design Program - Federal RSTP (Regional Surface. Transportation Program), County Measure A Sales Tax, County Road Fund, SHRA – CDBG (Sacramento Housing and Redevelopment Agency - Community Development Block Grant)

Discussion: The corridor is approximately 2 miles long and is a well-traveled corridor, with commercial shopping centers and residential developments. In the Arden Way CSMP process, roadway alternatives were developed and garnered strong support. One of the aspects of these alternatives was a physically separated bike lane. The design team changed this physically separated bike lane into the Phase 1 project, however, it has created a non-standard condition which we are presenting to the SacBAC.

Looking at a cross section of the proposed roadway, Exhibit B, the north side of the roadway shows a sidewalk with a landscape separation and a bicycle lane separated from the roadway with a curb and gutter. The south side of the roadway, the right side of the page, shows a bike lane and sidewalk separated from the vehicle lane by a curb and gutter. The bicycle facility and sidewalk are adjacent to one another and are at the same elevation. In plan view, Exhibit C, this adjacent sidewalk and bike lane would occur for approximately 925' between Morse Avenue and Professional Drive and additional 225' between Professional Drive and Watt Avenue.

Unfortunately, there is not much guidance by the Federal nor State standards on this sidewalk and bike lane condition. There has been a robust study conducted for the San Francisco Department of Public Works, presented in two documents:

- Delineator for Separated Bike Lanes at Sidewalk Level. Journal of the Transportation Research Board, 2020. (Exhibit D)
- Better Market Street Delineator Summary Report, prepared for San Francisco Public Works, October 2020. (Exhibit E)

A number of surfaces were examined and tested by vision and mobility-impaired users, as well as bicyclists, shown on Exhibit B. In these documents, there is strong support for a trapezoidal delineator. However, there are not any installations of this delineator in use between a pedestrian and bicycle facility. There is a trapezoidal delineator installed on Treasure Island, used to mark the street crossing for a bicycle, and deter the pedestrian to use the pedestrian street crossing, picture shown in Exhibit B.

SacDOT seeks a delineation solution with the following properties:

- Low maintenance and long-service life
- Amenable to vision and mobility-impaired users, as well as bicyclists
- Will fit in a finite amount of space as the corridor is already very constricted.

There are additional concepts that could be used in this corridor, but the trapezoidal delineator has the most study for use between a sidewalk and bike lane.

For the Arden Way Phase 1 project, the environmental review is complete and is currently in the design and right of way acquisition process. Construction is scheduled for Summer 2023. The Arden Way CSMP is expected to complete the public outreach process in Summer 2022 and finalize the report shortly thereafter.

Today, SacDOT seeks the SacBAC input and perspective on the Class IV facility, transitions between the Class II facility and Class IV facility, sidewalks and bike lanes adjacent to one another and at the same elevation.

Note: Sacramento County DOT is meeting with the Strong Go vendor on Wednesday, May 25th, to "see" the product and further consider its use on public streets.

Attachments: (with brief narrative description)

Exhibit A: Vicinity Map showing limits of the Phase 1 design and construction project, between Morse Avenue and Watt Avenue; and the Arden Way Complete Streets Master Plan, between Ethan Way and Morse Avenue.

Exhibit B: Arden Way Complete Streets Phase 1 – Plan View: North side of the roadway shows a sidewalk with a landscape separation and a bicycle lane separated from the roadway with a curb and gutter. The south side of the roadway shows a bike lane and sidewalk separated from the vehicle lane by a curb and gutter.

Exhibit C: Arden Way Cross Section: North side of the roadway shows a sidewalk with a landscape separation and a bicycle lane separated from the roadway with a curb and gutter. The south side of the roadway shows a bike lane and sidewalk separated from the vehicle lane by a curb and gutter. The bicycle facility and sidewalk are adjacent to one another and are at the same elevation.

- Excerpts include an image of the tested surfaces that were in the Better Market Street Delineator Study.
- Picture of an installation of the trapezoidal shaped delineator used as a detectable warning surface adjacent to a roadway.

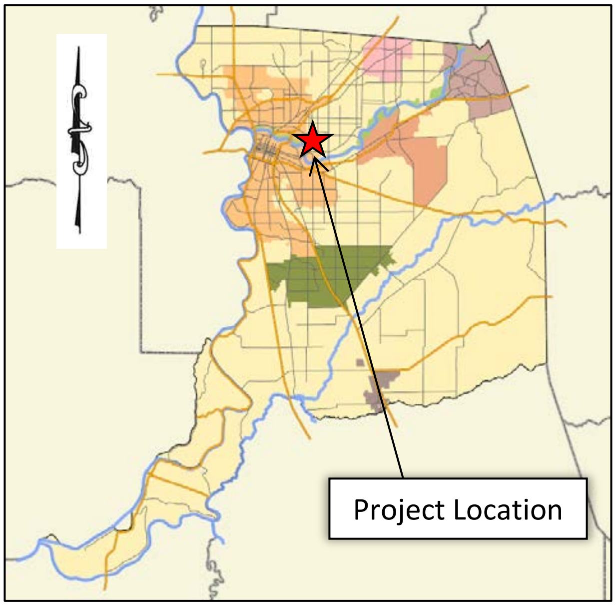
Exhibit D: Delineator for Separated Bike Lanes at Sidewalk Level. Journal of the Transportation Research Board, 2020.

Exhibit E: Better Market Street Delineator Summary Report, prepared for San Francisco Public Works, October 2020.

SACRAMENTO COUNTY

Sacramento County Bicycle Advisory Committee

Item 4
05/18/2022

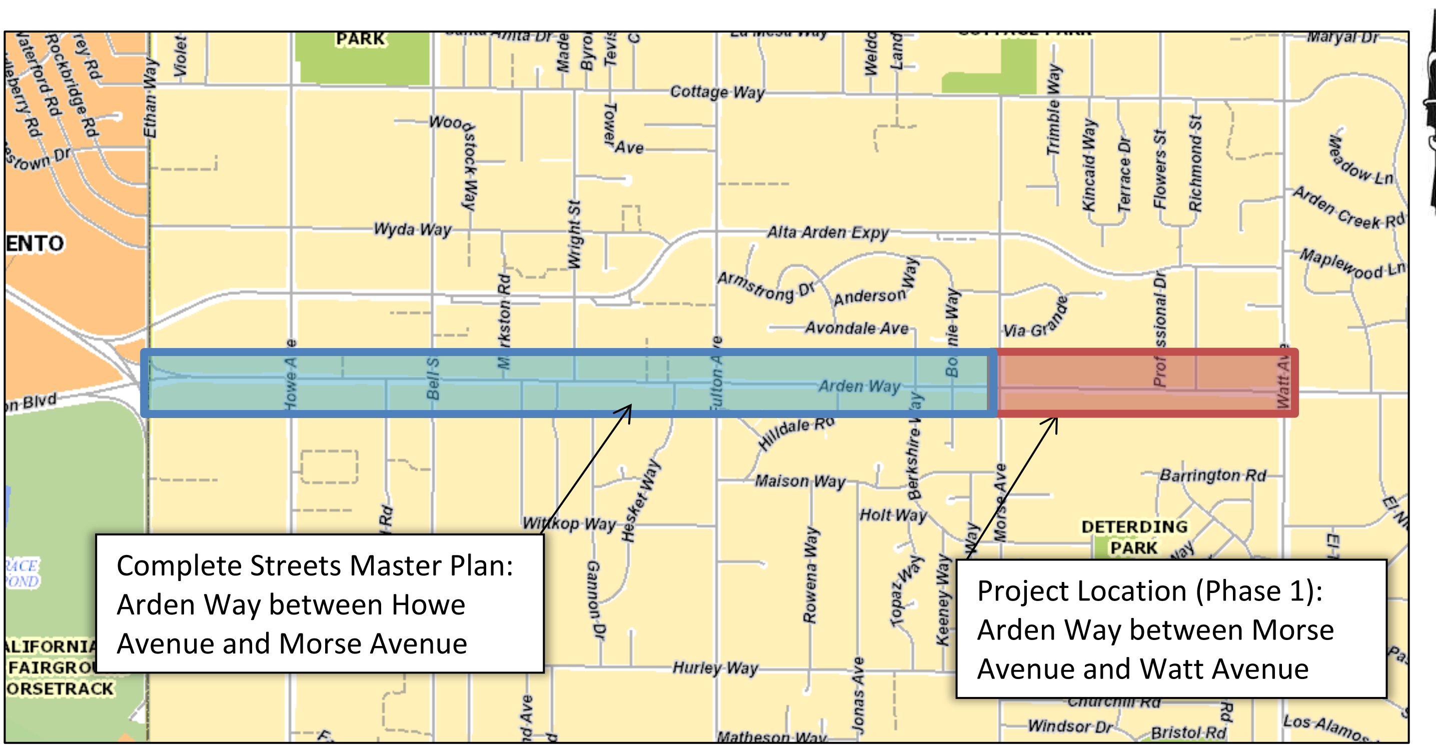


NOT TO SCALE

Exhibit A - Vicinity Map

Arden Way Complete Street Improvement Project - Phase 1: Morse Avenue to Watt Avenue

Complete Streets Master Plan:
Arden Way between Howe Avenue and Morse Avenue



NOT TO SCALE

Exhibit B

ARDEN WAY

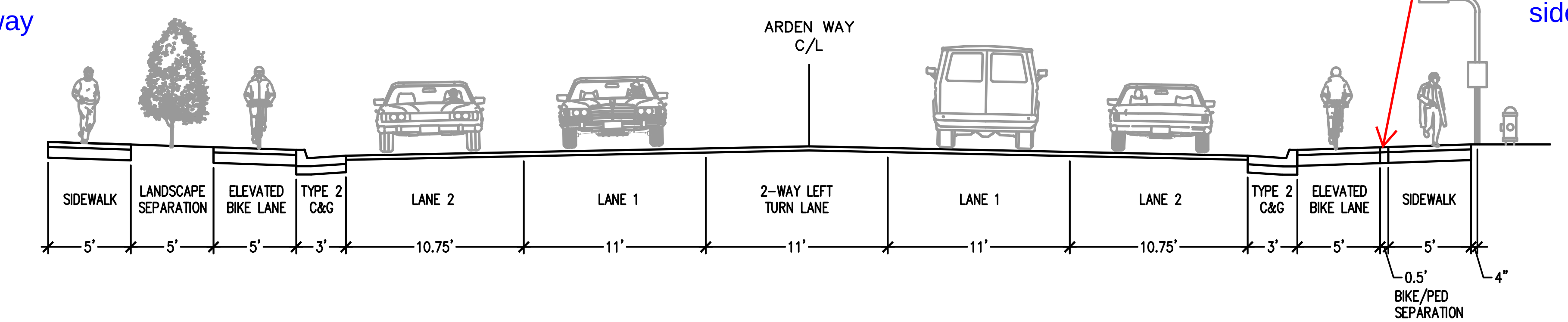
ARDEN WAY COMPLETE STREETS (PHASE 1)
MORSE AVENUE TO WATT AVENUE
PRELIMINARY DESIGN LAYOUT
MARCH 2022
SCALE: 1"=40'

DRAFT - NOT FOR CONSTRUCTION

PROPOSED SEPARATION BETWEEN BICYCLE AND SIDEWALK FACILITY

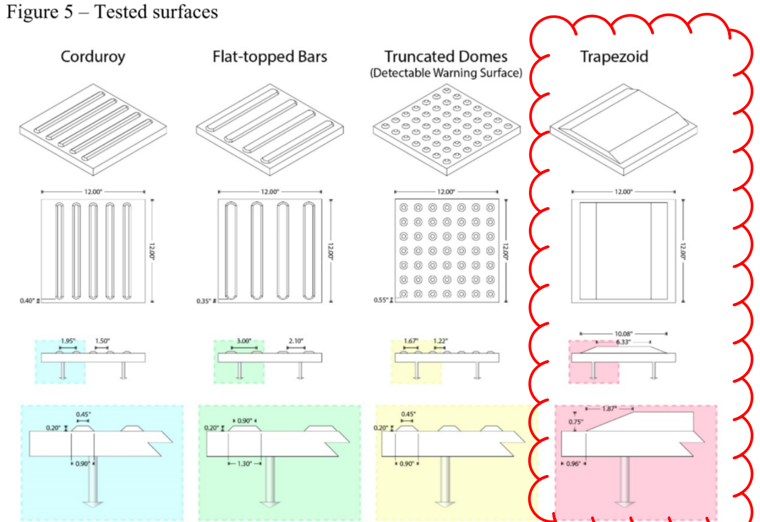
NORTH side of roadway

SOUTH side of roadway



ALTERNATIVE #1
ELEVATED BIKE LANE WITH SIDEWALK SEPARATION WITH UTILITIES

Figure 5 – Tested surfaces



NOT TO SCALE

Better Market Street Delineator Study. Examples of surfaces that were tested by vision- and mobility-impaired users as well as bicyclists.

Treasure Island, San Francisco. Installation of trapezoidal shaped delineator, not used as a delineation between bicycle and pedestrian facility.

COMMUNITY SERVICES AGENCY
SACRAMENTO COUNTY
DEPARTMENT OF TRANSPORTATION
SACDOT

SAMPLE CROSS SECTION EXHIBIT
ARDEN WAY COMPLETE STREETS
PHASE 1 – MORSE AVE TO WATT AVE

Exhibit C

DATE: FEB 2022	HORIZONTAL SCALE: NONE	VERTICAL SCALE: NONE	DRAWN BY: MOW	DESIGN BY: HAY	CHECK BY: HAY	DWG 1 OF 1

TRR
JOURNAL OF THE TRANSPORTATION RESEARCH BOARD

Research Article

Transportation Research Record
1–12

DOI: 10.1177/0361198120922991
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SAGE

Delineator for Separated Bicycle Lanes at Sidewalk Level

Billie Louise (Beezy) Bentzen[1], Alan C. Scott[2], and Linda Myers[3]

Abstract

The City and County of San Francisco sponsored research to identify a delineator for separated bicycle lanes at sidewalk level that is at least as detectable as truncated-dome detectable warning surface (DWS) by pedestrians with visual impairments, and that is not a barrier to pedestrians with mobility impairments. Tested as potential delineators were a 12-in. wide continuous raised trapezoid (0.75 in. high), and 12- and 24-in. wide installations of relatively wide flat-top bars (FTBs) and of a "corduroy" surface of narrower bars spaced more closely together (both 0.2 in. high). Thirty-one visually-impaired participants detected all five surfaces in addition to DWS, a total of six times each, from 90° and 25° approaches, with mean detection accuracies better than 90% for all surfaces (no significant differences). The long white cane intruded into the cycle track significantly less frequently with 24-in. wide surfaces. In a counterbalanced manner, participants also briefly stepped onto each surface eight times, each time identifying it as "domes,""bars," or "trapezoid." They identified the trapezoid significantly better (mean rate of correct identification = 98.8%) than all other surfaces. A majority of participants with vision disabilities preferred the trapezoid. Thirty participants with a variety of mobility impairments, using a variety of aids, crossed each surface four times with little significant difference from the DWS in effort, instability, and discomfort or pain. No surface was found to be a barrier to crossing. The trapezoidal surface was recommended as the delineator, although the 24-in. FTBs also performed very well.

There is increasing interest in the U.S.A. in installing separated bicycle lanes (SBLs) at sidewalk level, and it is recognized that absence of a means of separating bicycles and pedestrians compromises the safety of pedestrians, especially those having visual impairments (VI). In the re-design of Market Street, the City and County of San Francisco plans to provide a safer environment for bicycles by creating a sidewalk level SBL. The City proposes a physical element to separate the cycle track from the sidewalk; however, there is no standard material for such a delineator. Research was thus undertaken to identify a delineator that is at least as detectable as the truncated-dome detectable warning surface (DWS) by pedestrians with VI, and that is not a barrier to people with mobility impairments (MI). Intrusion of the long white cane and the participants' bodies into the bicycle lane were also investigated, and because right of way is often limited where SBLs are being considered, two potential delineators were tested at two widths.

To function effectively as a delineator for sidewalk level SBLs, a delineator must be readily detectable and identifiable when encountered from various angles of approach by pedestrians having VI. DWS indicates the end of the pedestrian way and the beginning of a vehicular way, and is typically used only to indicate crossing locations in areas such as shared streets or bicycle lanes. It is important that the SBL delineator not be confused with DWS.

Previous research on tactile walking surface indicators (TWSIs) was considered in selecting surfaces for testing, especially research on delineator surfaces and surfaces that might be used for guidance on shared streets. A truncated-dome DWS has been found in U.S. and international research to be highly detectable, and to require a depth (in the direction of travel across it) of 24 in. (61 cm) to enable pedestrians with little or no vision to detect it, and come to a stop without going beyond it (*1–3*). The DWS is the only TWSI in the U.S. that has repeatedly been shown to be highly detectable.

Researchers in the UK have repeatedly investigated TWSIs for delineators. Williams (*4*) identified a continuous raised trapezoidal surface, 150 mm (5.9 in.) wide at the base, and either 12 mm (0.47 in.) or 20 mm (0.79 in.)

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in height, that was detectable and usable by pedestrians with VI as a delineator between bicycle and pedestrian sides of a sidewalk level SBL. In 1998 a 20 mm (0.79 in.) high trapezoid became the recommended delineator for sidewalk level SBLs in the UK (*5*), although a 12 mm (0.47 in.) high trapezoid was permitted.

Subsequent research by Childs et al. (*6*), Savill et al. (*7*), and research commissioned by Guide Dogs for the Blind (*8*), together included 24 potential surfaces (varying in surface geometry, width, and orientation of the geometry) for use as delineators for SBLs or for guidance in shared streets. They confirmed the detectability of the trapezoid at 20 mm (0.79 in.), but not at 12 mm (0.47 in.). Two other surfaces were also highly detectable: a guidance surface of 35 mm (1.38 in.) wide bars raised 5 mm (0.20 in.), and a surface dubbed "corduroy," which consisted of rounded bars, 2 mm (0.08 in.) wide at the base, and 6 mm (0.24 in.) high. The three surfaces were all found to be crossable by people with MI.

Method

Materials

Five potential delineator surfaces were tested; DWS was tested as a baseline. All surfaces were made of the same high-polymer concrete, had the same micro-texture to increase slip resistance, and were installed in a 1.5-in. (38.1 mm) thick mortar base. The surfaces were selected on the basis of prior research indicating that they were highly detectable to people with VI and crossable by people with MI. Two surfaces were tested in two widths, 12 in. (305 mm) and 24 in. (610 mm), to determine minimum effective width and other width-dependent effects. The full array was 120 ft long by 32 ft wide (36.58 m × 9.75 m) with cement pads about 6 ft wide (1.83 m) on the "outside" of the surfaces and running the full length of the array (Figure 1). The array was marked with chalk for the researchers, indicating the starting positions and headings for participants with vision disabilities as they approached and detected each surface. The two bar-type surfaces were installed with the bars parallel to the long axis of the test array.

The DWS tested had the geometry preferred by San Francisco (42.4 mm dome center spacing); a section 24 in. (610 mm) wide was installed.

A continuous trapezoidal surface with a 10.08-in. (256.03 mm) base width, 6.33-in. (160.78 mm) top width, and 0.75-in. (19.05 mm) height, on a 12-in. (305 mm) wide tile was tested at that width only. The height of the trapezoid and the angle of slope of the sides were the same as those repeatedly found to be highly detectable in UK research (*4*, *5*). The trapezoid tested was wider, based on the suggestion of participants in UK research and on concern that there would be more intrusion of the long cane into the bicycle lane with a narrower delineator.

A surface comprised of flat-top bars (FTBs) was tested at two widths: 12 in. (305 mm) and 24 in. (610 mm). The bars were 0.2 in. (5.08 mm) high, and had 1.3-in. (33 mm) base width, 0.9-in. (23 mm) top width, and 3.0-in. (76.2 mm) center spacing. Research in the UK (*6*, *8*) and in Japan (*9*, *10*) demonstrated that this surface is highly detectable, and can be crossed by people having MI. However, research by Childs et al. (*6*) suggests that the 12-in. (305 mm) width will not be readily detected from a 90° approach.

The final surface, dubbed "corduroy," was also tested at the 12-in. (305 mm) and 24-in. (610 mm) widths. It was comprised of narrower bars, 0.2 in. (5.08 mm) high, with 0.45-in. (11.43 mm) top width, and 0.9-in. (22.86 mm) base width, more closely spaced at 2.4 in. (60.96 mm). Surfaces with similar geometry, but fully rounded on top, had been found to be highly detectable (*3*, *6*). To have a micro-texture on the bars to increase slip resistance, they were slightly flattened on top.

Participants

Thirty-one participants having little or no vision individually completed the human factors research tasks. They varied in age, sex, race, and ethnicity and frequency or extent of independent travel. Five participants who customarily travel using a dog guide completed the detectability task using a Juno technique, in which a dog guide instructor simulated dog guide travel by holding the empty harness and guiding as a dog would. The Juno technique is a part of the training for all dog guide users. Dog guides become confused by repetitive tasks and are not typically used in research.

Thirty individuals having MI participated in the study while using the following aids: five with manual wheelchairs, five with power wheelchairs, one with power mobility scooter, five with walkers, three with crutches, and seven with support canes. Four individuals had walking difficulties but used no aid while participating. The participants varied in age, sex, race, and ethnicity and frequency or extent of independent travel.

Procedure

On arrival at the test site, participants signed the consent form and were given an honorarium. All participants then completed the experimental procedure individually. They were guided by a certified orientation and mobility specialist, who gave them instructions, asked for their feedback, and ensured their safety. Another researcher recorded observed performance, responses to structured questions, and additional feedback. The participants who were VI using a long cane had three tasks (detection, identification, and following) and the participants using Juno had two tasks (detection and identification). All participants were asked follow-up questions.

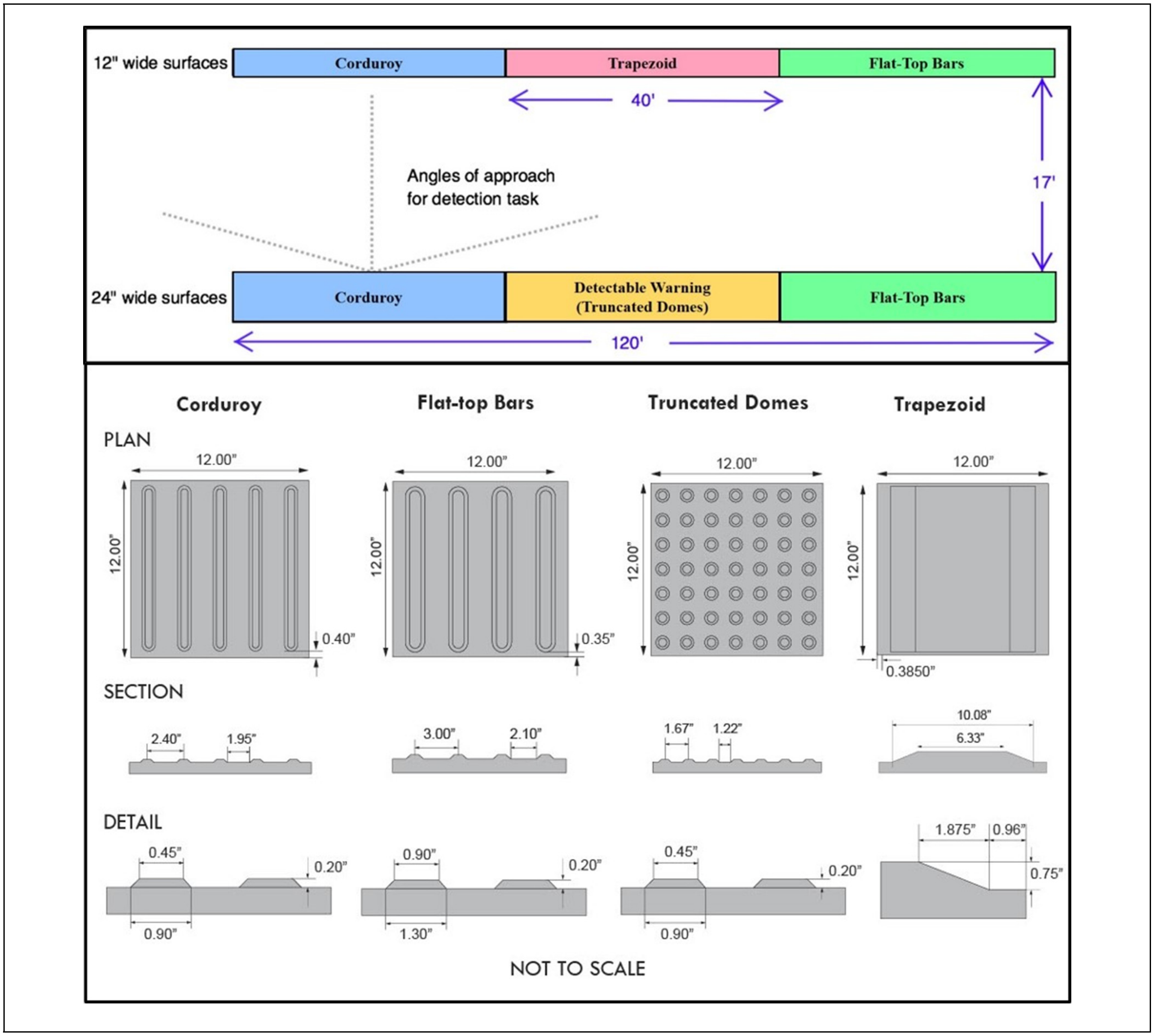


Figure 1. (*Top panel*) The test array and (*bottom panel*) the geometries of the tested surfaces.

Detection Task. Participants having VI approached each of the six surfaces six times. They were instructed to stop when they detected a surface either in front of them or beside them on the left or right, and to say that they found a surface. Two approaches to each surface were from 90 degrees, and two approaches each were at approximately 25 degree angles to the left and to the right. Approach distance was varied. The order of surfaces, approach direction, and distance to surface were counterbalanced to control for learning the locations of surfaces and whether to anticipate them in front, to the left, or to the right.

Identification Task. Participants with vision disabilities were guided onto each surface from various angles eight times, and then guided off the surfaces after no more than 3 s. Each time, they had to identify the surface they had stepped on (they were not allowed to touch the surface with their cane or hand) as domes (the DWS), bars (either the corduroy or the FTB), or trapezoid. They were not asked to discriminate between the two types of raised bar surfaces.

Following Task. Participants who used a long cane were asked to follow each of the delineators for 40 ft (12.2 m) two times, once with the surfaces on the left and once with them on the right.

Crossing Task. Participants who were MI were first asked to cross the DWS, concentrating on their experience while crossing it, and they then provided information about whether (and to what extent) it made them feel at all unstable or caused them any discomfort or pain. Participants were then asked to cross each of the other five surfaces two times. The order for crossing the surfaces was counterbalanced across participants. After each back and forth crossing of a surface, they were asked to rate their experience in crossing that surface (effort, stability, and comfort) relative to their experience crossing the DWS. After crossing each surface two times, participants were asked whether they would be comfortable repeating the procedure. All participants repeated the procedure, thus crossing all surfaces four times each.

Preferences. After all experimental tasks had been completed, participants were asked about their preferences and concerns, and given an opportunity to share additional feedback.

Analyses

The analyses are a series of one-way and two-way repeated-measures ANOVAs and dependent *t*-tests. Huynh-Feldt or Greenhouse-Geisser corrections were used for violations of sphericity, and post-hoc comparisons employed Bonferroni corrections (family-wise error = 0.07). The *p*-values reported provide the alpha value used to evaluate the statistic.

Results: Participants with Vision Disabilities

Detection Trials

For each detection trial, it was recorded if and when the surface was detected, and whether at any point in the trial their cane, foot, or both, intruded into the simulated cycle track. Cane intrusions were recorded if the cane extended 6 in. (15.2 cm) or more beyond the far edge of the delineator surface. If the cane tip extends less than 6 in. past the surface, this might be considered a low risk event (not no risk) for contact with a bicycle. Foot intrusions were recorded if any part of the participant's foot crossed the far-side edge of the delineator; if any part of the foot has crossed the bicycle-side edge, the pedestrian would be at risk of collision with bicycles.

Cane Users. Detection of the delineator: Consideration of surfaces and delineator width—The mean number of approaches in which participants detected the surface with either their cane or their feet (before walking fully across the surface) was very high for all surfaces (94.8% or higher) at the widths tested (no significant differences: $F[2.33, 58.22] = 2.025$, $p > 0.05$). See Table 1 for the mean performance in each of the six conditions for this and other detection trial variables. The rates of such detections also did not significantly differ for 12- and 24-in. delineators ($t[25] = 1.656$, $p > 0.05$). When adding those trials in which detection was announced just after the participant stepped off the delineator on the far side, overall detection rate was 98.2%.

The mean number of approaches in which participants detected the delineator with their cane (before their foot contacted the surface) significantly differed for the various delineators ($F[5,125] = 14.846$, $p < 0.05$). The mean number of detections by cane was significantly lower for the trapezoid than for the other surfaces ($t[25] = 5.87$, 3.20, 5.53, 5.95, and 4.60; comparisons with DWS, 24 in. corduroy, 24 in. FTB, 12 in. corduroy, and 12 in. FTB, respectively; $p < 0.0047$). For other significant comparisons, see Table 1.

An analysis of rates of detection by cane by delineator width revealed a very small advantage when detecting 24-in. versus 12-in. delineators (83.8% versus 79.7%; $t[25] = 2.906$, $p < 0.05$). However, the larger difference in rates for individual delineators suggests those differences are likely more attributable to the design of the surfaces than to any differences in their widths.

Intrusions into the "bike lane": Consideration of surfaces and delineator width—The mean number of trials in which cane intrusions occurred significantly differed for the various delineators ($F[5,125] = 43.303$, $p < 0.05$). All pairwise comparisons were significant at $p < 0.0047$ with the exception of two (DWS versus 24 in. FTB, $t[25] = 0.16$; 12 in. corduroy versus 12 in. FTB, $t[25] = 0.72$). Overall, the mean rate of cane intrusions was considerably higher for the 12-in. delineators ($M = 9.88$ of 18 trials, 54.9%) than for the 24-in. delineators ($M = 3.62$ of 18 trials, 20.1%) ($t[25] = 10.168$, $p < 0.05$). While delineator width appears to play a sizeable role in the likelihood of cane intrusions, the significance of pairwise comparisons for some surfaces of the same width suggests that surface texture/geometry is also a contributing factor.

The overall rates of foot intrusions were much lower than for cane intrusions, but did occur in around 7.5% of all trials. Despite a significant omnibus effect of type of delineator ($F[2.36,58.92] = 3.088$, $p < 0.05$), no pairwise comparisons achieved statistical significance. When treatments were considered together, there was a significantly higher rate of foot intrusions for 12-in. versus 24-in. delineators ($t[25] = 2.611$, $p < .05$).

Detection of the surface: Consideration of surfaces and angle of approach—Two-way, repeated-measures ANOVAs (6 [surface/width] × 2[angle of approach]) were employed to consider the effects of perpendicular versus angled approaches (25^{o}). The analysis of percentage of approaches in which participants detected the surface with either their cane or their feet (before walking fully across the surface) found no significant interaction

Table 1. Summary of Cane Users' Performance: All Surface and Width Combinations

Measure	24 in. delineators			12 in. delineators		
	Detectable warning surface (a)	24 in. corduroy (b)	24 in. flat-top bars (c)	12 in. corduroy (d)	12 in. flat-top bars (e)	Trapezoid (f)
Mean # of detections by cane or while foot was in contact with delineator (6 trials)	5.89 (98.2%)	5.77 (96.2%)	6.00 (100%)	5.77 (96.2%)	5.69 (94.8%)	5.96 (99.3%)
Mean # of trials in which delineator was not detected (6 trials)	0.077 (1.3%)	0.154 (2.6%)	0.00 (0%)	0.192 (3.2%)	0.192 (3.2%)	0.038 (0.6%)
Mean # of detections by cane (6 trials)*	5.27 (87.8%) –b, f**	4.73 (78.9%) –a, d, f	5.08 (84.6%) –f	5.15 (85.9%) –b, f	5.00 (83.3%) –f	4.19 (69.9%) –a, b, c, d, e
Mean # of trials in which delineator was contacted with the cane (6 trials)	6.00 (100%)	5.89 (98.1%)	6.00 (100%)	5.81 (96.8%)	5.81 (96.8%)	5.81 (96.8%)
Mean # of cane intrusions (6 trials)*	0.92 (15.4%) –b, d, e, f	1.81 (30.1%) –a, c, d, e, f	0.88 (14.7%) –b, d, e, f	2.88 (48.1%) –a, b, c, f	3.04 (50.6%) –a, b, c, f	3.96 (66.0%) –a, b, c, d, e
Mean # of foot intrusions (6 trials)	0.31 (5.1%)	0.46 (7.7%)	0.04 (0.6%)	0.54 (9.0%)	0.73 (12.2%)	0.65 (10.9%)

*Significant pairwise comparisons at $p < .0047$ (Bonferroni-adjusted value).

**For a given measure, letters in individual cells indicate those conditions against which performance significantly differs (e.g., rate of cane detection of DWS [b, f] significantly differs from the rate for 24 in. corduroy [b] and the rate for trapezoid [f]).

($F[2.79,69.85] = 2.481$, $p > 0.05$) and no significant main effect of surface ($F[2.49,62.12] = 2.353$, $p > .05$). There was a significant main effect of angle of approach ($F[1,25] = 8.827$, $p < 0.05$), with lower rates for perpendicular approaches (Figure 2).

The analysis of percentage of approaches in which participants detected the surface with their cane (before their foot contacted the surface) resulted in a significant interaction ($F[4.04,101.06] = 5.207$, $p < .05$) (Figure 3). Perpendicular approaches did tend to result in lower rates of detection by cane than did angled approaches ($F[5,125] = 19.768$, $p < 0.05$). The interaction is largely a product of the difference in cane detection of the trapezoid for angled versus perpendicular approaches. For angled approaches, cane detection of the trapezoid was nearly as good as detection of all other surfaces. There is a significant simple main effect of surface for angled approaches ($F[3.142,78.544] = 3.341$, $p < .05$), but the only significant pairwise comparison is between the trapezoid and the 12-in. corduroy ($t[25] = 3.143$, $p < 0.0047$). However, for perpendicular approaches, there was a significant simple main effect ($F[3.21,80.28] = 10.558$, $p < .05$) and the rate of cane detection of the trapezoid was significantly lower than for DWS, 24-in. FTB, 12-in. corduroy, and 12-in. FTB ($t[25] = 5.14$, 4.79, 4.17, 3.64, respectively, $p < 0.0047$). Also, the rate of detection by cane was worse with the 24-in. corduroy than with the DWS ($t[25] = 3.33$, $p < 0.0047$). Note that while detection of the trapezoid by cane was more difficult than detection of other surfaces, particularly when approaching perpendicular to the surface (Figure 3), detection by cane *or foot* was excellent for either angle of approach (Figure 2). Thus the trapezoid was hard to miss with the foot and highly recognizable as a delineator.

Intrusions into the "bike lane": Consideration of surfaces and angle of approach—An analysis of the percentage of detection trials with cane intrusions found no significant interaction ($F[5,25] = 2.200$, $p > 0.05$). Cane intrusions were more common on perpendicular approaches ($M = 51.9\%$) than angled approaches ($M = 30.3\%$) ($F[1,25] = 36.812$, $p < 0.05$), and there was a main effect of surface ($F[5,125] = 41.890$, $p < 0.05$), with the effect clearly associated with the width of the delineator (overall mean rates ranged 16.3–34.6% for 24 in. surfaces, and 52.9–70.2% for 12 in. surfaces).

While the rates of foot intrusions were lower than for cane intrusions, the pattern of findings is largely the same. The analysis of percentage of detection trials with foot intrusions found no significant interaction ($F[3.24,81.00] = 2.533$, $p > 0.05$). Foot intrusions were more common on perpendicular approaches ($M = 12.8\%$) than angled approaches ($M = 5.0\%$) ($F[1,25] = 14.552$, $p < 0.05$), and there was a main effect

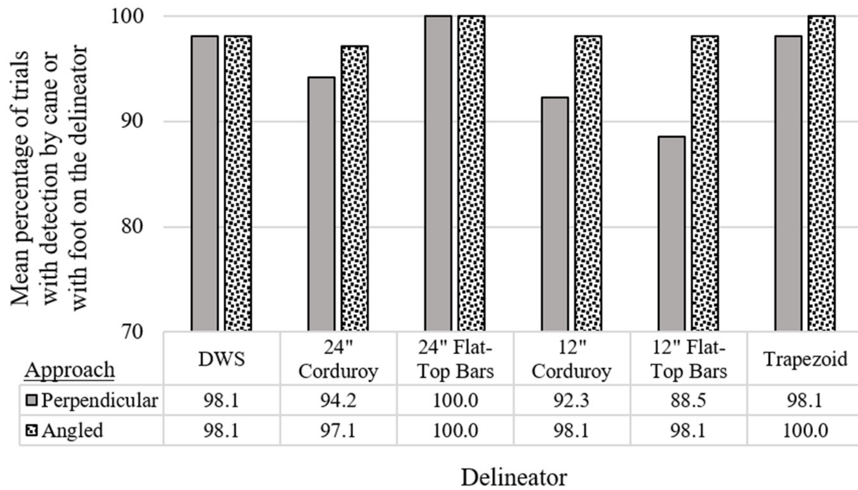


Figure 2. Mean percentage of approaches by cane users with detection by cane or with a foot on the delineator, by surface and angle of approach.
Note: DWS = detectable warning surface.

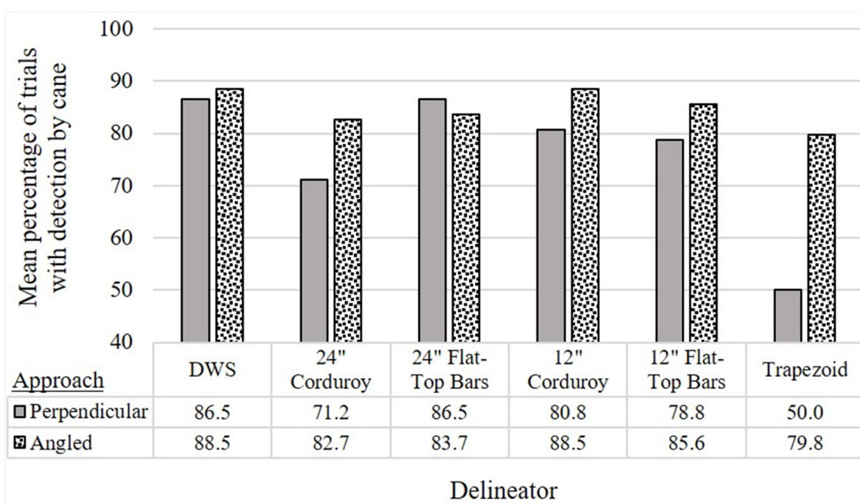


Figure 3. Mean percentage of approaches by cane users with detection by cane, by surface and angle of approach.
Note: DWS = detectable warning surface.

of surface (F[2.55,63.85] = 3.436, $p < 0.05$), with the effect clearly associated with the width of the delineator (overall mean rates ranged between 0.5% and 9.6% for the 24 in. surfaces, and 10.6–13.9% for 12 in. surfaces).

Guide Dog Users using Juno Technique. There was a rather small sample of guide dog users using Juno technique, and so the results for this group should be understood as rather exploratory in nature.

Detection of the surface: Consideration of surfaces and delineator width—For those five participants using the Juno technique, detection was only possible by sensing the delineator underfoot as they did not use a cane. As a result of the faster rate of travel of the guide dog users, there were a significant number of trials in which the participants detected the delineator, but by the time they announced it and stopped, they had crossed fully over it. For total detection rate (detections announced while a foot was in contact with the delineator or just after

Table 2. Summary of Guide Dog (Juno) Users' Performance—All Surface and Width Combinations

	24 in. delineators			12 in. delineators		
Measure	Detectable warning (a)	24 in. corduroy (b)	24 in. flat-top bars (c)	12 in. corduroy (d)	12 in. flat-top bars (e)	Trapezoid (f)
Mean # of detections while foot was in contact with the delineator or just after crossing it (6 trials)	5.40 (90.0%)	5.80 (96.7%)	6.00 (100%)	5.60 (93.3%)	5.00 (83.3%)	5.80 (96.7%)
Mean # of trials in which delineator was not detected (6 trials)	0.60 (10.0%)	0.20 (3.3%)	0.00 (0%)	0.40 (6.7%)	1.00 (16.7%)	0.20 (3.3%)
Mean # of detections while foot was in contact with delineator (6 trials)*	4.60 (76.7%) –d**	5.20 (86.7%) –e	5.40 (90.0%) –	2.80 (46.7%) –a, f	2.80 (46.7%) –b	5.20 (86.7%) –d
Mean # of detections occurring after both feet had crossed the delineator (6 trials)	0.80 (13.3%)	0.60 (10.0%)	0.60 (10.0%)	2.80 (46.7%)	2.20 (36.7%)	0.60 (10.0%)
Mean # of foot intrusions (6 trials)	5.80 (96.7%)	5.60 (93.3%)	5.40 (90.0%)	6.00 (100%)	6.00 (100%)	6.00 (100%)

*Significant pairwise comparisons at $p < .0047$ (Bonferroni-adjusted value).
**For a given measure, letters in individual cells indicated those conditions against which performance significantly differs (e.g., rate of foot detection with 12 in. corduroy [a, f] significantly differs from the rate with DWS [a] and with trapezoid [f]).

having crossed), participants succeeded in detecting the delineator on 93.3% of all trials for all delineators (no significant differences; F[5,20] = 1.641, $p > 0.05$). See Table 2 for the mean performance in each of the six conditions for this and other detection trial variables. The rates of such detections also did not significantly differ for 12-in. and 24-in. delineators (t[4] = 1.372, $p > 0.05$).

The mean number of approaches in which participants detected the surface while at least one foot was still on the surface significantly differed for the various delineators (F[5,20] = 8.424, $p < 0.05$); however, the low power of the analysis creates an unclear picture with respect to those differences that are statistically significant (Table 2). An analysis of these rates by delineator width did reveal an overall significant advantage when detecting 24-in. (84.4%) versus 12-in. (60.0%) surfaces (t[4] = 5.880, $p < 0.05$), though in this small sample, the rate of such detections of the 12-in. trapezoid was more comparable to the 24-in. delineator surfaces, an occurrence that speaks to its highly identifiable nature.

Intrusions into the "bike lane": Consideration of surfaces and delineator width—The overall rate of foot intrusions was very high (overall rate of 96.7% of trials) and was high for all delineators (no significant differences; F[1.27,5.08] = 2.087, $p > 0.05$). Foot intrusions occurred on every trial with perpendicular approaches (60 of 60), and on every trial approaching a 12-in. delineator (90 of 90). Rates remained high in other conditions (85% and higher), though there were some instances of participants avoiding foot intrusions when making angled approaches to 24-in. delineators.

Detection of the surface: Consideration of surfaces and angle of approach—Two-way, repeated-measures ANOVAs (6 [surface/width] × 2 [angle of approach]) were employed to consider the effects of perpendicular versus angled approaches (25°). The analysis of the total detection rates (i.e., detection announced while a foot was in contact with the delineator or just after crossing it) clearly suggests some trends, and the low power of the analysis is likely the driving factor in finding no significant effects (Interaction, F[5,20] = 0.943, $p > 0.05$: Main effect of surface, F[2,20] = 1.486, $p > 0.05$: Main effect of approach, F[1,4] = 7.50, $p > 0.05$) (Figure 4). The main effect of approach orientation was trending toward significance ($p = 0.052$), with a higher observed detection rate on angled approaches (M = 97.5%) than on perpendicular approaches (M = 85%).

The analysis of percentage of approaches in which participants detected the delineator while at least one foot was still on the surface produced no significant interaction (F[5,20] = 0.620, $p > .05$) (Figure 5). Participants were more likely to detect the delineator while a foot was still on it when the delineator surface was 24 in. wide than when it was 12 in. wide (F[1,4] = 19.761, $p < 0.05$). Type of surface was also a significant factor (F[1.77,7.10] = 8.415, $p < 0.05$); however, with the limited sample size, and the use of the Bonferroni procedure, only two pairwise comparisons were statistically significant. Juno users were more likely to detect the delineator with a foot still on the surface with the trapezoid than with the 12-in. corduroy

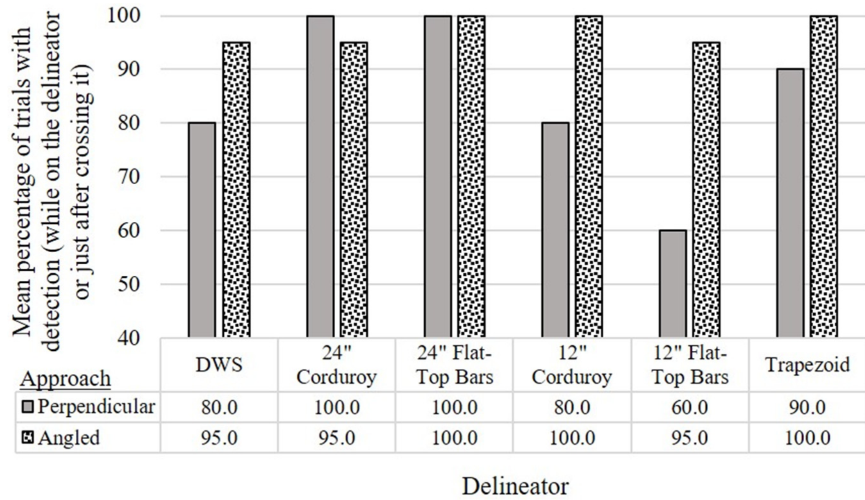


Figure 4. Mean percentage of approaches by Juno users in which the surface was detected, by surface and angle of approach.
Note: DWS = detectable warning surface.

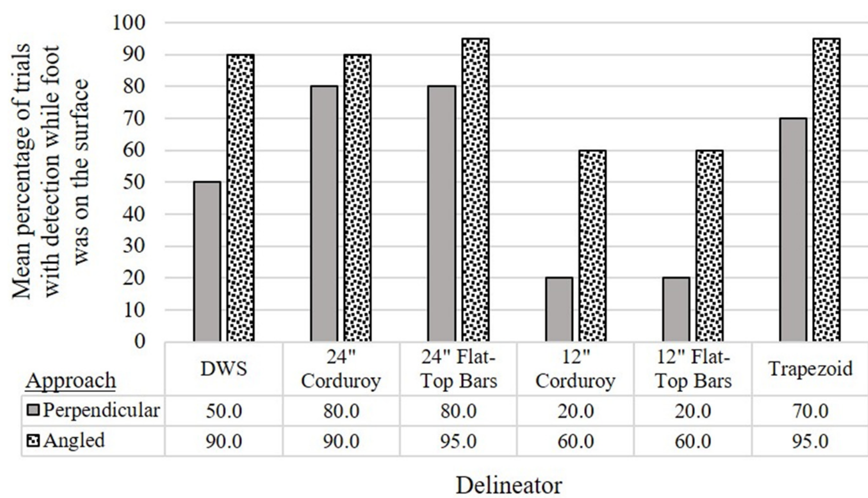


Figure 5. Mean percentage of approaches by Juno users with detection while in foot contact, by surface and angle of approach.
Note: DWS = detectable warning surface.

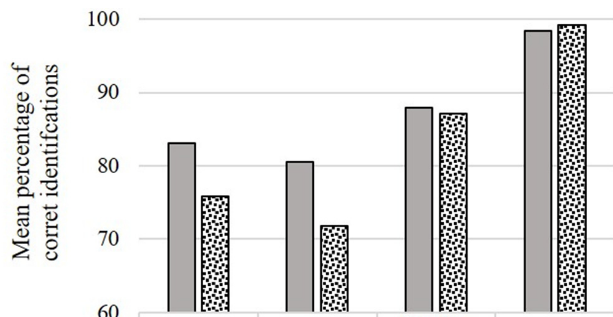
(t[4] = 8.50, $p < 0.0047$), and with 24-in. corduroy than with 12-in. FTB (t[4] = 9.00, $p < 0.0047$).

Intrusions into the "bike lane": Consideration of surfaces and angle of approach—A 6 (surface/width) × 2 (angle of approach) analysis of the percentage of detection trials in which Juno users' feet intruded into the "bike lane" found no significant effects (Interaction, F[1.270,5.280] = 2.087, $p > 0.05$: Main effect of surface, F[1.270,5.280] = 2.087, $p > 0.05$: Main effect of approach, F[1,4] = 2.250, $p > 0.05$).

Identification Task

In a fully factorial manner, participants' ability to identify each surface by foot was evaluated in a 4 (type of surface) x 2 (angle of approach) manner. Both cane users and Juno users completed this task (n = 31).

An analysis of rates of correct identification revealed no significant interaction (F[2.42,72.65] = 1.499, $p > 0.05$), and no main effect of approach angle (F[1,30] = 3.197, $p > 0.05$). There was a significant main effect for surface type (F[3,90] = 12.620, $p < 0.05$)



Approach	DWS	Corduroy	Flat-Top Bars	Trapezoid
Perpendicular	83.1	80.6	87.9	98.4
Angled	75.8	71.8	87.1	99.2

Delineator

Figure 6. Percentage of trials with correct identification of the surface.
Note: DWS = detectable warning surface.

(Figure 6). Overall, identification of the trapezoid was nearly perfect (mean # of correct identifications was 7.903 out of 8.00 [98.8%]). Participants were significantly more successful at correctly identifying the trapezoid than FTB, corduroy, or DWS (t[30] = 3.66, 6.73, and 4.00, respectively, $p < 0.012$). Participants were also significantly more successful in identifying the FTB as bars than identifying the corduroy as bars (t[30] = 3.23, $p < 0.012$). The other pairwise comparisons were not statistically significant.

Participants were making a three-option, forced-choice judgment (there was no distinction to be made between the two types of bars). Participants correctly identified the trapezoid in 245 of 248 total trials, and only incorrectly identified some other surface as the trapezoid in seven of 744 trials with the other surfaces. Thus the trapezoid was very clearly identifiable and distinguishable from all of the other surfaces. When identification errors occurred in the other conditions, they were almost always a confusion between the DWS truncated domes and one of the bar surfaces. Combined with participants being more successful at identifying the FTB surface than the corduroy, it suggests that the FTB surface is specifically more distinguishable from the DWS than is the corduroy surface which had narrower and somewhat more rounded bars and a larger gap between the bars.

Following Task

While attempting to follow each of the delineators for 40 ft at a time, it was recorded whether participants ever lost the surface (taking six steps and completing three full cane sweeps without contacting the surface), and whether their cane or feet ever intruded into the imagined bike lane on the far side of the delineator. For this final task, participants were asked to attempt to follow each specific combination of surface and width two times.

Participants successfully followed the surfaces without losing them on 302 of 312 total trials (with nine instances of losing surfaces committed by one participant). There is thus no significant influence of surface type (F[3,75] = 1.228, $p > 0.05$) or of width of surface (t[25] = 1.443, $p > 0.05$) on likelihood of successfully following the delineator.

Analyses found few significant effects when comparing performance within each width category (e.g., comparing performance with the three 12 in. delineators). However, when comparing performance between the different widths (collapsing for surface type), participants were found to have higher rates of cane intrusions with the 12-in. delineator surfaces (M = 3.81 of six trials; 63.5%) than with the 24-in. delineator surfaces (M = 1.88 of six trials; 31.3%) (t[25] = 4.858, $p < 0.05$). The mean number of foot intrusions also appeared higher with the 12-in. delineators (M = 0.65 of six trials; 10.8%) than with the 24-in. delineators (M = 0.35 of six trials; 5.8%), but the difference was not statistically significant (t[25] = 1.316, $p > 0.05$).

Participants' Subjective Evaluations of Surfaces

After completing all tasks, and when asked, almost all VI participants provided a specific preference, with a majority (58.1%) selecting the trapezoid. When asked if they had specific opposition to the possible use of a surface as the delineator, nearly half the participants (48.4%) said all surfaces were OK, while 22.6% expressed opposition to the corduroy.

Results: Participants with Mobility Disabilities

Willingness and Ability to Cross

It was explained to participants with MI that if they thought any surface was unsafe, difficult, or uncomfortable to cross they should inform the experimenter and they would not be asked to cross. Therefore, if a surface appeared hazardous or overly difficult to cross, or if crossing it once actually did require an uncomfortable degree of effort, or caused the participant pain, or made a participant feel unstable particularly to the point that they feared tripping, tipping, falling, or any combination of these, it was expected that they would decline to cross the surface. Not once in the 720 trials did a participant request not to cross a surface, and not once did a participant fail to cross any of the delineators successfully. Additionally, participants were allowed to ask for assistance or support if they felt it necessary; such a request for assistance was made in only two of the 720 trials (one participant, requesting to take the experimenter's arm for two crossings of the trapezoid).

Experimenter Ratings of Crossing Continuously

Using each participant's movement as they traveled over the plain cement as a baseline, observations were made to assess whether participants were able to cross surfaces in a continuous manner. This measure served to identify instances in which the participant needed to engage in attentive effort (e.g., pausing to prepare for a particular movement), instances of things such as crutch tips getting trapped, or instances of a wheelchair rocking back after an unsuccessful initial attempt to cross a raised element. There were no significant differences between the average number of four crossings of each surface in which participants were rated as having crossed continuously (F[1.96, 56.78] = 1.462, $p > 0.05$). The observed rates of crossings judged to be continuous ranged from an average of 3.77 (out of 4.00) crossings of the DWS (94%) to 3.50 crossings of the Trapezoid (87.5%).

Experimenter Ratings of Instability

As participants crossed each surface, an experimenter looked for any evidence of instability. The instability was rated using a three-point scale, with a zero indicating no evidence of any change in stability compared with when they were traveling on the smooth concrete, and a 2 being significant instability (e.g., evidence of a near fall while crossing the surface). A score of 1 was used for everything in between (e.g., any noticeable loss of balance, any visible pitching forward or back, or visible tipping to one side or the other, which was different than any observed when traveling on the concrete). Instability (a score other than zero) was noted in only 10 of 720 crossings of the six delineators (1.5% of all crossings); nine were instances of momentary instability which the participant rather quickly corrected, and there were no falls. ANOVA did not reveal any significant differences between the average instability scores for any of the six delineators (F[1.37, 39.72] = 2.365, $p > 0.05$).

Subjective Participant Assessments

The first two crossings each participant made were of the DWS, and they were asked about their level of stability and any discomfort or pain while crossing. They were later asked to compare their experience crossing other surfaces with their experience crossing the DWS. The participants then made two crossings of each of the delineators. After each pair of crossings, participants were asked whether crossing the surface required any more effort, made them feel any more unstable, or caused them any more discomfort or pain, than when crossing the DWS (questions asked one at a time). A score of zero was recorded if they indicated no more effort/unstable/discomfort, and if they indicated that it was more, they were asked to rate how much more from 1 to 3 (a little bit more, a fair amount more, or a great deal more). The result was a four-point scale from 0 to 3. Participants crossed each delineator twice at each of two different points in the study; they were asked these three questions after each pair of crossings, and their answers to each question at these two points in time were averaged to obtain their final assessments.

There is evidence to suggest that the responses being provided in many cases may not have been valid with respect to the descriptors participants were asked to use (e.g., a fair amount more, or a great deal more), and that asking participants to make a comparison rather than to rate each surface independently, may have biased them toward reporting that they experienced some difference. For example, many participants were observed to have confidently crossed a delineator, doing so quickly and with no evidence of any disruption to their normal travel, nor any observed evidence of instability or discomfort, and then responded that it caused them some amount of greater discomfort or instability then when crossing the DWS. In some such cases, they responded that it caused them a "great deal more discomfort or pain than that caused by the detectable warning" or made them feel "a great deal more unstable" or required "a great deal more effort." Consider that despite responses that a certain surface caused them "a great deal more pain" or made them feel "a great deal more unstable," every participant who was asked to cross the same surface at a later point in the study did so with no observed hesitation. However, having no way to judge valid from invalid responses objectively, all ratings provided by participants were included in the analyses reported here, and thus the means are likely inflated relative to the descriptive terms. Differences in how they rated their experiences with different surfaces is likely informative; however, caution should be used in interpreting the numbers relative to the descriptors (i.e., a little bit more, a fair amount more, a great deal more).

Effort. The mean amount of additional effort reported to cross each surface compared with what it took to cross the DWS did significantly differ for the various delineators (F[2.27, 65.70] = 8.134, $p < 0.05$). The mean scores ranged from 0.37 for the 12-in. corduroy to 1.13 for the trapezoid. Those differences which are significant are between the 12-in. and 24-in. corduroy (0.37 versus 0.67; t[29] = 3.674, $p < .007$), and between the trapezoid and both the 12-in. corduroy and 12-in. FTB (0.45) (t[29] = 3.776 and 3.371, respectively; $p < 0.007$).

Instability. The mean amount of additional instability reported when crossing each surface compared with what was experienced when crossing the DWS significantly differed for the various delineators (F[1.93, 55.86] = 11.669, $p < 0.05$). The mean scores ranged from 0.35 for the 12-in. FTB to 1.22 for the trapezoid. Those differences which are significant are between the trapezoid and all other surfaces: 12-in. corduroy (0.45), 24-in. corduroy (0.62), 12-in. FTB (0.35), and 24-in. FTB (0.62) (t[29] = 4.446, 3.095, 4.521, and 2.983, respectively; $p < 0.007$), and between the 12-in. FTB and 24-in. corduroy (t[29] = 3.002, $p < 0.007$).

Discomfort or Pain. Despite a significant omnibus analysis for the effects of different delineators on the ratings of discomfort or pain (F[2.43, 70.33] = 3.246, $p < 0.05$), no pairwise comparisons were significant when the Bonferroni procedure was employed. The mean ratings of effort ranged from 0.23 for both the 12-in. corduroy and 12-in. FTB, to 0.55 for the trapezoid.

Final Participant Evaluations of the Surfaces. After completing all tasks, participants were asked if they had a preference in relation to which surface should be used as the delineator or which surface (if any) should not be used as the delineator: 37% had no specific preference, 27% preferred the corduroy, 23% preferred the FTB, and 13% selected the trapezoid. When asked if there was one surface they would prefer not to be used as a divider, 23% said any of them would be fine, 7% disliked the corduroy, 7% disliked FTB, and 63% disliked the trapezoid.

Discussion

Considering detection by either long cane or foot, all three alternative surfaces (FTBs, corduroy, and trapezoid) were as detectable to participants with VI as DWS, regardless of width. Each of the three surface alternatives and the DWS were detected on average in more than 94% of trials by participants with VI who used long canes, and the detection rates for all 24-in. wide surfaces (FTBs, corduroy, DWS) and the trapezoid were at or above 90% in the small sample of guide dog users. Participants having MI crossed all surfaces four times, with no observed hesitation or reluctance to cross, and no significant differences were observed in the effects of the different delineators on their crossing independence, continuity of crossing, or stability. There was no evidence to suggest that any of the surfaces would be a barrier to crossing for those with MI. Therefore, any of the surfaces could be selected as a delineator for SBLs at sidewalk level on the two broad criteria of detectability by long cane or foot, which was at least as good as that for DWS, and crossability by people with MI. Therefore, the authors looked to other measures to guide the recommendation.

Participants were significantly more accurate in identifying the trapezoid (mean rate of correct identification was 98.8%) than in identifying the other three surfaces. DWS and bars were often confused with each other. Participants were also significantly more successful in identifying FTBs as bars than identifying the corduroy as bars. Quick and accurate identification of a delineator surface is essential to its effective use; it should indicate to the pedestrian, "Don't cross this surface because there are bikes on the other side." DWS indicate, "There is a vehicular hazard in front of you. If it's a street crossing, prepare to cross the street." FTBs are increasingly used in the U.S.A. and internationally as a guidance surface meaning, "This is a safe path for you to travel; you may cross it, and you may walk on either side."

Because bicycles are essentially inaudible, pedestrians with VI who are in a bicycle lane or whose cane is in the bicycle lane may make no attempt to avoid a conflict. The intrusion of a long cane into the bicycle lane has the potential to cause a cyclist to crash, and cane–bicycle or pedestrian–bicycle collisions may injure either or both individuals. There were significantly more cane intrusions on approaches to 12-in. wide surfaces, including the trapezoid, than to 24-in. wide surfaces.

A majority of all participants having vision disabilities preferred the trapezoid as a delineator, while a majority of participants with mobility disabilities preferred that the trapezoid not be used for a delineator. However, there is no evidence that the trapezoid would be a barrier to crossing by those with mobility disabilities.

Conclusion

The researchers recommended that a raised trapezoid of the design tested in this research be used as a delineator for the SBL at sidewalk level for the Better Market Street project, primarily because of its high detectability, the nearly perfect identification accuracy for this surface, and because it was the surface preferred by a majority of participants with vision disabilities. It is recognized, however, that there will be more intrusions into the bike lane than with the 24-in. FTBs, which performed as well or better on most objective measures. The City and County of San Francisco plan to install 6-in. (152 mm) wide strips of pavers in the same color as the trapezoid on each side of the trapezoid to discourage cyclists from traveling immediately beside the trapezoid.

Additional considerations for recommending the trapezoid instead of the FTB are that the trapezoid on a 12-in. (305 mm) tile requires half as much right of way as the 24-in. (610 mm) FTBs, and the cost of materials for a 12-in. delineator would be less than that for a 24-in.

delineator. It is also likely that a FTB surface will be recommended as a guidance surface in the U.S.A. as it already is internationally, and the trapezoid is readily discriminated from FTBs. It is important that a delineator for use on SBL at sidewalk level be readily distinguished from a guidance surface because the message to pedestrians who are vision disabled is different. The delineator should convey, "Don't cross this indicator because you will be in danger from cyclists," whereas a guidance surface should convey, "You can safely follow this surface, and you will not be in danger from cyclists if you cross it."

Moreover, the trapezoid at a height (0.75 in., 19.05 mm) three times that of the FTBs (0.2 in., 5.08 mm) was judged by many to "look" more like a barrier than the FTBs, despite the evidence that it is not a barrier even to people having MI. It is expected that the trapezoid will be more likely to discourage both pedestrians and cyclists from crossing the delineator.

The trapezoid surface used for the research was slip resistant and had narrow channels for drainage. Any trapezoidal surface used as a delineator needs to be slip resistant and to provide for drainage.

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The authors acknowledge the City and County of San Francisco and in particular San Francisco Public Works, the San Francisco Municipal Transportation Agency, the Mayor's Office on Disability and the Port of San Francisco. The authors also acknowledge Arup for leading the consultant team conducting the research and are grateful for the participation of people with disabilities in the San Francisco Bay Area.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: B.L. Bentzen, A.C. Scott; data collection: A.C. Scott, L. Myers; analysis and interpretation of results: A.C. Scott; draft manuscript preparation: B.L. Bentzen, A.C. Scott. All authors reviewed the results and approved the final version of the manuscript.

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Data Accessibility

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San Francisco Public Works

Better Market Street Delineator

Summary Report

Issue | October 26, 2020

Job number 267200-00

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Contents

1 Executive Summary

Plans for Better Market Street include a sidewalk-level bikeway that will improve conditions for bikes. It also introduces challenges for more vulnerable sidewalk users by introducing new opportunity for conflicts between bicyclists and pedestrians.

Detectable surfaces in the built environment typically serve to warn of severe changes in infrastructure (e.g., the truncated domes that warn of train platform edge) or guidance along a route (e.g., long parallel bars that indicate the route to a train platform).

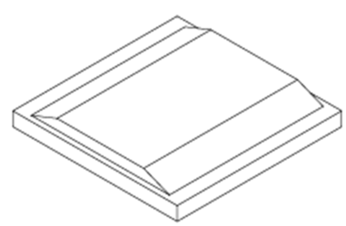
The Better Market Street Delineator project rigorously tested several geometry options for suitability as a delineator between bikeway and sidewalk that is highly detectable by vision-disabled users and poses no impediment to mobility-disabled users. This material should also be clearly distinguishable from other detectable surfaces and as narrow as possible.

The literature review identified several surfaces and widths to test and a testing area was identified and constructed in the Pier 38 building. Vision-disabled participants were asked to detect and identify the surfaces when approaching from different angles. Mobility-disabled participants were tested for their ability and comfort crossing the surfaces. All participants were asked for their subjective opinions on the suitability of the different surfaces. Bicyclists were also asked to ride across the surfaces and provide qualitative feedback.

Testing determined that a trapezoidal geometry (see Figure 1) is the best option, as it is both detectable and identifiable by vision-disabled users and does not pose an impediment to people using mobility devices.

For vision disabled participants, 24-inches of the flat-topped bars and 12-inches of the trapezoid were the two best-performing surfaces across all metrics. Flat-topped bars are currently used as a guidance surface locally and globally and are likely to be adopted as a standard for the US in the future. Consequently, they may not be easily distinguishable as delineating surface, too.

Figure 1 – Recommended surface



The trapezoid geometry was demonstrated during testing to be both highly detectable from any angle and highly discriminable from other surfaces. However, cane intrusions from vision-disabled participants were more likely with the trapezoid. Thus, it is recommended that the installation of the trapezoid material include additional buffer treatment to reduce the risks posed by cane intrusion into the bikeway.

2 Introduction

Better Market Street (BMS) is an initiative of the City and County of San Francisco intended to recognize the importance of Market Street not only as a corridor for the movement of people and goods, but also as a public space. Several significant infrastructure changes are planned to more safely accommodate all people on the street, including upgrading the existing bike facility to become a bikeway at sidewalk level between Octavia and 8th/Hyde/Market Streets. This will provide a safer environment for bikes by vertically separating bikes from the nearby bus lanes and loading vehicles. Similar raised bikeways are planned as part of BMS from 8th/Market to the Embarcadero.

Figure 2 – Example section of sidewalk and bikeway (Better Market Street, 2019)

Figure 3 – Illustration of loading interaction with bikeway (Better Market Street, 2019)

To provide a safe environment for all users, the City has proposed a physical element to separate the bikeway and the sidewalk However, there is no standard for a detectible delineation between bicycle and pedestrian space when the two functions are at the same grade (i.e., without curb separation). The limited design options for detectable separation for at-grade parallel movements has been an issue on numerous San Francisco projects (Seventh Street, Shipyard/Hunters Point, and Treasure Island).

A previous pilot of a partially raised bikeway on Market Street used tactile, high-visibility truncated domes ("domes") to separate bikeway and sidewalk (Figure 4). This treatment was initially proposed along the entire BMS raised bikeway.

Figure 4 – Google Streetview Imagery of Pilot near Market and Gough Streets (2018)

However, given the standard use of domes at intersections and abrupt grade changes (e.g., the edge of train platforms), a distinct material is preferred to denote the edge of a bikeway. In particular, feedback from local and national stakeholder groups has advised that domes should be substituted with a different type of separation when outside intersection crossings and platform drop-offs. In October 2017, the Federal Highway Administration also released a draft document that describes how tactile domes shall only be used at vehicular crossing points, not along the entirety of street blocks.

It is important that BMS be perceived as best-practice infrastructure and not as just a pilot. The human factors testing of delineator material was intended to facilitate this goal by conducting due diligence on potential alternatives for separation between bikeway and sidewalk with thorough research, testing, and evaluation for those with vision or mobility disabilities.

3 Human Factors Test

The human factors test aimed to identify the most suitable delineator between the bikeway and sidewalk along Market Street. To ensure an improved environment for all road users on Market Street, the delineator between sidewalk and bikeway must balance comfort and detectability for all users. The chosen delineator should be easily registered and clearly distinguishable from the domes widely used to indicate vehicle crossings or platform edges.

Minimal research exists evaluating the suitability of different delineators for both vision- and mobility-disabled pedestrians. The testing team identified no existing research on the detectability of delineators when approached by vision-disabled pedestrians at a narrow angle (as would likely happen on a sidewalk adjacent to a bikeway). However, the literature review did identify several surfaces and widths to test based on international precedent and geometry.

The goal of the human factors test was to identify a delineator that met the following criteria:

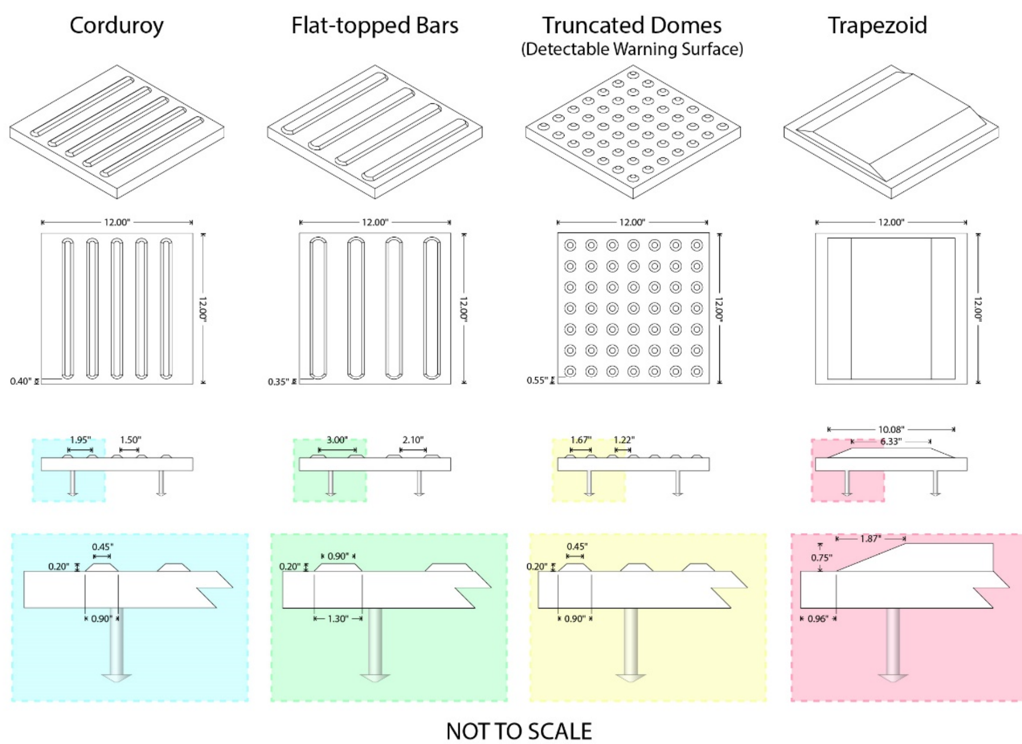
- Easily distinguishable from other detectable surfaces, to clearly communicate delineator meaning;
- At least as detectable as truncated domes, to keep people on the correct side of the delineator;
- Narrowest effective width, to reduce ROW requirements; and
- Meets City needs regarding cost, availability, color, durability, and ease of installation.

Testing also considered discouragement of crossing by bicyclists.

3.1 Test Methodology

Based on the literature review, three textures were chosen for testing: corduroy bars, flat-topped bars (also “directional”), and a trapezoid. The corduroy and flat-topped bars were tested in both 12-inch and 24-inch widths; the trapezoid was tested in a 12-inch width. The installed textures, illustrated in Figure 5, included three potential delineators and a standard detectable warning surface already in use throughout San Francisco (truncated domes). A suitable testing area was identified and constructed in the Pier 38 building.

Figure 5 – Tested surfaces



Participants included:

- 31 people with little or no vision (people with low vision were not included), who used canes (three different types of tips) or guide dogs;[1] and
- 33 people with mobility impairments, who used manual or power wheelchairs, a power mobility scooter, four- or two-wheel walkers, crutches, canes, or walked unassisted.

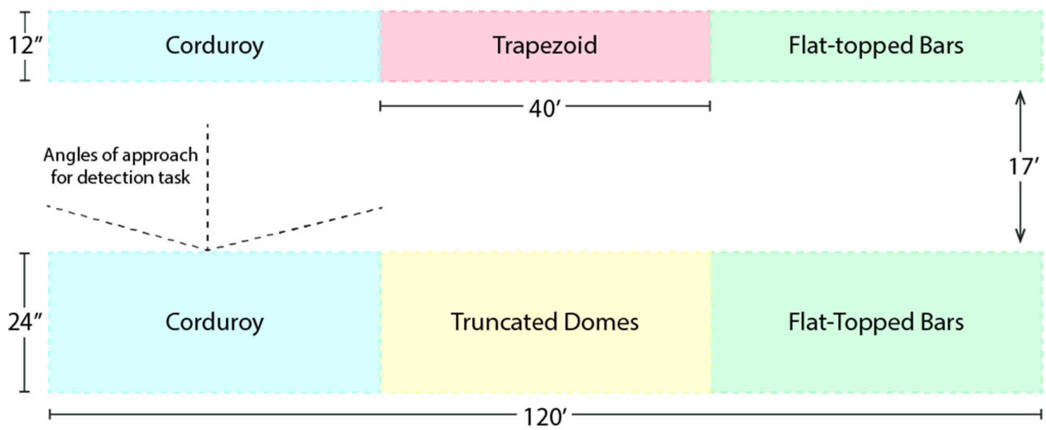
[1] Guide dogs often do not guide normally during focused research testing, as they are often confused by the repetitive nature of the tasks; an alternative method (the “Juno” technique) was employed with assistance from Guide Dogs for the Blind, and participants who use guide dogs detected and identified the surfaces with their feet.

Vision-disabled participants completed three tasks as shown in Figure 6:

- Surface detection when approaching from angles between 25°-90°
- Identification of the surfaces as truncated “domes,” “trapezoid,” or “bars” (which included corduroy and directional/flat-topped bars).
- Following each surface for 40-feet (as though walking down a sidewalk) without losing contact with the surface

Mobility-disabled participants were asked to cross each surface four times and rate the comfort and ease of crossing.

Figure 6 – Layout of testbed



Separate from the testing, bicyclists were also asked to provide a subjective evaluation of the surfaces; these results are discussed in Section 4.

Participants’ objective and subjective interactions with the potential delineator materials were compared to their experience crossing the domes. The comparison with domes ensured that the delineator surface was clearly distinguishable from the domes (to prevent confusion on the street) and that the delineator surface is highly detectable (the commonly found domes served as a baseline for detectability). The “Detectable Warning” domes tested were 24-inches wide.

Surfaces were installed in 40-foot sections to enable vision-disabled participants to imitate walking along a sidewalk without losing track of the delineator; the corduroy and flat-topped bars were tested in both 12- and 24-inch-wide surfaces (see Figure 6).

3.2 Objective Test Results

Data collected about the vision-disabled participants' three tasks included:

- Detection of the surface (approaching from both perpendicular and acute angles)
- Cane or foot intrusion into the "bike lane" (i.e., cane or foot traveling across and beyond the surface by more than six inches)
- Identification of surface type

Data collected about the mobility-disabled participants' surface crossings included whether:

- Participants fully crossed the surface;
- Crossings were continuous, or if participants hesitated or readjusted prior to crossing;
- Any instability was noted during the crossing (e.g., adjustment in balance or device wobbled); and
- Participant required assistance to prevent a fall.

Table 1 shows the average results of participant tests for different testing criteria, for both vision and mobility testing.

Table 1 – Average test results for vision and mobility tests

Average of trials that achieved:[2]	Truncated domes	Trapezoid *(recommended surface)*	Corduroy		Flat-topped bars	
Vision-disabled testing						
Detection of delineator (cane or foot)	98.1%	99.1%	95.7%	95.2%	100%	93.3%
Failure to detect delineator	1.0%	1.0%	2.4%	4.4%	0.0%	4.4%
Correct identification of surface type	79.5%	98.8%	76.2%[3]		87.5%	
Rating of confidence in identification of surface type (from 0 to 3)	2.42	2.94	2.43		2.59	
Mobility-disabled testing						
Completed crossing	100%	100%	100%	100%	100%	100%
Discontinuity in crossing (e.g., paused to readjust, hesitated)	94.2%	87.5%	88.3%	93.3%	91.7%	92.5%
Average rating of instability (from 0 to 3)	0.01	0.06	0.03	0.00	0.00	0.00
Any instability while crossing	0.8%	5.0%	2.5%	0.00%	0.00%	0.00%

3.3 Preference Testing

During human factors testing, participants were asked about their preference for different surfaces. Vision-disabled participants strongly preferred the trapezoid (58.1%), though 19.4% did not think it should be used.

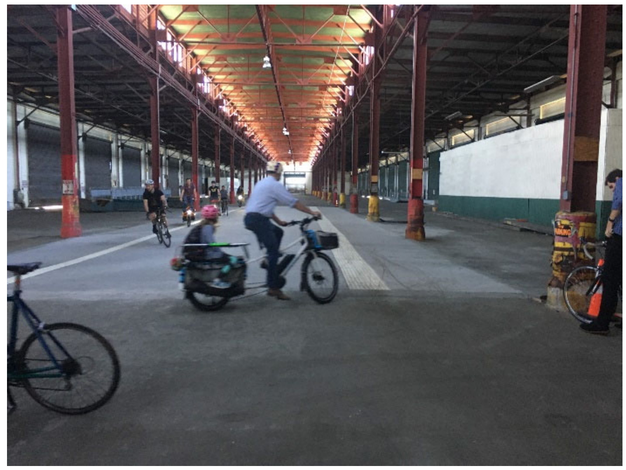
As a group, mobility-disabled participants more conclusively expressed a preference against the trapezoid (63%), possibly because crossing it required more effort and increased feelings of instability and discomfort. However, all mobility-disabled participants successfully crossed all surfaces, including the trapezoid.

[2] For tests that included perpendicular (90°) and angled (25° - 45°) crossings, this table shows the average of both perpendicular and angled results.
[3] Test participants were asked to identify surface texture only, not surface width, so results for corduroy and flat-topped bars do not distinguish between widths here.

4 Bike User Review

The planned Market Street bikeway is expected to improve bicyclist safety. However, a sidewalk delineator should still allow emergency egress from the bikeway and access to street furniture (e.g., bike racks).

Figure 7 – Bicyclists riding across different surfaces at the testing site

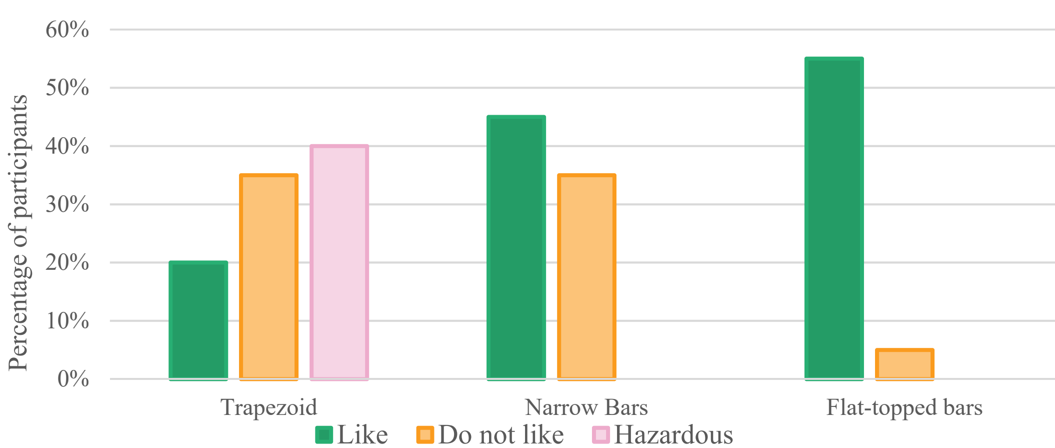


Following the formal testing period described above, 20 bike users from the San Francisco Bicycle Coalition and City staff provided qualitative feedback about riding bikes across the surfaces, both wet and dry.

Testing consisted of riders on different bike styles circling the testbed while crossing back and forth over the surfaces (see Figure 7). While a few users reported minor instability when crossing wet surfaces, none experienced significant issues. Bicyclists expressed some concern about all geometries and one group had particular reservations about the trapezoid.

As shown in Figure 8, all surfaces were liked to some extent by the testing group, although the trapezoid was the least-liked surface and the only one rated as "hazardous" by the bicyclists. Concerns expressed by bicyclists about this surface may actually make the trapezoid more conclusively suitable: it did not cause any slips or falls, despite the impression of being hazardous. This suggests it may effectively discourage bike crossings while still allowing for access to the sidewalk to dismount safely off the bikeway and access bike racks.

Figure 8 – Bicyclists' subjective review of surfaces



5 Recommendation

Arup recommends using the trapezoid surface as a delineator between bikeway and sidewalk. The human factor testing indicates that the trapezoid is clearly detectable and identifiable by vision-disabled pedestrians. It is the most preferred surface for these participants. Testing shows mobility-disabled pedestrians and bicyclists were able to cross the surface with no difficulty. Both groups liked this delineator least, suggesting it will effectively discourage unnecessary crossings.

Additional considerations supporting the recommendation of the trapezoid as delineator include:

- It is important that the chosen delineator surface be clearly understood as a delineator, and not as a guidance surface (flat-topped/directional bars are likely to be recognized as standard for this purpose in the future) or as an indicator of vehicle activity or crossings (typical use of truncated domes). The trapezoid meets these criteria.
- The trapezoid is taller than the other tested surfaces, which will help communicate that it is a barrier to all pedestrians, not just those with vision disabilities.
- The trapezoid requires only 12-inches to be effective, half the right-of-way (ROW) as the 24-inches tested treatments. However, as cane intrusions are more likely with the trapezoid than with the 24-inches flat-topped bars, additional ROW and possibly other design elements to buffer bicyclists from the sidewalk are suggested along narrow segments of the bikeway.

The full human factors recommendations, testing methodology, and literature review are included in the final testing report in Appendix A.

Appendix A– Human Factors Report

BETTER MARKET STREET

Detectable Separation between Sidewalk and Sidewalk-Level Cycle Track Study:

Literature Review and Human Factors Testing

Billie Louise Bentzen, Alan Scott, and Linda Myers
July 31, 2019

LITERATURE REVIEW

Background
Sidewalk-level cycle tracks (SBL) are a relatively recent phenomenon in the US, and it is recognized that they are a challenging environment, especially for pedestrians who are blind or who have low vision. There is no US or international standard for a delineator between the pedestrian and bicycle sides of a SBL at sidewalk level, but several US jurisdictions have installed tactile walking surface indicators (TWSIs) that are intended to enable pedestrians who have vision disabilities to determine and to remain on the pedestrian side of a SBL at sidewalk level. See Figure 1 A and B.

Figure 1 A 6 inch wide raised bar delineator used in SBLs in Seattle was subjectively evaluated by pedestrians with vision impairments as too narrow (panel A). It is being replaced with a 12 inch wide raised bar delineator produced in methyl methacrylate (MMA; panel B).

To function effectively as a delineator for sidewalk level SBLs, a delineator must be readily detectable by pedestrians who have vision disabilities, both from a 90 degree approach and from a narrow angle approach. Pedestrians may be exiting a building onto a SBL and wanting to know the limit of the pedestrian way; in this case they are likely to be approaching the delineator from approximately 90 degrees. They may be walking on the pedestrian side of the SBL, and be attempting to stay on that side, much as they would walk down any sidewalk that is bounded by a curb, landscaping, or a building. However, it is common that pedestrians who have vision disabilities veer somewhat as they walk. Therefore, they may suddenly come to a delineator beside them, approaching it unexpectedly from a very narrow angle of approach, need to quickly recognize it, and adjust their direction of travel. Having found the delineator, some of them will choose to simply follow the delineator as a boundary, rather than walking in more open space on the pedestrian side.

While a SBL delineator is not intended to be used in a location where it would regularly need to be crossed by people having mobility impairments, it is nonetheless important that it not be a barrier, that is, that it be crossable by people with mobility impairments. A person having very limited mobility, including frail elders who travel with an assistant, may choose to park or be dropped off as close as possible to a destination along a street having a sidewalk level SBL. In this case, they will need to cross the bike lane, cross the delineator, and then continue across the sidewalk to their destination.

A truncated dome detectable warning surface (DWS) has been found in US and international research to be highly detectable, but to require a depth (in the direction of travel across it) of 24 inches to enable travelers with little or no vision to detect it, and come to a stop without going beyond it (Bentzen et al., 1993; Bentzen et al., 1994; Bentzen et al., 2000; Böhringer, 2007; Fujinami et al., 2005; Gallon et al., 1991; Hughes, 1995; McGean, 1991; Murakami et al., 1991; National Institute for Technology Evaluation, 1998 & 2000; O'Leary et al., 1996; Peck & Bentzen, 1987; Ratelle et al., 1995). The DWS is the only TWSI in the US that has repeatedly been shown to be highly detectable when approached from 90 degrees. Therefore, it is standardized for warning pedestrians with vision impairments that they are coming to the end of a pedestrian way and approaching a vehicular way, such as at a curb ramp or transit platform. An SBL delineator needs to be as effective as the truncated dome warning surface in terms of the ability of pedestrians with vision disabilities to detect and stay on the correct side of it, as well as to follow it. It needs to be readily discriminable from truncated domes. It also needs to be crossable by people with various mobility impairments.

There has been some research, especially in the UK and Japan (Childs et al, 2010; Fujinami et al., 2005; Gallon et al., 1991; Murakami et al., 1991; National Institute for Technology Evaluation, 1998 & 2000; Savill, et al, 1997; *Testing proposed delineators to demarcate pedestrian paths in a shared space environment,* 2008; Williams, 1987), that has found a few other surfaces to be highly detectable when approached at 90 degrees, and to be able to be followed quite accurately, without crossing over the surface to the other side. However, no research has been identified that examines the ability of pedestrians with vision disabilities to detect potential delineator surfaces when approached from a very narrow angle, such as would be the case if they were walking on a sidewalk and gradually veered toward the cycle track.

US research and experience has found the DWS to be crossable by people having mobility impairments (Bentzen et al., 1993; Bentzen et al., 1994; Hauger et al., 1996; Hughes, 1995), though it is disliked by many. UK research has identified potential delineators that are (and are not) crossable by people with mobility impairments (Childs et al, 2010; Savill, et al., 1997; *Testing proposed delineators to demarcate pedestrian paths in a shared space environment,* 2008; Williams, 1987).

Research on delineators

The only research specifically on delineators appears to be that done in the UK over a number of years (Childs et al, 2010; Savill, et al, 1997; *Testing proposed delineators to demarcate pedestrian paths in a shared space environment,* 2008; Williams, 1987).

Williams (1987) identified a raised trapezoidal surface that was detectable and usable by pedestrians with vision disabilities as a delineator between bicycle and pedestrian sides of a sidewalk level SBL. In 1998, this became the recommended delineator for sidewalk level SBLs in the UK (*Guidance on the use of Tactile Paving Surfaces*, (1998).

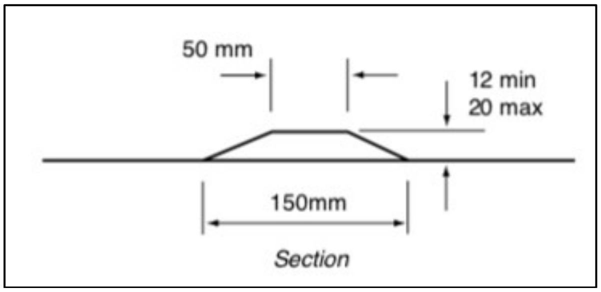


Figure 2 Trapezoidal delineator

Further research on delineators was reported by Savill et al. in 1997. The limited experience with the raised trapezoidal strip, by that date, indicated that pedestrians with vision disabilities were having difficulty staying on the correct side of the trapezoidal delineator. The delineator was typically manufactured from thermoplastic, which had a tendency to slump in height and loose its profile. Advocates also surmised that the raised trapezoid was not as easy to detect with long canes having a roller ball tip, which was becoming common, instead of the "pencil" tip that long been standard.

Savill et al. (1997) conducted research comparing effects of ten potential central delineators for pedestrians who had vision disabilities and cyclists. Five potential delineators were trapezoidal in cross section. All ten delineators were 150mm wide. The trapezoidal delineators were either 12mm or 20mm in height, and were constructed of thermoplastic, cast concrete, brick, or a hot applied polymer modified bitumen-based compound incorporating graded rubber and granite aggregates, reinforced with metal and glass fibers that was formed by hand using a mold. Two surfaces were versions of raised bars perpendicular to the direction of travel; one surface was a rough, flat, raised bar; one was an inverted T shape; and one was a raised, domed bar, 45mm high.

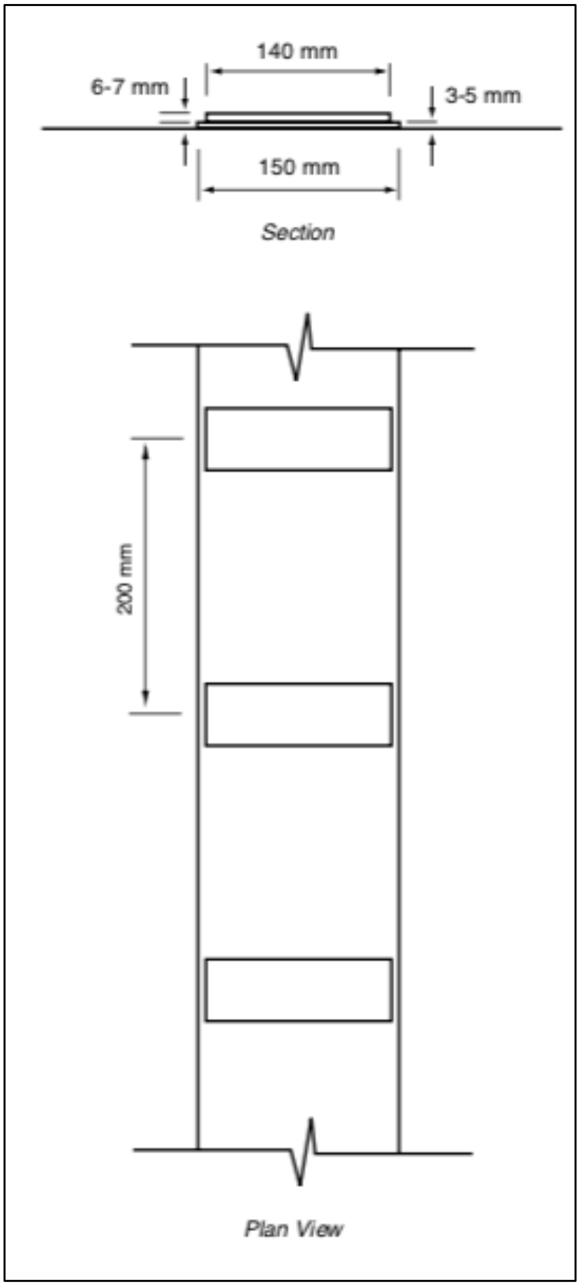


Figure 3 Preformed ribs laid on top of a thermoplastic screed, as used for rumble-strips

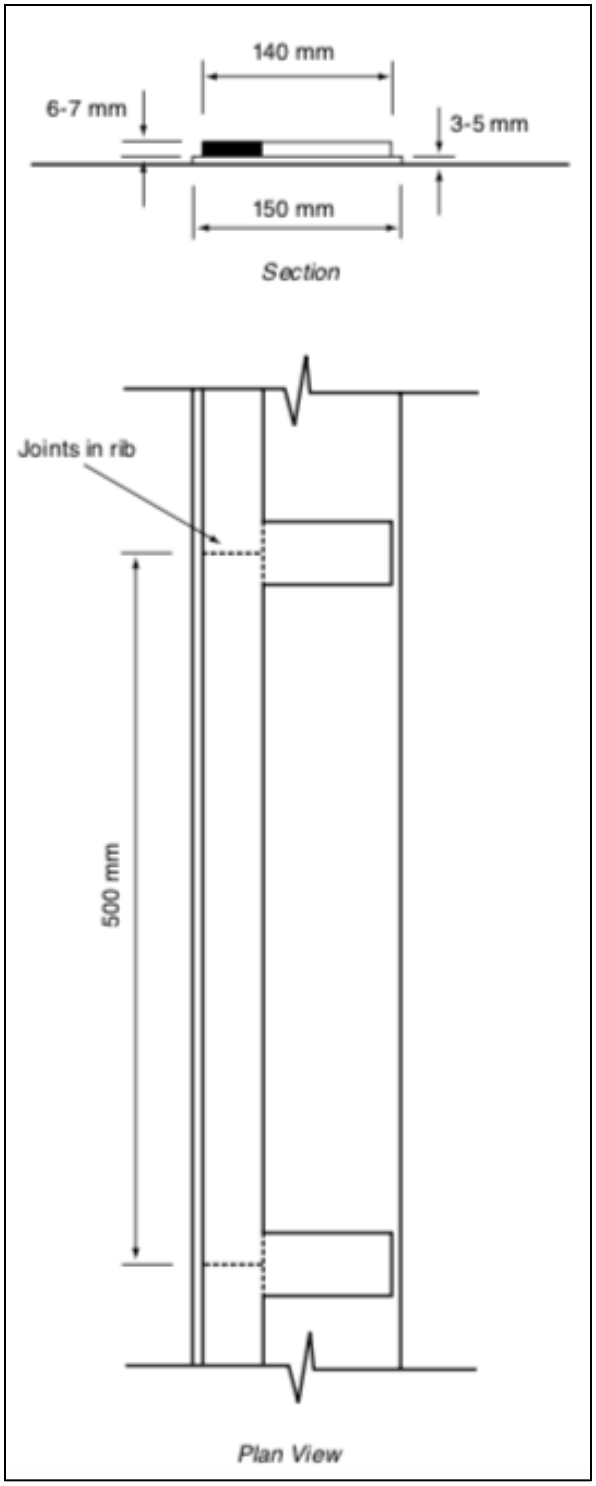


Figure 4 Longitudinal raised bar on one side, with orthogonal intersecting bars; made of preformed bars laid on top of a thermoplastic screed.

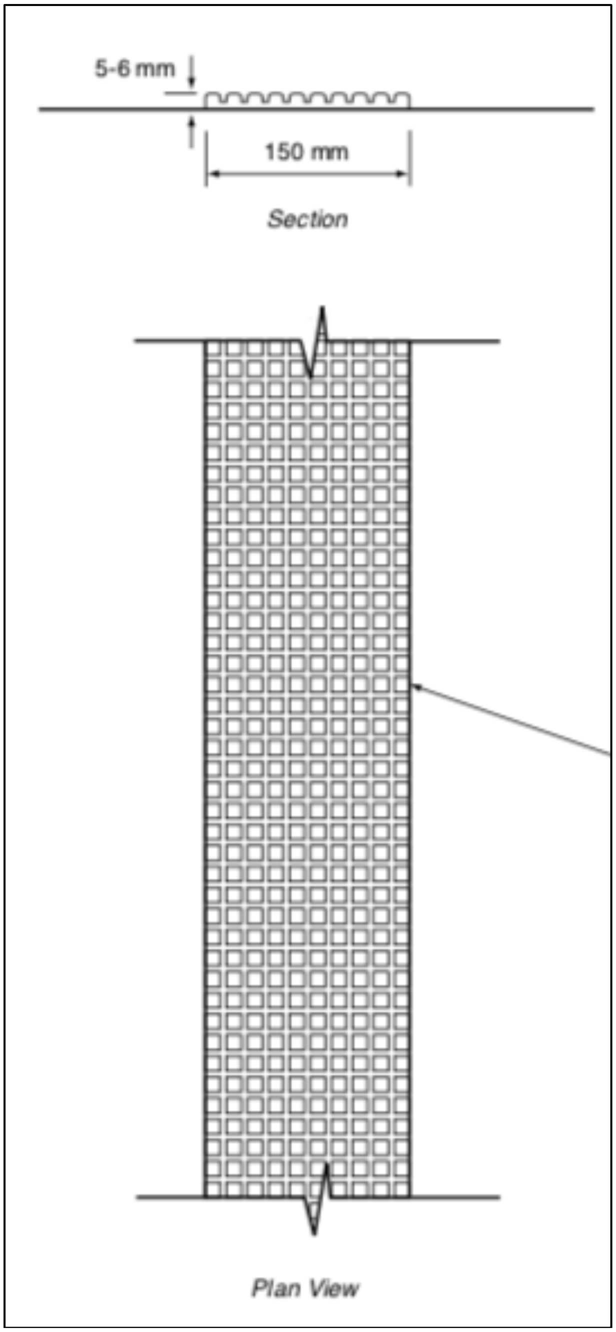


Figure 5 Single rough-textured bar made of a two-component methacrylic road cold plastic that was formed by rolling.

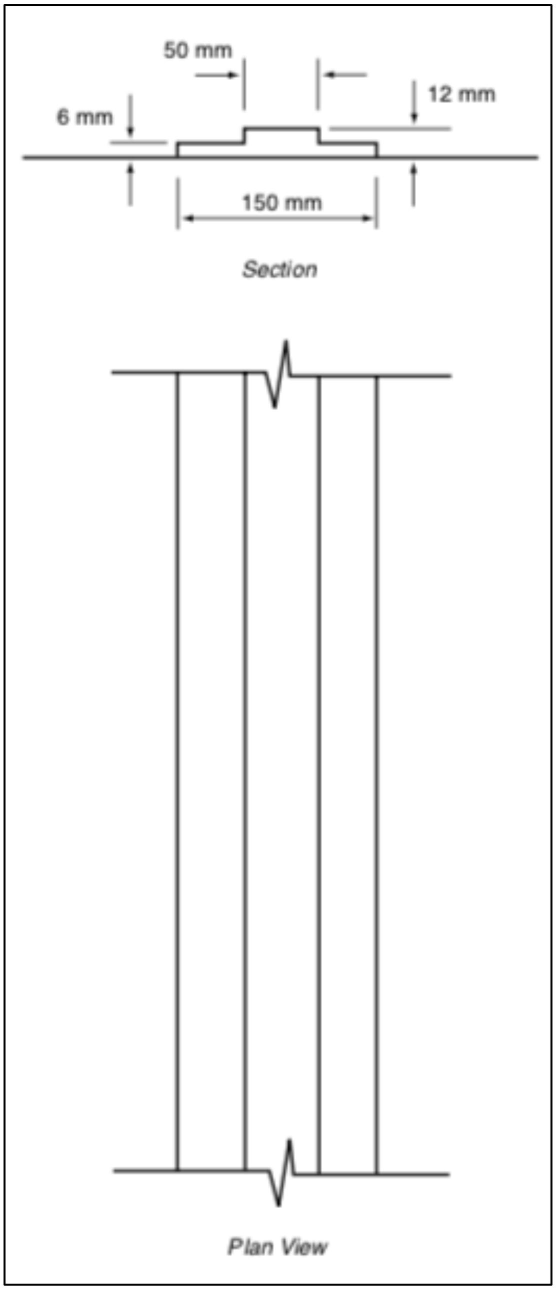


Figure 6 Inverted T shape made of a hot applied polymer modified bitumen-based compound incorporating graded rubber and granite aggregates, reinforced with metal and glass fibers.

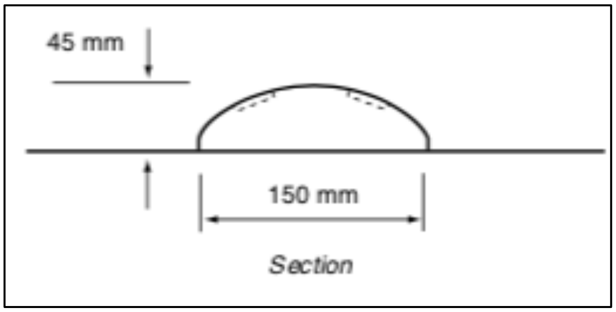


Figure 7 Domed preformed strip made of rubber, recycled from vehicle tires, with a binder added to the rubber and the mixture molded under pressure, incorporating a metal strengthening bar to obtain the finished profile.

Forty-eight participants having vision disabilities completed the experiment; 27 had little or no vision; 21 had some useful vision. They all used a long cane having either a roller ball or a pencil tip, as they preferred. They were positioned a meter back from the beginning of each strip, asked to locate it, and then follow it for a distance of 20 meters. The test was completed with the delineators both to the right and to the left of participants. Results from both sides were similar. The 20mm high trapezoidal strips made of concrete and of the bitumen-based compound were located by all participants regardless of level of vision and cane tip. However, participants who used canes with a roller ball tip had slightly more difficulty following most of the strips. Detection and following were worse for all other surfaces except the domed strip. More participants preferred the two 20mm high trapezoidal strips made of concrete or a bitumen-based compound than any other strips.

Forty-two cyclists using either touring bikes or mountain bikes crossed the strips from two directions; when riding along side each strip, and from a 90 degree approach. The two 20mm high trapezoidal strips preferred by participants with vision disabilities were judged to be less safe than all other surfaces but the domed surface, which was not evaluated by cyclists.

Savill et al. (1997) concluded that the trapezoidal profile was the best compromise for pedestrians with vision disabilities and cyclists and recommended that it be 20mm high.

By 2006, shared spaces were appearing in the UK, and research undertaken by Guide Dogs for the Blind (Guide Dogs) documented that safety, confidence, and independence of visually disabled pedestrians was undermined by shared spaces (Guide Dogs for the Blind, 2006). Guide Dogs then commissioned research to identify a tactile walking surface for use in shared spaces that was highly detectable by pedestrians with vision disabilities and also negotiable by persons with mobility impairments (*Testing proposed delineators to demarcate pedestrian paths in a shared space environment: Report of design trials conducted at University College London Pedestrian Accessibility and Movement Environment Laboratory,* 2008). Results of this laboratory research are not limited to shared streets, but are equally relevant with regard to SBLs.

Thirty participants who were blind or who had low vision, and 15 people with mobility impairments participated in the research, which included 2 surfaces to be installed on a level surface, and 5 surfaces that involved curbs or slopes of different designs or angles (see Figure 8). The results for the two surfaces appropriate for installation in a level surface are relevant to consideration of surfaces to be tested in the BMS project.

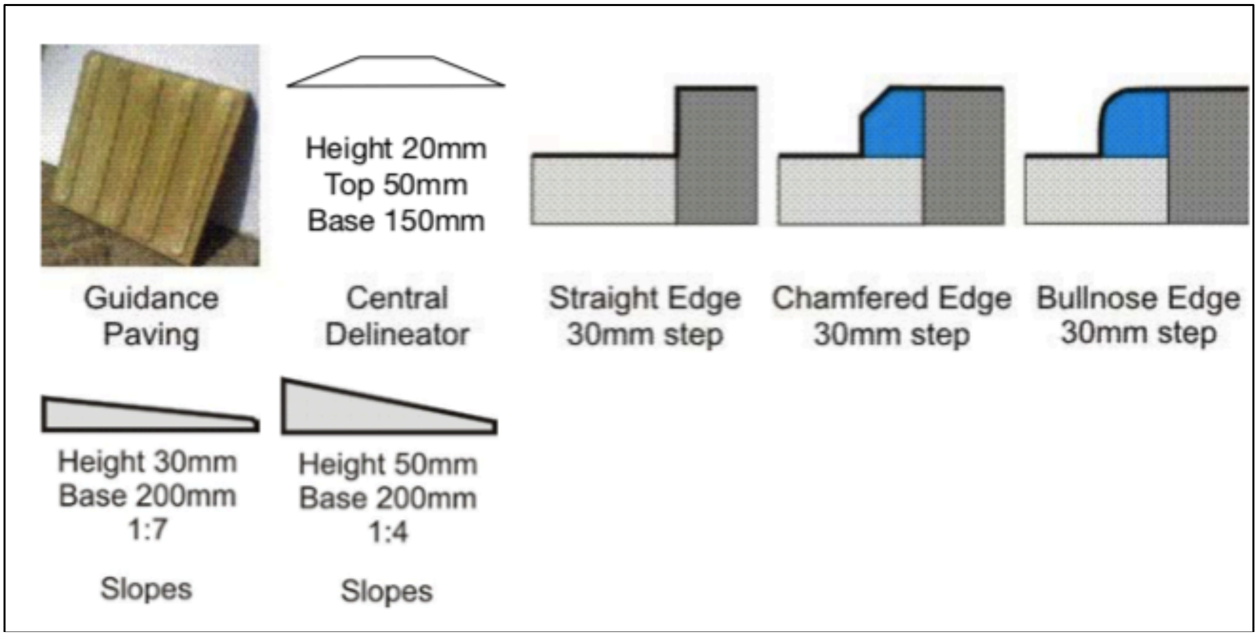


Figure 8 The seven surfaces tested in *Testing proposed delineators to demarcate pedestrian paths in a shared space environment: Report of design trials conducted at University College London Pedestrian Accessibility and Movement Environment Laboratory,* 2008. The edge and slope surfaces were tested when approached and followed from both above and below the surfaces.

The two relevant surfaces for guidance in shared spaces were the "central delineator" trapezoidal strip investigated by Savill et al., which had been the recommended method of delineating SBLs in the UK since 1998 (*Guidance on the use of Tactile Paving Surfaces*), and "guidance paving," which was recommended in the same publication for use where there is no traditional guidance such as a curb, landscaping or a building line. The guidance surface was comprised of raised, flat-top bars running in the direction of pedestrian travel. The bars were 5.5mm (±0.5mm) high, 35mm wide at the base, and spaced 45mm apart (see Figure 9). The surface installed for testing was 400 mm wide. A similar surface of raised flat-top bars is specified in California Title 24. The bars are 5mm high, the width at the bottom is 33mm, but the spacing is somewhat wider, at 76.2mm.

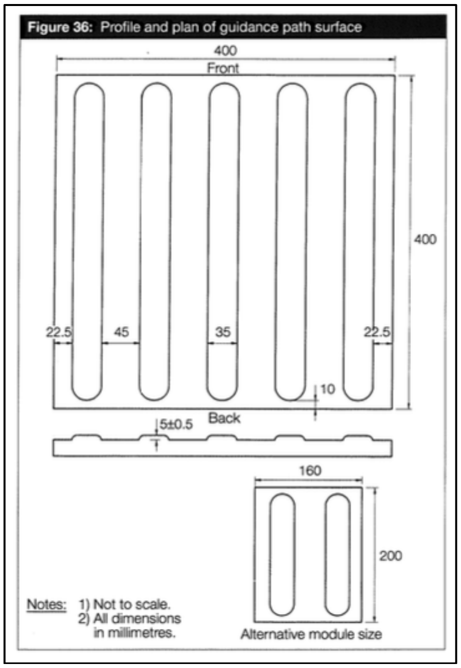


Figure 9 UK Guidance Surface

Thirty participants who were visually disabled were asked to approach, detect, and then follow each delineator for two minutes. They completed the experiment using either a long cane, dog guide, a human guide, or no mobility aid. Participants were guided to within 2m of each delineator, and asked to locate it, as if they were leaving a building intending to find a delineator to lead them to the left or right. They approached each of the curbs and slopes from both above and below. Participants were then asked to find each delineator again, and follow it as long as they could, within two minutes. Most of the participants using a long cane had roller tips that alerted them when they contacted the delineators. Participants using dog guides or human guides detected and followed the delineators under foot. Participants using no aid detected the delineators using some combination of foot and low vision. Some participants who normally travel with dog guides used long canes or human guides, as the dogs were confused by the task.

Performance measures were detection and effort as indicated by travel speed and Total Heart Beat Index (TBI) in comparison with unobstructed travel on adjoining smooth concrete pavers. After detecting and following each delineator, participants rated it for ease of detection and following.

The trapezoidal central delineator was found to be the easiest to detect of all 12 surfaces, including the various curbs. It also had the highest ratings of all the surfaces for detection, and for confidence and safety for navigation. Some participants suggested that it might function even better if it was wider, if the corners were rounded, and if it had good visual contrast with the adjacent surface. The raised bar guidance surface was also detected by all participants with vision disabilities, and was rated almost as highly as the central delineator for detectability, and for confidence and safety in navigation.

Some participants with vision disabilities walked with one or both feet on both the trapezoidal delineator or the guidance surface when following them. The long canes of some participants who walked with their feet on either surface over shot the surface, and the cane intruded into the space beyond the surface.

Fifteen participants having various mobility impairments completed the experiment; 11 used a manual wheelchair, 2 used a cane, 1 used a rollator walker, and 1 used no mobility aid. Participants with mobility impairments were asked to cross each delineator multiple times; the curbs and slopes were crossed from approaches both above and below. Success or failure to cross each surface was recorded, TBI was measured in comparison with baseline travel on the adjoining surface of relatively smooth concrete pavers, and participants rated each surface for ease of crossing and "acceptability" in a shared street environment.

All participants having mobility impairments were able to cross both the trapezoidal delineator and the guidance surface comprised of flat-top bars. 87% of the mobility impaired participants rated the trapezoidal delineator easy to cross, but only 60% found the guidance surface easy to cross. Only 53% of mobility impaired participants considered either the trapezoidal delineator or the raised bars acceptable to be acceptable for guidance in shared spaces. The only surface that mobility impaired participants were all able to cross, and that was rated higher in terms of acceptability was a 30 mm slope (1:7).

The report of this research concluded that the trapezoidal delineator was a good choice but that further research should be undertaken, possibly widening the delineator and rounding the edges. The raised bar guidance surface was recommended only to indicate a path for following, but not a boundary indicating the limit of a "safe space."

Further research on shared space delineators was undertaken by Childs et al. in 2010. This time 15 delineators were tested. Some were tested at both 400mm and 800mm widths, and some were tested on slopes. A "corduroy" surface of rounded bars (see Figure 10), as well as the guidance path of flat-top bars used in the previous research were tested both when oriented parallel to the crossing direction and perpendicular to the crossing direction (i.e. parallel with the direction of travel along a sidewalk). The trapezoidal central delineator 20mm high with a top width of 50mm and a base width of a 150mm was modified to provide gaps for wheels (see Figures 2 and 11).

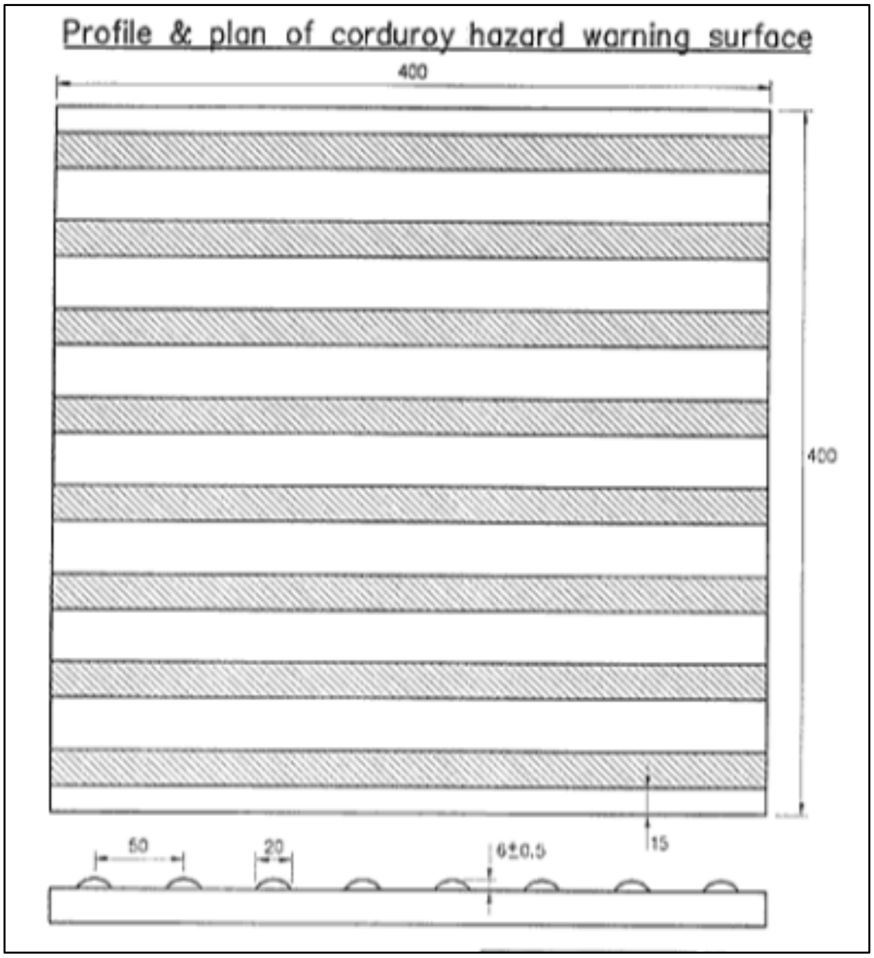


Figure 10 Profile and plan of corduroy surface.

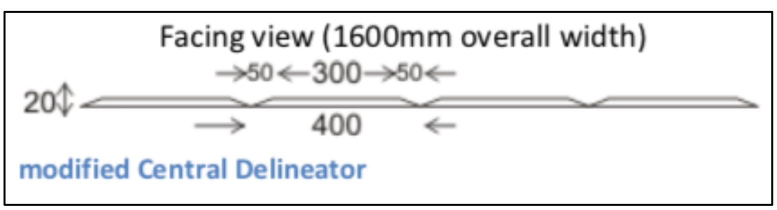


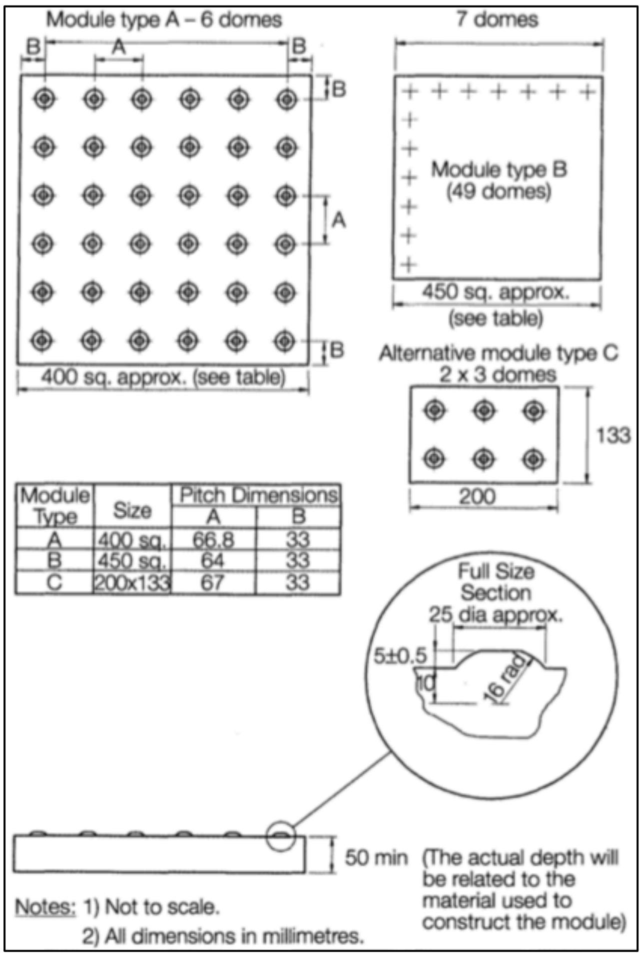
Figure 11 Side view profile, in direction of travel, of modified trapezoidal central delineator.

The experiment was done in four iterations, with six surfaces tested each time by participants with vision disabilities and participants with mobility impairments. This meant that results of testing in each iteration could be used in selection of surfaces for the next iteration.

In all, 24 surface/width/orientations were tested. Twenty-five to 29 participants with vision disabilities completed the experiment each time, and 14 to 22 participants with mobility impairments completed the experiment each time.

No curbs were tested this time. Each surface was produced on a 400mm paver, the standard paver size in the UK, and all surfaces were produced in either concrete or natural stone. Each surface was just 1600mm long. This research required that participants with vision disabilities detect each surface from approaches at 90 degrees and 45 degrees; surfaces were not followed. Participants with mobility impairments were required to cross each surface. After detecting or crossing each surface, each participant was asked to rate it on a 10-point scale for ease of detection or ease of crossing.

The first iteration included "blister paving" at 400mm wide, as a baseline. Blister paving is a truncated dome surface that is standard in the UK to indicate the location of a street crossing (see Figure 12). The geometry of blister paving (base diameter 25mm, center spacing 64mm, height 5mm) is similar to that required by California Title 24 (base diameter 22.9-23.4mm, center spacing 58-61mm, height 5mm) and is within the range permitted by ADAAG 2010 and ISO 23599. It also included the modified trapezoidal central delineator at 20mm height. Results for these surfaces can, thus, be compared with results for other surfaces. A subsequent iteration included blister paving at 800mm wide.



Module Type	Size	Pitch Dimensions A	Pitch Dimensions B
A	400 sq.	66.8	33
B	450 sq.	64	33
C	200x133	67	33

Figure 12 UK "blister paving"

Results will be discussed for level surfaces only, in comparison with the blister surface, as these are most relevant to Better Market Street. First, it is important to note that the bister surface at 400mm (15.7 inches) wide was not detected as well or rated as easy to detect as the blister surface at 800mm (31.4 inches) wide. Failure to detect rate for the 400mm blister paving was 19% for participants with vision disabilities, who also rated it harder to detect than 800mm wide blister paving. Failure to detect rate for blister paving at 800mm width was only 1%. No participants with mobility impairments failed to cross the blister paving at either width.

11% of participants with vision disabilities failed to detect the trapezoidal delineator and it was also rated as harder to detect than 800mm wide blister paving. The researchers conjectured that the somewhat poor detection rate was because the surface was so narrow (only 150mm compared to 400mm or 800mm). No participants with mobility impairments failed to cross the trapezoidal delineator, but it was rated as harder to cross than the 800mm blister paving.

Only 1% of participants with vision disabilities failed to detect the 800mm wide corduroy warning surface when it was oriented parallel to the direction of travel on the sidewalk, and it was rated no more difficult to detect than the 800mm blister surface. It was more difficult to detect when installed perpendicular to the direction of travel on the sidewalk. No participants with mobility impairments failed to cross the corduroy surface, and they also rated it no more difficult to detect than the 800mm blister surface.

Only 4% of participants with vision disabilities failed to detect the guidance surface, but it was rated more difficult to detect than the 800mm blister paving. Like the corduroy warning surface, the guidance surface was more difficult to detect when the bars were perpendicular to the direction of travel on the sidewalk. No participants with mobility impairments failed to cross the guidance surface, and it was also rated no more difficult to cross than the 800mm blister surface.

A surface having 15mm high domes, 100mm in diameter, installed so that the tops of the domes were level with the surrounding smooth pavers was as detectable to participants with vision disabilities, both by experimenter observation and participant rating, as the 800mm blister paving. It was also crossed by all participants with mobility impairments, but they rated it more difficult to cross than the 400mm blister paving.

A similar surface of relatively large domes, (15mm high, installed so that the base of the domes was level with the surrounding pavers) was also as easy to detect for participants with vision disabilities by both objective and subjective measures, but not all participants having mobility impairments were able to cross it; they also rated it harder to cross than the 800mm blister paving.

Childs et al. (2010) concluded that surfaces that are the most highly detectable are those that are most difficult to cross. Therefore, a compromise solution will be necessary.

The BMS Research

This research was designed to identify a delineator for use between the pedestrian and cycle sides of the sidewalk level cycle SBL to be as effective as the truncated dome warning surface in terms of the ability of pedestrians with vision disabilities to detect and stay on the correct side of it, as well as to follow it. It also needed to be crossable by people with various mobility impairments.

It was desirable to have a delineator that is as narrow as possible, so it will not require more right-of-way than necessary, nor inconvenience people with mobility impairments more than necessary, but the width must be sufficient to promote safe travel for pedestrians with visual impairments. It was also important that long canes used by pedestrians with vision disabilities intrude as little as possible into the cycle track. The research, therefore, included determining the minimum effective width of a SBL delineator.

Also important, but outside the scope of the research, was that the surface should be highly visible in varied lighting conditions, including to pedestrians having low vision, but it should not have unintended negative consequences for other pedestrians and for cyclists. It should discourage crossing by cyclists.

Test Surfaces and Array on Experimental Site

Choosing Surface Geometries for Testing

Choice of the surfaces was based on both City considerations and human factors considerations. Only five surfaces could be tested in addition to truncated domes. The City considerations were:

- Cost
- Availability
- Durability
- Ease of installation
- As narrow as possible

Human factors considerations were:

- Research shows that surfaces are likely to be highly detectable to pedestrians with vision disabilities
- Research or experience shows that surfaces are likely to be crossable by people with mobility impairments

There are no surfaces that have received controlled human factors testing in the US specifically for use as delineators for SBLs. A number of surfaces are in use around the US, however, and these have had some informal evaluation. Most of the surfaces that are in use as central delineators in the US are some type of raised bars oriented parallel to the direction of travel on the separated bike lane.

It is helpful when choosing the geometries of materials for testing to understand the factors that affect the detectability of TWSIs. Under-foot detectability requires that the raised elements be far enough apart for the foot to deflect between them. Raised elements must also be sufficiently high to be detected. Detectability using a long cane requires that textures be sufficiently pronounced that the cane will "chatter" as it crosses them in a gliding technique, and that they have sufficiently regular spacing between elements that the "chatter" will have a distinctive pattern. Detectability of TWSIs is decreased when TWSIs are surrounded by rough surfaces such as textured pavers or coarse aggregate concrete.

In so far as possible, it is beneficial to test at least two widths so minimum effective width can be determined. US research shows minimum detectable width of a truncated dome surface is 24" (Bentzen et al., 1993). UK research shows minimum detectable width of a raised bar surface is between 400mm and 800 mm (15.7 inches and 31.5 inches). UK research found trapezoidal strips 150mm (6 inches) at base highly detectable and traversable by people having mobility disabilities (Childs et al, 2010; Savill, et al, 1997; *Testing proposed delineators to demarcate pedestrian paths in a shared space environment,* 2008; Williams, 1987), but researchers suggested a wider trapezoidal surface might be better (*Testing proposed delineators to demarcate pedestrian paths in a shared space environment,* 2008; Childs et al., 2010).

The following surfaces were selected for testing (see Figure 13).

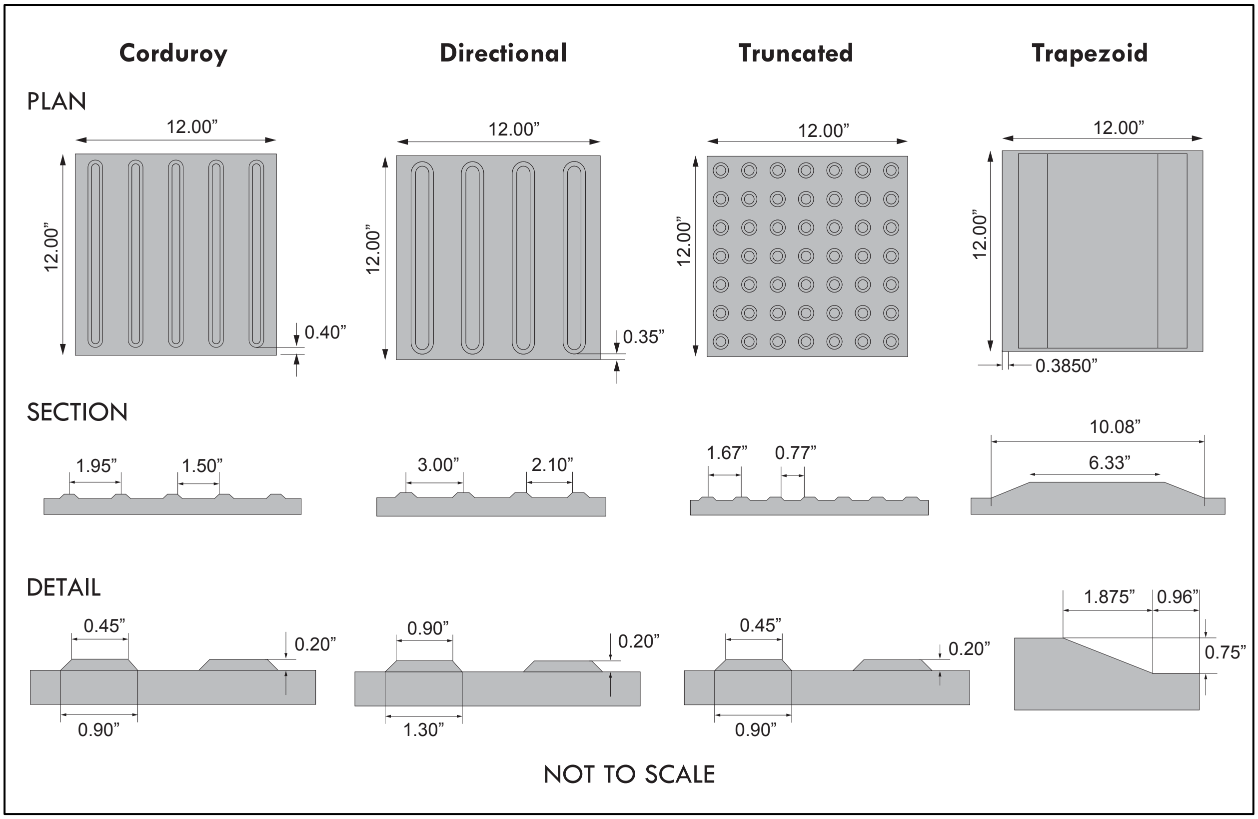


Figure 13 Surfaces tested

Truncated Dome Detectable Warning Surface
The truncated dome detectable warning surface had the dimensions regularly used in San Francisco and was constructed of the cast material that is considered the best choice by Public Works (Tekway by StrongGo) (see Figure 13). The surface dimensions are within the range permitted by ADAAG 2010 and Draft PROWAG, however the spacing between domes is somewhat less than that required by California Title 24. The truncated dome detectable warning surface was installed 24 inches wide, the width that prior research has determined is sufficient for detection and stopping by people having vision impairments when approached at 90 degrees, and the minimum width that is required by ADAAG 2010 and by Draft PROWAG at curb ramps, hazardous vehicular ways, or transit platforms. It was essential to include the truncated domes used in San Francisco in the group of test surfaces so equivalent performance of other surfaces could be determined and documented.

Trapezoidal Central Delineator
A trapezoidal surface 150 mm (5.9 inches) wide at base, 50 mm (1.97 inches) wide that the top, and 20 mm (.79 inch) high was the only surface we identified that had been repeatedly tested as a delineator specifically for separated bicycle lanes. In UK research cited above, it was consistently found to be quite detectable to research participants who were vision disabled and it was also crossable by people having various mobility impairments, traveling with a variety of aids. UK researchers (Childs et al., 2010; *Testing proposed delineators to demarcate pedestrian paths in a shared space environment: Report of design trials conducted at University College London Pedestrian Accessibility and Movement Environment Laboratory,* 2008) suggested that

detectability of the trapezoidal central delineator might be even better if the surface was wider. The single trapezoidal surface tested in BMS research was 10.08 inches (256.03mm) wide at base, 6.33 inches (160.78mm) wide at top, and 0.75 inches (19.05mm) high, on a 12" wide tile. This surface was not commercially available, but was prototyped by StrongGo in the polymer concrete that is favored by the City of San Francisco. The same micro-texture used in TekWay truncated domes was incorporated into the design of the top and sloping sides of the trapezoid.

Guidance Surface Comprised of Raised Flat-Top Bars

Delineator surfaces comprised of raised flat-top bars were installed at 12 inches (305mm) and 24 inches (610mm) wide. Research in the UK and in Japan demonstrated that such a surface can be readily detected, and is crossable by people having mobility impairments. Because it is desirable to have a delineator that is as narrow as possible, it was decided to test the guidance surface of raised flat-top bars at 12 inches wide, although previous research suggests that it will not be readily detected, especially from a 90 degree approach. Therefore it was tested at both 12 inches ((305mm) and 24 inches (610mm) wide.

California Title 24 specifies a surface of raised flat-top bars for guidance (33mm base bar width; 23mm top bar width; 76.2mm center spacing). There is no US specification for a raised-bar guidance surface. The geometry of this surface is similar to the raised bar surface that Japanese research (National Institute for Technology and Evaluation, 2000) found to be highly detectable and highly discriminable from truncated domes. It is important that a guidance surface, which might also be used as a delineator, be readily discriminated from the truncated dome detectable warning surface. The bar geometry specified in California Title 24 seems appropriate. A surface of raised flat-top bars having the correct geometry, and manufactured in the same material, including the micro-texture, was obtained from StrongGo.

Raised bar guidance surfaces of varying geometries are being used as separated bike lane delineators in the US in widths of 6 inches and 12 inches. Informal evaluation of a 6-inch raised bar delineator in Seattle found it to be too narrow (see Figure 1 A) (Elliott et al., 2017), and it is now being replaced by a raised bar delineator that is 12 inches wide (see Figure 1 B). Raised bar guidance surfaces of varying widths are also being used by California transit properties to provide guidance in large open spaces (see Figure 14). No formal evaluation has been done.

Figure 14 Guidance surfaces installed by California transit properties

ISO 23599 recommends that a guidance surface intended to be followed should have a minimum effective width (measured between the outer edges of the bases of the two outer bars) of 250mm (9.8 inches), but a guidance surface that needs to be detected from an approach should have a minimum effective width of 550mm (21.7 inches). The delineator for Better Market Street will need to be highly detectable when approached from 90 degrees, such as when a person leaves an address and wants to find the delineator to be sure they are on the correct side of the separated bike lane, or to follow the delineator. Childs et al. (2010) reasoned that if a truncated dome surface 400mm (15.7 inches) wide could not be readily detected, but a truncated dome surface 800mm (31.5 inches) wide was readily detected, then a raised bar guidance surface also needed to be 800mm wide for good detection, however, they recognized that something between 400mm and 800mm might be sufficient.

"Corduroy" Surface Comprised of Rounded Bars
Delineator surfaces comprised of rounded bars were installed at 12 inches (305mm) and 24 inches (610mm) wide. Peck and Bentzen (1987) compared a corduroy surface to truncated domes and found them to be equally highly detectable in the laboratory. The corduroy surface they tested had 3/16 inch (4.8mm) high ribs, 0.75 inch (19.1mm) wide, that were spaced 2 inches (50.8mm) apart on center.

Participants detected and stopped within 24 inches on more than 90% of trials for both surfaces. Research participants in a field test of truncated domes and corduroy at transit platform edges in BART found the truncated domes to be slightly more detectable. Participants with mobility impairments negotiated both surfaces with relative ease; 9 of 24 of these participants judged that either or both the truncated domes or corduroy would be helpful in their travel.

Childs et al. (2010) also found a corduroy surface 800mm wide (31.5 inches) to be as detectable and easy to cross at 800mm width as the UK blister paving at 800mm, which is similar to the US truncated dome detectable warning surface. The corduroy surface tested by Childs et al. (2010) (see Figure 10), had 6 ± 0.5mm (.23 inch) high rounded ribs, 20mm (.79 inch) wide, and 50mm (1.97 inch) apart on center.

The geometry of these two corduroy surfaces was not identical, but it was quite close. These corduroy surfaces have been tested at widths of 24 inches (610mm) (Peck and Bentzen, 1987), 31.5 inches (800mm) (Childs et al., 2010), and 48 inches (1220mm) (Peck and Bentzen, 1987). Corduroy surfaces have not been tested at 12 inches (305mm). Because it is desirable to identify a delineator that requires minimal right-of-way, the BMS research tested a corduroy surface at both 12 inches (305mm) and 24 inches (610mm) wide.

As far as we know there is no commercially available corduroy surface, so a prototype surface was fabricated for this project by StrongGo, in the polymer concrete that is favored by the City of San Francisco (see Figure 13). Because it was desired to include the same micro-texture to prevent slipping on the corduroy, the ribs were slightly flattened on top rather than being fully rounded as those used in previous research. The ribs were .20 inches (5.08mm) high, .45 inches (11.43mm) wide on top, .90 inches (22.86mm) wide at bottom, with a center spacing of 2.40 inches (60.96mm).

METHOD – VISION DISABLED

The Test Array
Forty-foot lengths of the five surfaces, plus truncated dome detectable warnings, all constructed of high polymer concrete, were installed by San Francisco Public Works in a mortar bed approximately 1½" thick, over the rough asphalt surface of Pier 38, The Embarcadero, San Francisco (see Figure 15). The full array was 120' long by 32' wide with cement pads about 6' wide on the "outside" of the surfaces and running the full length of the array. The test array was marked with chalk, indicating the starting positions and headings for vision disabled participants as they approached and detected each surface.

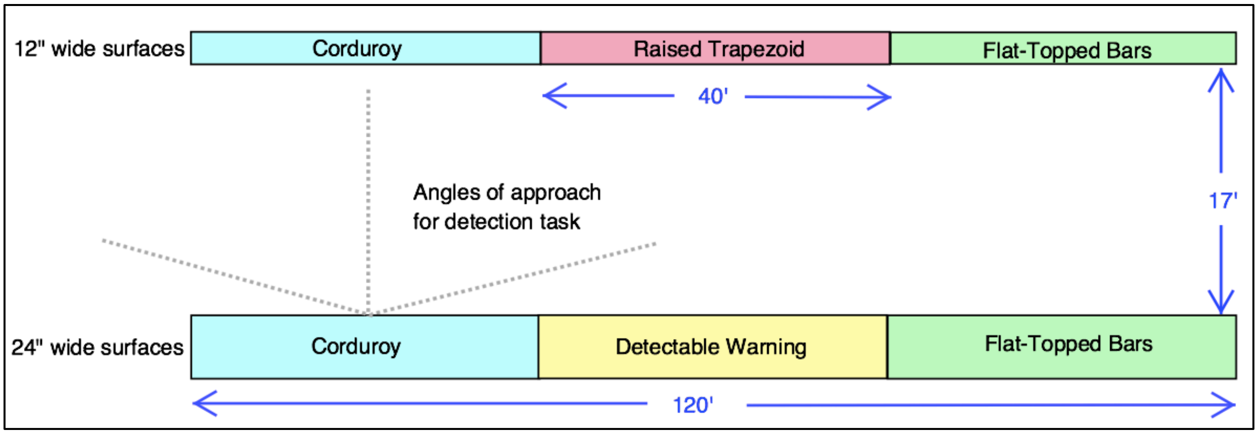


Figure 15 Design of test array.

Participants – Vision Disabled

Thirty-one participants having little or no vision individually completed the human factors research tasks. They varied in age, sex, race or ethnicity and frequency or extent of independent travel.

The aim of the research tasks for vision disabled participants was to determine the physical detectability and discriminability of the proposed surfaces. In assessing this, we needed to eliminate the possibility that some participants would detect or discriminate between surfaces on the basis of some vision. Operationally, the criterion of "little or no vision" was determined by responses to the following interview questions. "Are you ever able to see crosswalk lines?" "Are you ever able to see curbs or poles?" Potential participants who respond in the affirmative to either of these questions were not invited to participate in this research. Participants were also required to be active travelers.

It is recognized that a large majority of people having vision disabilities have some useful vision, however people having low vision were not included in this research. The objective of the research was to identify a delineator surface that is equivalent in detectability under foot or by use of a long cane, to truncated dome detectable warnings. If participants having low vision were included, there would be no way to determine whether detection was based, in part, on visual input. In addition, statistically significant differences on tests of orientation and mobility tasks are rarely achieved for participant groups having low vision, so inclusion of participants with low vision might have obscured important differences in performance related to the surface geometries for people with little or no vision. The direction of results for participants with low vision has been found to be the same as for participants with little or no vision (Marston and Bentzen, 2012), so we are confident that detection of the surfaces under foot, or by use of a long cane, by people having low vision, will follow the same pattern as for people having little or no vision. Truncated domes are required to have a minimum 70% visual contrast with adjacent materials (light on dark, or dark on light), so any delineator surface identified in this research will need to meet this requirement.

Of the 31 total participants, 26 completed the experiment using a long cane as a travel aid, while 5 who customarily travel with the aid of a dog guide, completed the detectability task using the "Juno technique," in which a dog guide instructor simulated dog guide travel by holding the empty dog harness, guiding as a dog would. Although the proportion of vision disabled persons traveling with the aid of a long cane far outnumbers the proportion using dog guides, it is important to consider the detectability and usability of the surface by people who travel with the aid of a dog guide because they have only their feet to detect changes in surface texture.

Researchers have found that dog guides are typically confused by the repetitive nature of focused research tasks such as those required to determine detectability and usability of tactile walking surface indicators and do not guide as they normally do when going from one place to another (R. Manduchi, S. Kurniawan (eds.) *Assistive Technology for Blindness and Low Vision*. CRC Press, a Taylor & Francis Group. Boca Raton, FL.; *Testing proposed delineators to demarcate pedestrian paths in a shared space environment: Report of design trials conducted at University College London Pedestrian Accessibility and Movement Environment Laboratory (PAMELA)*(2008). Reading, UK: Guide Dogs for the Blind Association). Marc Gillard, a dog guide instructor at Guide Dogs for the Blind, San Rafael, suggested that the Juno technique might be a good way to obtain valid data about the performance of dog guide users on repetitive mobility tasks. Mr. Gillard used Juno with all five of the dog guide participants, adjusting his guiding to as closely as possible replicate the speed and style of travel to which each individual was accustomed. Mr. Gillard was familiar with the speed and style of 4 of the 5 participants' travel, and in the one case in which he was not familiar with speed and style of travel, a practice walk was taken to assure he could replicate the speed before testing began. After a few trials all participants were consulted to assure that the Juno speed was correct.

The 26 participants completing the experiment with their long canes used different kinds of cane tips (5 pencil tips, 10 rolling marshmallow tips, 11 metal glide tips), and used a variety of techniques with the cane (constant contact, two-point touch, touch and drag). Most used one technique for all trials and tasks, though a very small number used more than one technique when completing trials for a particular task or used different techniques for the two tasks for which they used their cane). A large majority used constant contact technique, in which the cane tip always remains on the surface. This has become the predominant technique used in developed areas. Participants varied greatly in the skill with which they traveled using the long cane, and varied greatly in style of footwear and thickness of sole. Several participants had mild hearing loss, and one was totally deaf-blind and completed the experiment with the assistance of an interpreter. At least one person reported peripheral neuropathy affecting the foot. Thus the combination of the 26 participants using long canes and the 5 participants who customarily travel using a dog guide and who completed the experiment using the Juno technique, create a sample of participants who were quite representative of the population of travelers in the San Francisco Bay area having little or no vision.

Procedure – Vision Disabled

On arrival at the test site at Pier 38, participants signed the consent form and were given a debit card for $100. All participants then completed the experimental procedure individually. They were guided by Linda Myers, Certified Orientation and Mobility Specialist, who gave them instructions, asked for their feedback, and ensured their safety. Alan Scott, PhD, followed closely, recording observed performance, responses to structured questions, and additional feedback. The participants who were vision disabled using a long cane had three tasks (detection, identification, and following) and the participants using Juno had two tasks (detection and identification). All participants were asked follow up questions (see Appendix A for the detailed protocol for vision disabled participants).

For the detection task, participants who were vision disabled were asked to approach each of the six surfaces six times, and to stop when they detected a surface either in front of them, or beside them on the left or right, and to say that they found a surface. Two approaches to each surface were from 90 degrees, and two approaches each were at approximately 25 degree angles to the left and to the right. Four approach distances were used – 8 feet, 14.5 feet, 16 feet, and 22 feet – such that from trial to trial participants would not be able to predict the distance they would walk before reaching a surface. Surfaces, and approach direction and distance were counterbalanced across participants to control for learning the locations of surfaces and whether to anticipate them in front, to the left, or to the right.

For the identification task, vision disabled participants were also guided onto each surface from 90 degrees and from random angles (approximately 25-45 degrees) to the left or the right, and then guided off the surfaces after no more than 3 seconds. This was done 8 times for each surface type, with four trials each for the 90 degree and approximately 25-45 degree approaches. Each time participants stepped onto and then off of a surface they were asked to say whether they thought they were on "domes," "bars" or the "trapezoid"; (they were not asked to discriminate between the two types of raised bar surfaces). After identifying each surface, they were asked to rate their confidence in their identification.

For the following task, participants who used a long cane were asked to follow each of the surfaces for 40 feet two times, once with the surfaces on the same side as the hand in which they held their cane for the task, and once with the surface on the opposite side.

Measures – Vision Disabled

Data on the following measures was obtained by direct observation of pedestrians with vision disabilities.

- On the detection task
  - Announced detecting the surface when only their cane was on surface, when a foot was on the surface, after completely crossing the surface, or never detected
  - Contacted surface with cane
  - Contacted surface with foot
  - Cane intruded more than 6" beyond the surface into what would be the cycle track
  - Foot intruded any distance beyond the surface into what would be the cycle track
- On the identification task
  - Identified the surface as "domes," "bars," or "trapezoid"
  - Identification was correct/incorrect
  - Rated confidence in identifying the surface
    - 1 = not at all confident, 2 = somewhat confident, or 3 = very confident.
- On the following task
  - Participant lost contact with the surface (taking 6 steps and completing 3 full cane sweeps without contacting the surface) over a distance of 40 feet
  - Cane intruded more than 6" or foot intruded any distance into the imagined cycle track
- The following was also recorded.
  - Aid used for the experiment
  - If long cane was used, type of cane tip – pencil tip, rolling marshmallow tip, metal glide, or other

- Primary cane technique—constant contact (the cane tip remains on the surface most of the time); or touch technique (the cane tip touches or taps in front of each foot before the foot reaches that spot)
- Brief description of the type of shoe and shoe sole
- A rating of proficiency (1 = not very proficient to 5 = very proficient) in use of long cane (provided by the Orientation and Mobility Specialist on the research team)

After all experimental trials, participants were asked to name the surface they preferred as a divider (if any), and to name any surface they would not like to see as a divider (if any) and why. Finally, they were asked for other observations or suggestions, including differences in their experience between the flat-top bars and the “corduroy.”

RESULTS – VISION DISABLED

Analyses

The reported analyses are a series of one-way and two-way repeated-measures ANOVAs and dependent t-tests. When the assumption of sphericity was not met for any ANOVA effect, the Huynh-Feldt correction was applied when epsilon was greater than 0.75, and the Greenhouse-Geisser correction was applied when epsilon was less than 0.75 (see Girden, 1992 for discussion). Post-hoc comparisons were conducted using Bonferroni corrections with the family-wise error rate set at 0.07. In all cases, the “p >/<” statements report the alpha value which was used to evaluate the statistic, thus in the case of Bonferroni corrections this is the adjusted alpha value.

Detection Trials

Participants were tasked with approaching the surfaces from varied distances, different angles of approach, and with the surface directly ahead, on their left, or on their right. Their task was to detect the surface, stop, and indicate that they had found the surface (in most cases, this was done by saying “I found it”). At the time when they announced that they had found the delineator surface, the current condition was recorded – had they detected with their cane and prior to either foot contacting the surface, had they indicated that they detected the surface while one or both of their feet was on the surface, did they indicate they had detected the surface after both feet had completely crossed the surface (e.g., “oh, that was it”), or did they cross over the surface and continue traveling forward without ever indicating having detected it (after a few steps they were stopped by the experimenter and led to the next starting point). In many cases, the participant stopped and announced having found the surface at roughly the same time, but in some instances, participants announced having found the surface and their momentum then carried them one or more steps forward before they were able to come to a stop. At the point at which they came to a stop, four other things were recorded: 1.) whether their cane ever made contact with the surface, 2.) whether one of their feet ever made contact with the surface, 3.) whether their cane at any point in the trial intruded six or more inches into the simulated bike lane on the far side of the delineator, and 4.) whether either of their feet at any point in the trial intruded at all into the simulated bike lane.

With respect to these measures and the intention of a delineator, the ideal case would be that a blind pedestrian who uses a cane would detect the surface reliably with their cane and early enough to avoid allowing their cane or feet/body to intrude into the simulated bike lane.

For dog guide users, the detection would necessarily have to occur by foot contact, and the ideal situation would be reliable detection of the delineator and detection which occurs early enough to allow them to stop before allowing their feet/body to intrude into the simulated bike lane.

For the detection trials, the width of the surfaces was not varied in a fully factorial manner with the texture of the surface. The design of the trapezoid does not suggest the likelihood of improved performance with increasing width and thus it was tested at only a single width (i.e., a 12" tile), and federal standards regarding DWS led to testing the surface at only the 24" width. Thus one-way repeated-measures ANOVAs are used to compare the six unique combinations of surface texture/design and width (i.e., 24" DWS, 24" Corduroy, 24" Flat-Top Bars, 12" Trapezoid, 12" Corduroy, and 12" Flat-Top Bars). Additionally, data was combined across surfaces in order to evaluate the overall effects of delineator width on participant performance, resulting in 12" delineator (combining corduroy, flat-top bars, and trapezoid) and 24" delineator (combining corduroy, flat-top bars, and DWS) conditions which were analyzed using dependent t-tests.

Cane Users

Detection of the delineator – Consideration of surfaces and delineator width – The mean number of approaches in which participants detected the surface with either their cane or their feet (and prior to walking fully across the surface) was very high for all surfaces (94.8% or higher) at the widths tested and did not significantly differ for the various conditions [$F(2.33, 58.22) = 2.025$, $p > 0.05$]. See Table 1 for the mean performance in each of the six conditions for this and other variables described in this section. The mean number of approaches in which participants detected the surface with either their cane or their feet also did not significantly differ for the 12 inch and 24 inch delineators [$t(25) = 1.656$, $p > 0.05$]. See Table 2 for comparisons by delineator width. It was considered how often participants completely failed to detect the surface; thus these were instances in which the participant crossed the delineator completely and continued ahead, needing to be stopped by the researcher. There were no significant differences in the rates of failing to detect the various surfaces [$F(2.97, 74.19) = 1.695$, $p > 0.05$], nor was there a significant difference in the rates of failing to detect the delineator when comparing 12 inch vs 24 inch delineators [$t(25) = 1.547$, $p > 0.05$]. Overall, and considering all approaches to all surfaces, failure to detect the surface occurred on only 1.8% of trials.

The mean number of approaches in which participants detected the delineator with their cane (thus prior to their foot contacting the surface) significantly differed for the various surfaces at their particular widths [$F(5,125) = 14.846$, $p < 0.05$]. The mean number of detections by cane was significantly lower for the trapezoid than for each of the other surfaces [$t(25) = 5.87$, 3.20, 5.53, 5.95, and 4.60 for comparisons with DWS, 24" corduroy, 24" flat-top bars, 12" corduroy, and 12" flat-top bars respectively; $p < 0.0047$ in all cases]. There was also a significantly lower rate of detection by cane for the 24" corduroy as compared to DWS and 12" corduroy [$t(25) =$ 3.89 and 3.73, respectively; $p < 0.0047$]. These differences do appear to be attributable to the information received through cane contact with the different surfaces as the mean rates of making cane contact with the surfaces were very high for all six surface/width combinations (96.8% or higher) and there were no significant differences in the mean rates [$F(5,125) = 1.988$, $p > 0.05$].

An analysis of rates of cane detection by delineator width revealed a rather small but significant advantage when detecting 24" vs 12" surfaces [83.8% vs. 79.7%; $t(25) = 2.906$, $p <$

0.05]. However, note that from the above described analysis, it was found that there was no difference in the rates of detection by cane for the two widths of flat-top bars, and the rate of detection by cane was actually significantly higher for the 12" corduroy than the 24" corduroy. Thus delineator width does not seem to be the most significant factor influencing the ability of participants to detect the surfaces with their canes. The relatively high rates of detection by cane of the DWS, and the relatively low rates for the trapezoid, are most likely more attributable to the design of these surfaces than to the difference in the width of the delineators tested.

TABLE 1 Summary of Cane Users' Performance – All Surface and Width Combinations

Measure	24" Delineators			12" Delineators		
	Detectable Warning (a)	24" Corduroy (b)	24" Flat-Top Bars (c)	12" Corduroy (d)	12" Flat-Top Bars (e)	Trapezoid (f)
Mean # of detections by cane or while foot was in contact with delineator (6 trials)	5.89 (98.2%)	5.77 (96.2%)	6.00 (100%)	5.77 (96.2%)	5.69 (94.8%)	5.96 (99.3%)
Mean # of trials in which delineator was not detected (6 trials)	0.077 (1.3%)	0.154 (2.6%)	0.00 (0%)	0.192 (3.2%)	0.192 (3.2%)	0.038 (0.6%)
Mean # of detections by cane (6 trials)*	5.27 (87.8%) - b,f**	4.73 (78.9%) - a,d,f	5.08 (84.6%) - f	5.15 (85.9%) - b,f	5.00 (83.3%) - f	4.19 (69.9%) - a,b,c,d,e
Mean # of trials in which delineator was contacted with the cane (6 trials)	6.00 (100%)	5.89 (98.1%)	6.00 (100%)	5.81 (96.8%)	5.81 (96.8%)	5.81 (96.8%)
Mean # of cane intrusions (6 trials)*	0.92 (15.4%) - b,d,e,f	1.81 (30.1%) - a,c,d,e,f	0.88 (14.7%) - b,d,e,f	2.88 (48.1%) - a,b,c,f	3.04 (50.6%) - a,b,c,f	3.96 (66.0%) - a,b,c,d,e
Mean # of foot intrusions (6 trials)	0.31 (5.1%)	0.46 (7.7%)	0.04 (0.6%)	0.54 (9.0%)	0.73 (12.2%)	0.65 (10.9%)

** Significant differences were present between some treatments ($p < .05$).*
*** For a given measure, letters in individual cells indicate those conditions against which performance significantly differs [e.g., rate of cane detection of DWS (b,f) significantly differs from the rate for 24" corduroy (b) and the rate for trapezoid (f)].*

TABLE 2 Summary of Cane Users' Performance – 12" vs. 24" Delineator

Measure	24" Surfaces	12" Surfaces
Mean # of detections by cane or while foot was in contact with delineator (18 trials)	17.65 (98.1%)	17.42 (96.8%)
Mean # of trials in which delineator was not detected (18 trials)	0.23 (1.3%)	0.42 (2.4%)
Mean # of detections by cane (18 trials)*	15.08 (83.8%)	14.35 (79.7%)
Mean # of trials in which delineator was contacted with the cane (18 trials)	17.88 (99.4%)	17.42 (96.8%)
Mean # of cane intrusions (18 trials)*	3.62 (20.1%)	9.88 (54.9%)
Mean # of foot intrusions (18 trials)*	0.82 (4.5%)	1.92 (10.7%)

** Significant differences were present ($p < .05$).*

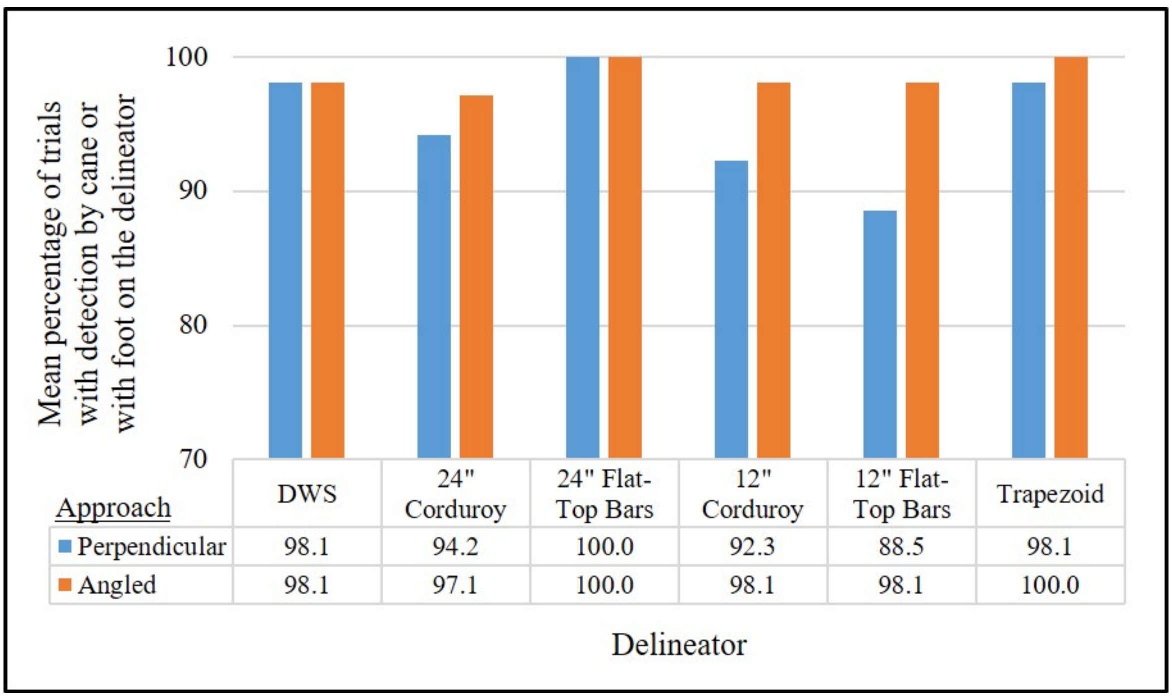
Intrusions into the "bike lane" – Consideration of surfaces and delineator width – In the simulated environment, it was treated as though participants were approaching the delineator from the pedestrian side and imagined that the bike lane was on the opposite side of the surface. Two types of intrusions were recorded; cane intrusions and foot/body intrusions. In cases in which the cane tip extends only an inch or two past the surface, this might be considered a low risk event (not no risk, but low risk) for contact with a bicycle. Thus cane intrusions were recorded if the cane extended 6 inches or more beyond the far edge of the delineator surface. For foot intrusions, if any part of the foot has crossed the bicycle-side edge of the delineator surface, the participant's foot, leg, and perhaps upper body would be at risk for collision with bicycles, especially bicycle handlebars. Thus foot intrusions were recorded if any part of the participant's foot crossed the boundary of the delineator and thus into the "bike lane."

The mean number of detection approaches in which participants' canes intruded into the "bike lane" significantly differed for the various surfaces at their particular widths [$F(5,125) = 43.303$, $p < 0.05$]. All pairwise comparisons were significant at $p < 0.0047$ with the exception of two [DWS vs. 24" Flat-Top Bars, $t(25) = 0.16$; 12" Corduroy vs. 12" Flat-Top Bars, $t(25) = 0.72$]. A review of the means in Table 1 seems to show a considerably higher rate of cane intrusions when the delineator was 12 inches wide as opposed to 24 inches wide. This was confirmed by demonstrating that the mean number of detection approaches in which cane intrusions occurred was considerably and significantly higher for the 12 inch delineators ($M = 9.88$ of 18 trials, 54.9%) than for the 24 inch delineators ($M = 3.62$ of 18 trials, 20.1%) [$t(25) = 10.168$, $p < 0.05$]. The cause of differences in rates of cane intrusions could be due to the surface textures/geometries, the overall width of the delineator, or some combination of the two. Considering the sizeable overall effect of delineator width on rates of cane intrusion, combined with the fact that the two pairwise comparisons which were not significant were between conditions at the same delineator width, does suggest that delineator width is playing a highly significant role with respect to the likelihood of cane intrusions. However, other pairwise comparisons were significant for surfaces within the two delineator width categories suggesting that surface texture/geometry is also a contributing factor.

The overall rates of foot intrusions were much lower than for cane intrusions, but did occur on around 7.5% of all trials. At the level of the omnibus analysis, the mean number of detection approaches in which participants' feet intruded into the "bike lane" appears to be significantly different for the various surfaces at their particular widths [$F(2.36,58.92) = 3.088$, $p < 0.05$]. However, with the Bonferroni procedure employed for the post-hoc comparisons, no pairwise comparisons achieved statistical significance (family-wise error would need to be at 20% before a single comparison would achieve significance). When the data is merged to consider the potential influence of delineator width, while the magnitude of difference between the rates was not as great as for cane intrusions, there was a significantly higher rate of foot intrusions for 12 inch delineators than for 24 inch delineators [$t(25) = 2.611$, $p < .05$].

Detection of the surface – Consideration of surfaces and angle of approach – Each participant approached each surface twice from a position perpendicular to the length of the delineator, and four times from positions at approximately 25 degree angles. Converting performance into percentages allowed conducting of two-way repeated measures ANOVAs in a 6 (surface/width) x 2 (angle of approach) manner.

The analysis of percentage of approaches in which participants detected the surface with either their cane or their feet (and prior to walking fully across the surface) found no significant interaction [$F(2.79,69.85) = 2.481$, $p > 0.05$] and no significant main effect of surface [$F(2.49,62.12) = 2.353$, $p > .05$]. There was a significant main effect of angle of approach [$F(1,25) = 8.827$, $p < 0.05$]. See Figure 16. The main effect appears to be rather strongly driven by the relatively lower detection performance on perpendicular approaches to the two 12" bar-type delineators.



Approach	DWS	24" Corduroy	24" Flat-Top Bars	12" Corduroy	12" Flat-Top Bars	Trapezoid
Perpendicular	98.1	94.2	100.0	92.3	88.5	98.1
Angled	98.1	97.1	100.0	98.1	98.1	100.0

Figure 16 Mean percent of approaches with detection by cane or with a foot on the delineator by surface and angle of approach – cane users

Considering how often participants completely failed to detect the surface is almost just the inverse of the data displayed in Figure 16. Thus a 6 (surface/width) x 2 (angle of approach) analysis of failure to detect the surface found no significant interaction [$F(2.96,73.94) = 2.243$, p

> .05] and no significant main effect of surface [$F(2.93,73.17) = 2.078$, $p > .05$]. There is a significant main effect of angle of approach [$F(1,25) = 5.328$, $p < 0.05$]. See Figure 17. Considered in this way, the main effect of angle of approach is rather strongly driven by the relatively higher rate of failure to detect the two 12” bar-type delineators when approached perpendicularly.

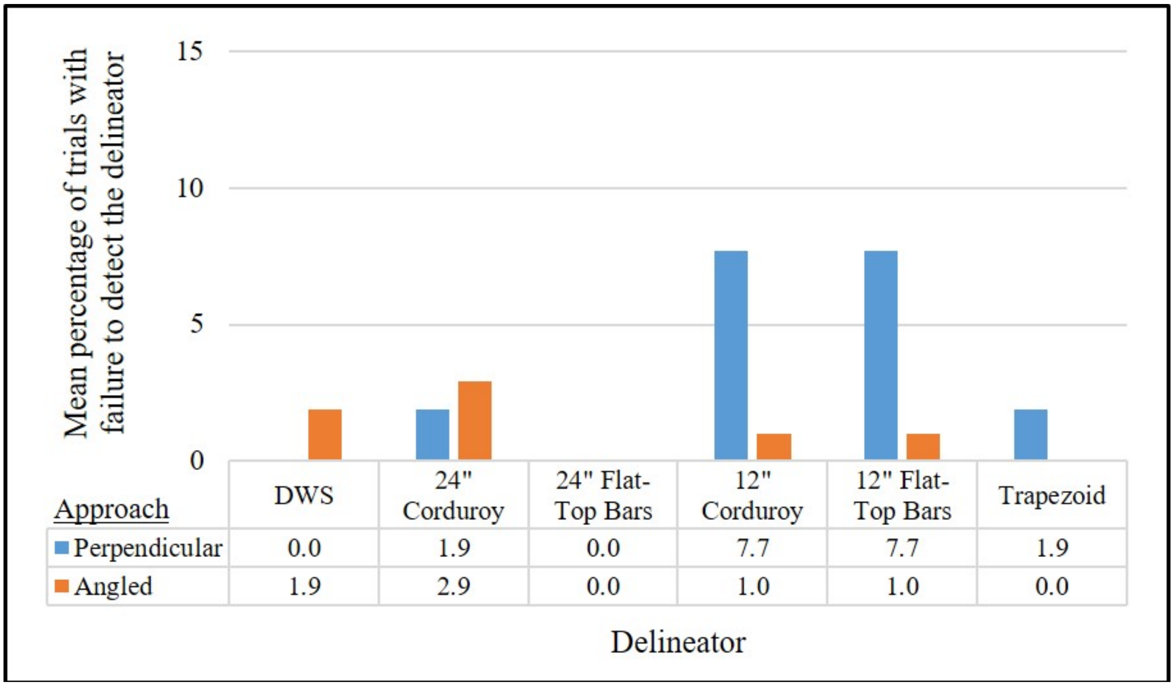


Figure 17 Mean percent of approaches in which the delineator was not detected by surface and angle of approach – cane users

The analysis of percentage of approaches in which participants detected the surface with their cane (thus prior to their foot contacting the surface) resulted in a significant interaction [$F(4.04,101.06) = 5.207$, $p < .05$]. See Figure 18. As is rather evident in the figure, on the whole, perpendicular approaches did tend to result in lower rates of detection by cane than did angled approaches, a fact confirmed by a significant main effect for angle of approach [$F(5,125) = 19.768$, $p < 0.05$]. The interaction is largely a product of the difference in cane detection of the trapezoid for angled versus perpendicular approaches. For angled approaches, cane detection of the trapezoid was nearly as good as detection of all other surfaces – there is a significant simple main effect of surface for angled approaches [$F(3.142,78.544) = 3.341$, $p < .05$], but the only pairwise comparison which was significant was for a lower rate of detection by cane for angled approaches to the trapezoid as compared to angled approaches to the 12 inch corduroy [$t(25) = 3.143$, $p < 0.0047$]. However, for perpendicular approaches, there was a significant simple main effect [$F(3.21,80.28) = 10.558$, $p < .05$] and the rate of cane detection of the trapezoid was significantly lower than for DWS, 24” Flat-Top Bars, 12” Corduroy, and 12” Flat-Top Bars [$t(25) = 5.14, 4.79, 4.17, 3.64$, respectively, $p < 0.0047$]. It was also the case that the rate of detection by cane was worse with the 24” corduroy than with the DWS [$t(25) = 3.33$, $p < 0.0047$]. It is of note that while detection of the trapezoid by cane was more difficult than detection of other surfaces, particularly when approaching perpendicular to the surface (see

Figure 18), detection by cane *or foot* was excellent for either angle of approach (see Figure 16). Thus the trapezoid was hard to miss with the foot and highly recognizable as a delineator.

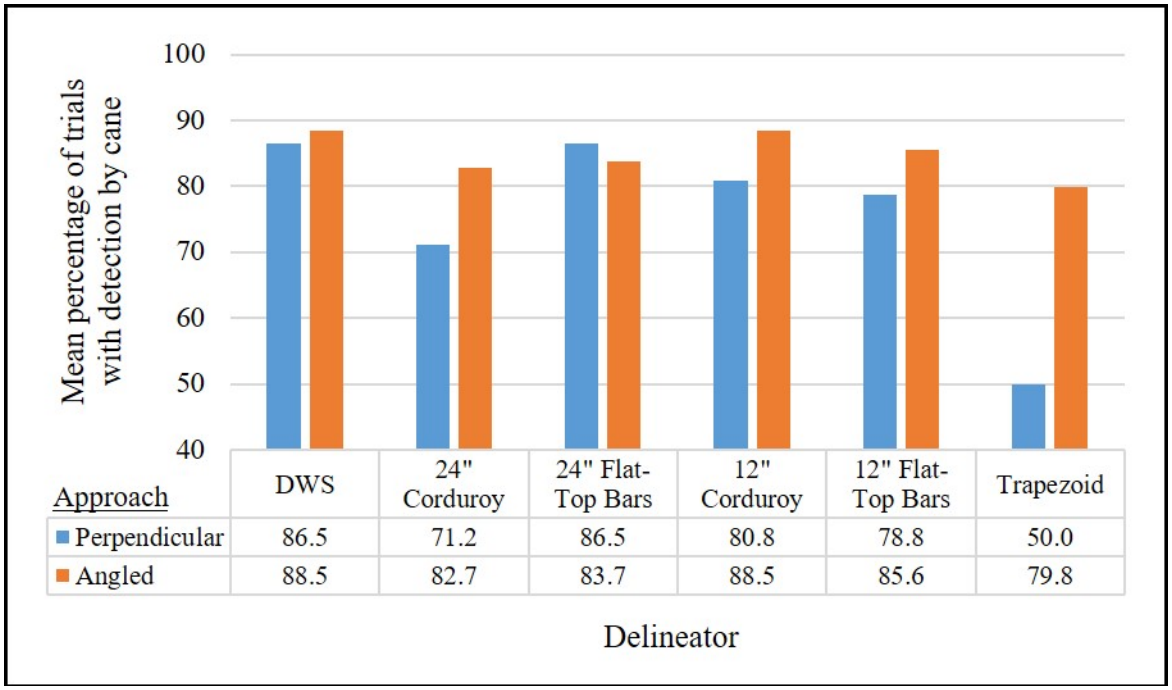
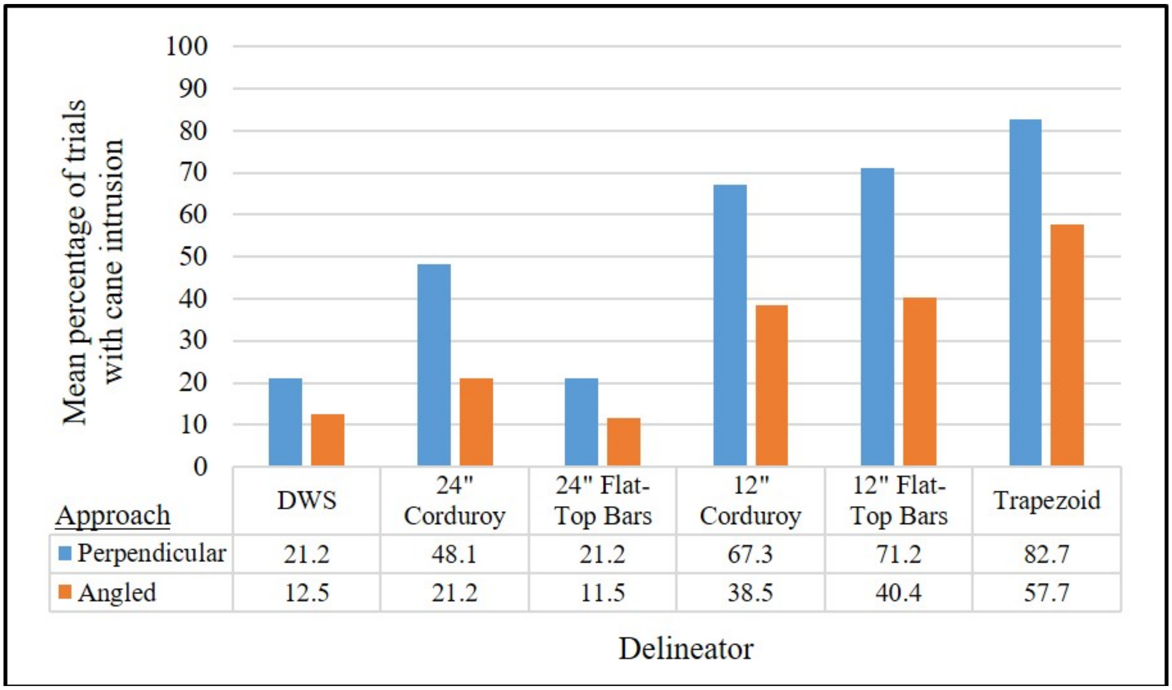


Figure 18 Mean percent of approaches with detection by cane by surface and angle of approach – Cane users

As with the other analyses, a 6 (surface/width) x 2 (angle of approach) analysis of rates of making cane contact with the surfaces revealed no significant effects [Interaction – $F(5,125) = 1.402$; Main effect of Surface – $F(5,125) = 1.954$; Main effect of Approach – $F(1,125) = 2.200$; $p > 0.05$].

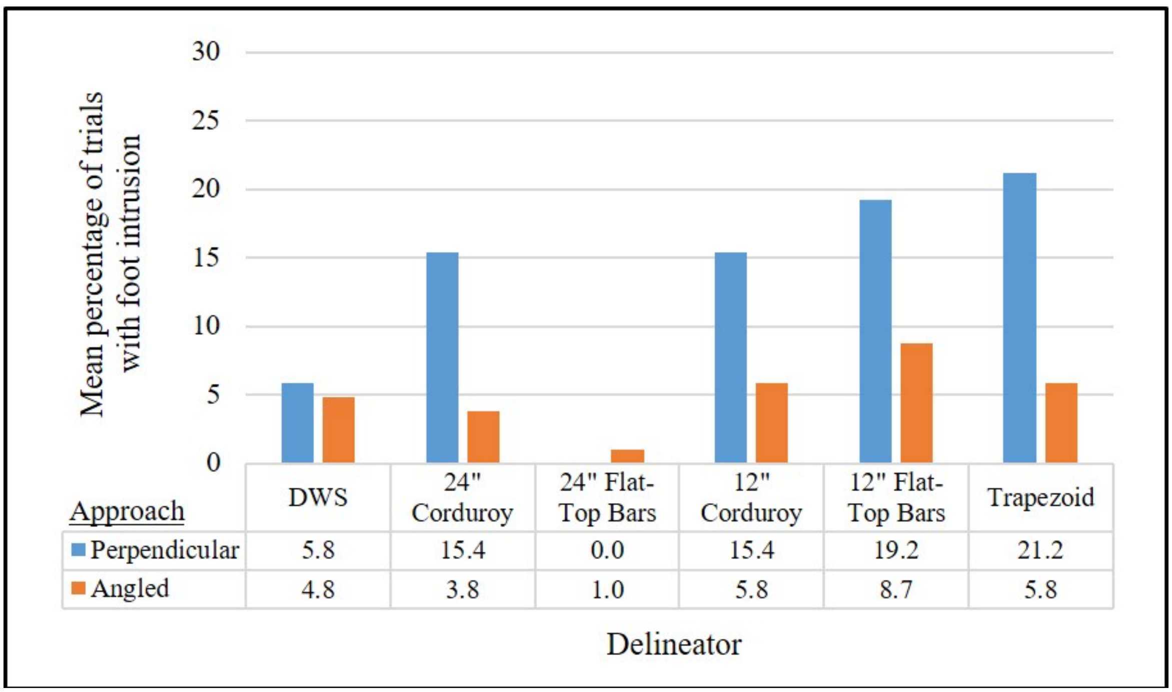
Intrusions into the "bike lane" – Consideration of surfaces and angle of approach – A 6 (surface/width) x 2 (angle of approach) analysis of the percentage of detection trials in which participants' canes intruded into the "bike lane" found no significant interaction [$F(5,25) = 2.200$, $p > 0.05$]. See Figure 19. Participants' performance is rather clearly explained by the two significant main effects. Participants were more likely to commit cane intrusions on perpendicular approaches than angled approaches [$F(1,25) = 36.812$, $p < 0.05$], and there was also a main effect of surface [$F(5,125) = 41.890$, $p < 0.05$], with the effect clearly associated with the width of the delineator (overall mean rates of cane intrusions were between 16.3% and 34.6% for the 24 inch surfaces, while they were between 52.9% and 70.2% for the 12 inch surfaces).

While the rates of foot intrusions were lower than for cane intrusions, the pattern of findings is largely the same. A 6 (surface/width) x 2 (angle of approach) analysis of the percentage of detection trials in which participants' feet intruded into the "bike lane" found no significant interaction [$F(3.24,81.00) = 2.533$, $p > 0.05$]. See Figure 20. Participants' performance is rather clearly explained by the two significant main effects. Participants were more likely to commit foot intrusions on perpendicular approaches than angled approaches [$F(1,25) = 14.552$, $p < 0.05$], and there was also a main effect of surface [$F(2.55,63.85) = 3.436$, $p < 0.05$], with the effect rather clearly associated with the width of the delineator (overall mean rates of foot intrusions were between 0.5% and 9.6% for the 24 inch surfaces, while they were between 10.6% and 13.9% for the 12 inch surfaces).



Approach	DWS	24" Corduroy	24" Flat-Top Bars	12" Corduroy	12" Flat-Top Bars	Trapezoid
Perpendicular	21.2	48.1	21.2	67.3	71.2	82.7
Angled	12.5	21.2	11.5	38.5	40.4	57.7

Figure 19 Mean percent of approaches with cane intrusions by surface and angle of approach – cane users



Approach	DWS	24" Corduroy	24" Flat-Top Bars	12" Corduroy	12" Flat-Top Bars	Trapezoid
Perpendicular	5.8	15.4	0.0	15.4	19.2	21.2
Angled	4.8	3.8	1.0	5.8	8.7	5.8

Figure 20 Mean percent of approaches with foot intrusions by surface and angle of approach – cane users

Dog Guide Users Using Juno Technique

Detection of the surface – Consideration of surfaces and delineator width – For those five participants who completed the detection task while using the Juno technique to simulate their use of a dog guide, detection was only possible by sensing the delineator surface underfoot as they did not use a cane. There is considerably less data as a result of the smaller sample of Juno users as compared to cane users, and so the results for this group should be understood as more exploratory in nature.

As a result of the faster rate of travel of the dog guide users using the Juno technique, there were a significant number of trials in which the participants announced that they had detected the surface after both feet had crossed fully over it. Thus in these instances, the participant did register the presence of the surface while stepping on it, but by the time they could process that information, report that they had detected it, and then stop, they had already travelled entirely across the surface. Consider first the total detection rate of the delineator surfaces; these included all detections announced while the participant's foot was in contact with the delineator or announced just after having crossed to the other side. Participants succeeded in detecting the delineator on 93.3% of all detection trials. The total detection rate for the cane users was 98.2%. Amongst those participants using the Juno technique, there were no significant differences between these total detection rates for the various surfaces [$F(5,20) = 1.641$, $p > 0.05$], nor was there a significant difference in the total detection rate when comparing 12 inch vs 24 inch delineators [$t(4) = 1.372$, $p > 0.05$]. The rates of failing to detect the delineator are simply the inverse of the total detection rates. See Table 3 for the mean performance in each of the six conditions for this and other variables described in this section, and see Table 4 for comparisons by delineator width.

The mean number of approaches in which participants detected the surface with their feet and while at least one foot was still on the surface significantly differed for the various surfaces at their particular widths [$F(5,20) = 8.424$, $p < 0.05$]. The low power of the analysis creates a rather unclear picture with respect to those differences which are statistically significant (see Table 3 for information about in which conditions performance significantly differed). However, looking at the rates as likely trends produces a somewhat clear picture in which the mean rates of detection of the 12" corduroy and 12" flat-top bar delineators while a foot was in contact with the surface were considerably lower than for other surfaces. For a dog-guide user traveling at typical speed, many travelers will only step one foot on the surface before quickly moving across to the other side (in some cases, it is certainly possible to step entirely over such a delineator without ever touching it; this was observed a few times). However, rate of detection of the 12" trapezoid was more comparable to the 24" wide delineator surfaces, an occurrence that speaks to the highly identifiable nature of the surface (more detail on identification accuracy follows in this report).

An analysis of rates of detection while the participant still had a foot on the surface by delineator width revealed a significant advantage when detecting 24" vs 12" surfaces [84.4% vs. 60.0%; $t(4) = 5.880$, $p < 0.05$]. Although a small sample, the magnitude of the difference is considerably greater for the Juno users than for the cane users, highlighting what is likely to be the greater challenge of detecting a 12 inch surface underfoot when travelling at speeds which on average tend to be faster.

TABLE 3 Summary of Dog Guide (Juno) Users' Performance – All Surface and Width Combinations

Measure	24" Delineators			12" Delineators		
	Detectable Warning (a)	24" Corduroy (b)	24" Flat-Top Bars (c)	12" Corduroy (d)	12" Flat-Top Bars (e)	Trapezoid (f)
Mean # of detections while foot was in contact with the delineator or just after crossing it (6 trials)	5.40 (90.0%)	5.80 (96.7%)	6.00 (100%)	5.60 (93.3%)	5.00 (83.3%)	5.80 (96.7%)
Mean # of trials in which delineator was not detected (6 trials)	0.60 (10.0%)	0.20 (3.3%)	0.00 (0%)	0.40 (6.7%)	1.00 (16.7%)	0.20 (3.3%)
Mean # of detections while foot was in contact with delineator (6 trials)*	4.60 (76.7%) - d**	5.20 (86.7%) - e	5.40 (90.0%) -	2.80 (46.7%) - a, f	2.80 (46.7%) - b	5.20 (86.7%) - d
Mean # of detections occurring after both feet had crossed the delineator (6 trials)	0.80 (13.3%)	0.60 (10.0%)	0.60 (10.0%)	2.80 (46.7%)	2.20 (36.7%)	0.60 (10.0%)
Mean # of foot intrusions (6 trials)	5.80 (96.7%)	5.60 (93.3%)	5.40 (90.0%)	6.00 (100%)	6.00 (100%)	6.00 (100%)

** Significant differences were present between some treatments ($p < .05$).*
*** For a given measure, letters in individual cells indicated those conditions against which performance significantly differs [e.g., rate of foot detection with 12" corduroy (a, f) significantly differs from the rate with DWS (a) and with trapezoid (f)].*

TABLE 4 Summary of Dog Guide (Juno) Users' Performance – 12" vs. 24" Delineator

Measure	24" Surfaces	12" Surfaces
Mean # of detections announced while foot was in contact with the delineator or just after crossing it (18 trials)	17.20 (95.6%)	16.40 (91.1%)
Mean # of trials in which surface was not detected (18 trials)	0.80 (4.4%)	1.60 (8.9%)
Mean # of detections announced while foot was in contact with the delineator (18 trials)*	15.20 (84.4%)	10.80 (60.0%)
Mean # of foot intrusions (18 trials)	16.8 (93.3%)	18.00 (100%)

** Significant differences were present ($p < .05$).*

An analysis or rates of announcing detection just after having crossed to the other side of the delineator did not reveal and statistically significant differences between the rates of this occurrence for the six surfaces at the widths which were tested [$F(2.09,8.38) = 3.434$, $p > 0.05$]; however, keep in mind the low sample size for this group of participants. As can be seen in Table 3, the observed rates were considerably higher in the 12" corduroy and 12" flat-top bars conditions as compared to the other four conditions.

Intrusions into the "bike lane" – Consideration of surfaces and delineator width – The overall rates of foot intrusions were extremely high for dog guide (Juno) users, and were so prevalent in all conditions as to result in no significant differences between surfaces at their particular widths [$F(1.27,5.08) = 2.087$, $p > 0.05$]. While there was a higher rate of foot intrusions in the 12" delineator condition than in the 24" delineator condition, with this small sample, the difference was not statistically significant [$t(4) = 1.500$, $p > .05$].

Detection of the surface – Consideration of surfaces and angle of approach – In order to consider how often participants detected the delineator, a 6 (surface/width) x 2 (angle of approach) analysis of the total detection rates was conducted (i.e., detection announced while a foot was in contact with the delineator or just after they crossed to the other side). The results clearly suggest some trends, and the low power of the analysis is likely the driving factor in finding no significant effects [Interaction, $F(5,20) = 0.943$, $p > 0.05$]: Main effect of surface, $F(2,20) = 1.486$, $p > 0.05$: Main effect of approach, $F(1,4) = 7.50$, $p > 0.05$]. See Figure 21. The main effect of approach orientation was trending towards significance ($p = 0.052$), and in this small sample, the observed mean percentage of trials in which the participant detected the delineator was higher for angled approaches ($M = 97.5\%$) than for perpendicular approaches ($M = 85\%$).

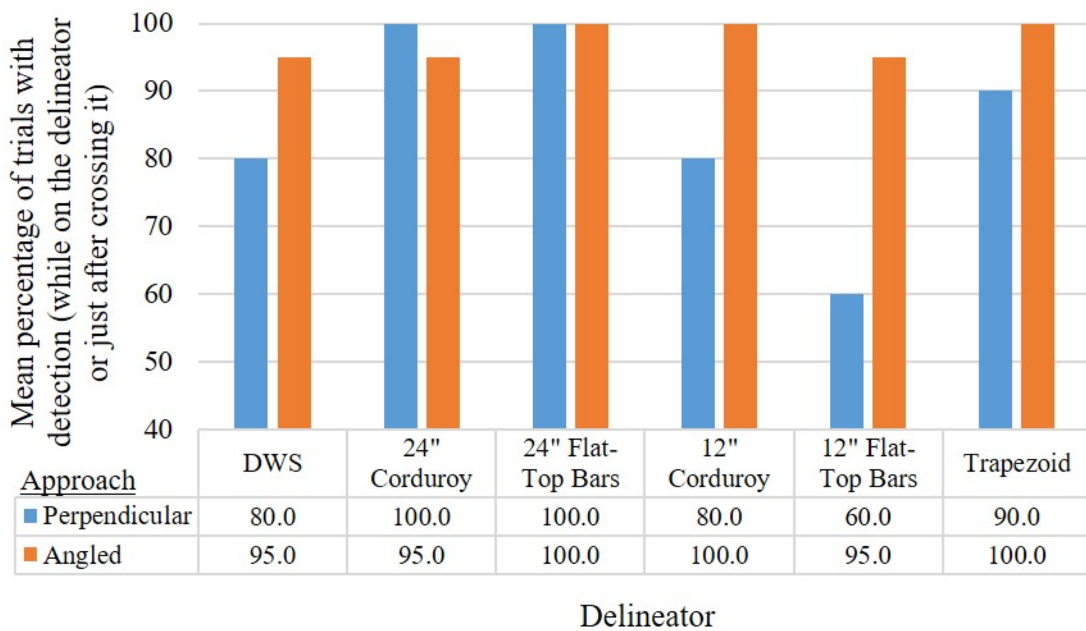


Figure 21 Mean percent of approaches in which the surface was detected by surface and angle of approach – Juno users

The analysis of percentage of approaches in which participants detected the delineator while at least one foot was still on the surface produced no significant interaction [$F(5,20) = 0.620$, $p > .05$: See Figure 22]. Participants were more likely to detect the delineator while a foot was still on it when the delineator surface was 24" wide as compared to when it was 12" wide [$F(1,4) = 19.761$, $p < 0.05$]. The type of surface was also a significant factor [$F(1.77,7.10) = 8.415$, $p < 0.05$]. With the limited sample size, and the use of the Bonferroni procedure, only two pairwise comparisons were statistically significant. Juno users were more likely to detect the delineator with a foot still on the surface with the trapezoid than with the 12" corduroy [$t(4) = 8.50$, $p < 0.0047$], and with 24" corduroy than with 12" flat-top bars [$t(4) = 9.00$, $p < 0.0047$].

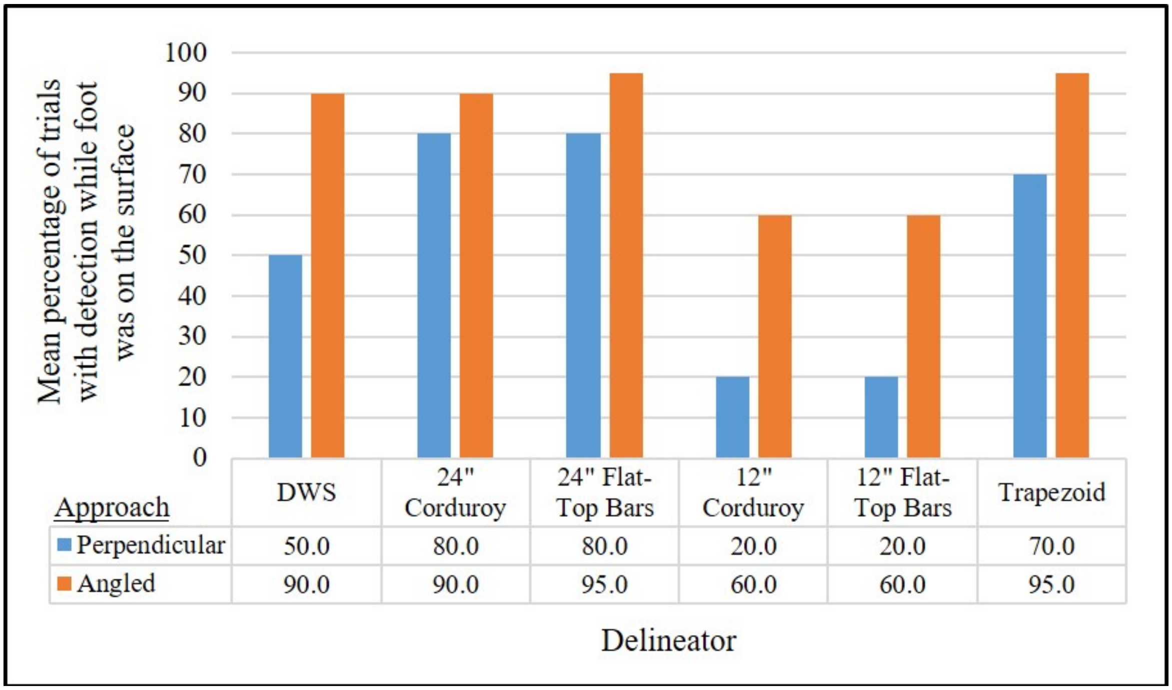
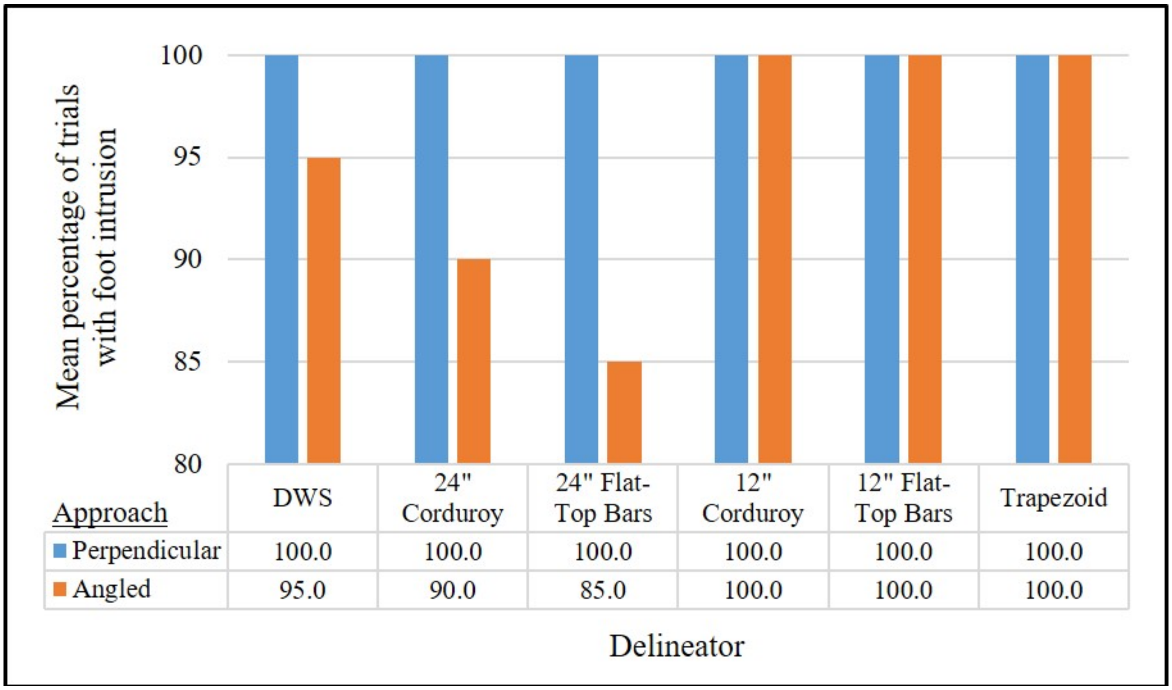


Figure 22 Mean percent of approaches with detection while in foot contact by surface and angle of approach – Juno users

Intrusions into the "bike lane" – Consideration of surfaces and angle of approach – A 6 (surface/width) x 2 (angle of approach) analysis of the percentage of detection trials in which Juno users' feet intruded into the "bike lane" found no significant effects [Interaction, $F(1.270,5.280) = 2.087$, $p > 0.05$: Main effect of surface, $F(1.270,5.280) = 2.087$, $p > 0.05$: Main effect of approach, $F(1,4) = 2.250$, $p > 0.05$]. See Figure 23. Of note is the fact that foot intrusions occurred on every trial with perpendicular approaches (60 of 60), and also occurred on every trial approaching a 12" delineator (90 of 90). Rates remained high in other conditions, though there were some instances of participants making angled approaches to 24" delineators in which they were able to detect the surface and stop before their feet crossed over the far side of the delineator and into the "bike lane."



Approach	DWS	24" Corduroy	24" Flat-Top Bars	12" Corduroy	12" Flat-Top Bars	Trapezoid
Perpendicular	100.0	100.0	100.0	100.0	100.0	100.0
Angled	95.0	90.0	85.0	100.0	100.0	100.0

Figure 23 Mean percent of approaches with foot intrusions by surface and angle of approach – Juno users

Identification Trials

Participants were led onto and off of each of the four surfaces (i.e., DWS, Corduroy, Flat-Top Bars, Trapezoid), and were only allowed a few seconds to explore the surface underfoot. They were not allowed to touch the surface with their hand or with their cane. Participants then had to identify the surface within three categories – domes (the DWS), bars (either the Corduroy or the Flat-Top Bars), or Trapezoid. Thus participants were not asked to make the more precise discrimination between the two types of bars as there was never any intention to consider using both in such a way as to expect this sort of discrimination. For half of the trials with each surface, the participant was led onto the surface in a direction which was perpendicular to the length of the delineator, and for the other half of trials they were led on from an angle (no attempt was made to have this be a precise angle, but at approximately 45 degrees). Thus in a fully factorial manner, participants' ability to identify each surface by foot was evaluated using 4 (type of surface) x 2 (angle of approach) two-way, repeated-measures ANOVAs. All participants, cane users and Juno users, completed this task (n = 31).

Using a two-way, repeated measures ANOVA, a 4 (surface) x 2 (angle of approach) analysis was conducted on the number of correct identifications. The analysis revealed no significant interaction [$F(2.42,72.65) = 1.499$, $p > 0.05$], and no main effect of approach angle [$F(1,30) = 3.197$, $p > 0.05$]. There was a significant main effect for surface type [$F(3,90) = 12.620$, $p < 0.05$]. The results are depicted in Figure 24 as percentages of trials. Ignoring the angle of approach, given the lack of a significant main effect, identification of the trapezoid was nearly perfect (Mean # of correct identifications was 7.903 out of 8.00 (98.8%)). This in fact reflected perfect identification of the trapezoid by 30 participants (240 such trials) and three errors by one participant. Participants were significantly more successful at correctly identifying the trapezoid than flat-top bars, corduroy, or DWS [$t(30) = 3.66, 6.73$, and 4.00, respectively, $p < 0.012$]. Participants were also significantly more successful in identifying the flat-top bars as bars than identifying the corduroy as bars [t(30) = 3.23, p < 0.012]. The other pairwise comparisons were not statistically significant.

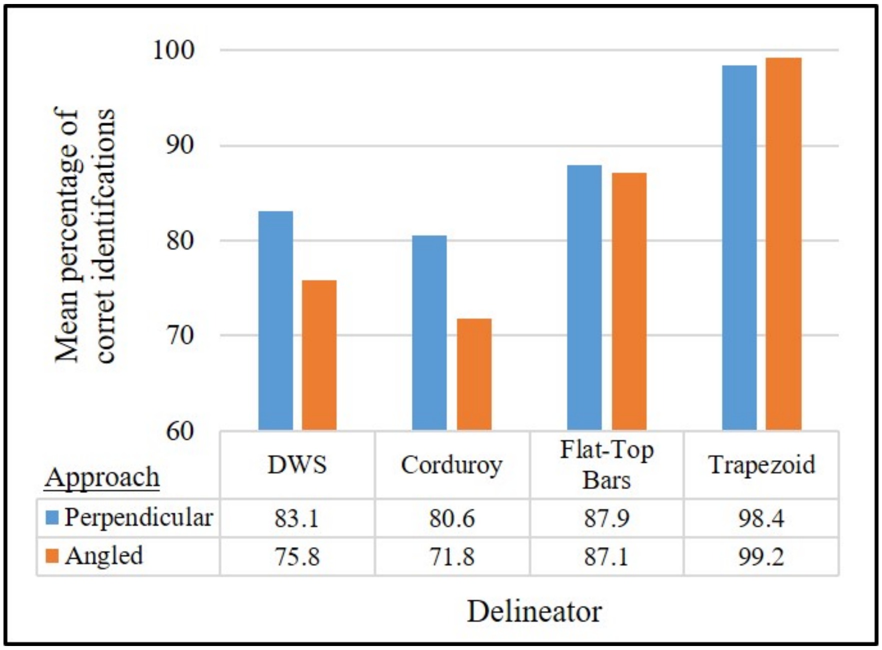


Figure 24 Percentage of trials with correct identification of the surface

In addition to identifying each surface, participants were asked to rate their level of confidence in having correctly identified the surface for every identification trial. An evaluation of the mean confidence ratings reveals a pattern of findings that very closely matches the actual performance accuracy (compare the patterns of results in Figures 24 and 25). Once again the analysis revealed no significant interaction between the effects of surface and angle of approach on participants' confidence [F(2.33,69.95) = 2.525, p > 0.05]. Participants did express greater confidence when approaching surfaces perpendicularly than from an angle [F(1,30) = 12.832, p < 0.05]. This greater confidence, though a small difference, does match the trend present in identification accuracy (the main effect of approach angle on identification accuracy was nearing significance, but was not statistically significant). There was also a main effect of surface on participants' confidence [F(2.65,79.42) = 26.769, p < 0.05], and once again, confidence was significantly higher when identifying the trapezoid than when identifying the flat-top bars, corduroy, or DWS [t(30) = 5.56, 6.36, and 7.58, respectively, p < 0.012]. Like the accuracy of judgement, the mean confidence rating in identifying the flat-top bars was greater than for the corduroy and the DWS; however, the differences in confidence ratings were not statistically significant.

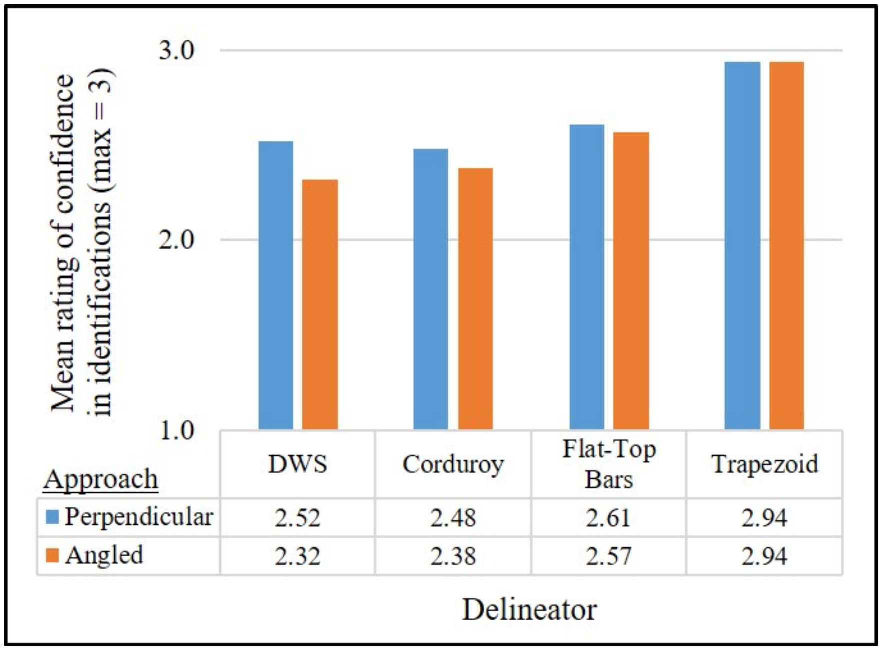


Figure 25 Mean confidence in having correctly identified the surface

As participants were making a three-option, forced-choice judgment, there was no distinction to be made between the two types of bars. Also, out of 248 total trapezoid trials (31 participants, 8 trials each), participants correctly identified it as the trapezoid on 245 of them. Also, out of 744 total trials with the other surfaces, participants only incorrectly identified them as trapezoid 7 times. Thus the trapezoid was very clearly identifiable and distinguishable from all of the other surfaces. This also means that when identification errors occurred in the other conditions, it was almost always a confusion between the DWS truncated domes and some sort of bar surface. Combine that with the fact that participants were more successful at identifying the flat-top bar surface than the corduroy, and it suggests that the flat-top bar surface is specifically more distinguishable from the DWS truncated domes than is the corduroy surface which had narrower and somewhat more rounded bars and a larger gap between the bars.

Following Trials

The final type of task participants were given was to attempt to follow each of the six surfaces at the given widths for a distance of 40 feet at a time. Participants completed this task twice, once with the surfaces on their left, and once with the surfaces on their right. While completing this task, it was recorded whether participants ever lost the surface (taking 6 steps and completing 3 full cane sweeps without contacting the surface), whether their feet ever came in contact with the surface, and whether their cane or feet ever intruded into the imagined bike lane on the far side of the delineator. For this final task, participants were only asked to attempt to follow each specific combination of surface and width two times. Thus there is less data regarding this task, and the analyses should be seen as more exploratory than those for the detection and identification tasks.

The overwhelming majority of the participants never lost any of the surfaces while following them. Of 312 total such trials, participants only lost the surface on 10 trials, and 9 of those were committed by one participant who lost multiple surfaces multiple times. Of the other 25 participants who completed the delineator-following tasks, there was only 1 instance of losing a surface out of 300 such trials. There is thus no significant influence of the type of surface [$F(3,75) = 1.228$, $p > 0.05$] or of the width of the delineator [$t(25) = 1.443$, $p > 0.05$] on likelihood to lose the delineator.

A one-way analysis was conducted to evaluate the effects of surface type on participant performance when the delineator was 12" wide (i.e., corduroy, flat-top bars, trapezoid). The analysis found no significant effects: no differences in rates of making foot contact with the surface [$F(2,50) = 1.123$, $p > 0.05$], cane intrusions [$F(1.72,43.09) = 0.553$, $p > 0.05$], or foot intrusions [$F(1.48,36.90) = 0.562$, $p > 0.05$]. A one-way analysis was also conducted to evaluate the effects of surface type on participant performance when the delineator was 24" wide (i.e., DWS, corduroy, flat-top bars). The corduroy proved somewhat more difficult to follow than the other surfaces. There was a significant effect of surface on likelihood to make foot contact with the surface [$F(2,50) = 4.587$, $p < 0.05$], with the rate of foot contact being higher for the corduroy than for the flat-top bars [$t(25) = 2.96$, $p < 0.023$]. There was also a significant effect of surface on likelihood to commit cane intrusions [$F(2,50) = 7.165$, $p < 0.05$], with the rate of cane intrusions being higher for the corduroy than for both the flat-top bars and DWS [$t(25) = 3.61$ and 2.61, respectively, $p < 0.023$]. At the level of the omnibus analysis, the mean rates of foot intrusions into the "bike lane" appears to be significantly different for the various 24" delineator surfaces [$F(2,50) = 3.261$, $p < 0.05$]; however, with the Bonferroni procedure employed for the post-hoc comparisons, no pairwise comparisons achieved statistical significance (family-wise error would need to be at 13% before a single comparison would achieve significance).

When considering differences with respect to delineators which are 12 inches versus 24 inches, participants in fact made foot contact with the 24 inch delineator surfaces ($M = 2.88$ of 6 trials; 48.0%) more frequently than the 12 inch delineator surfaces ($M = 2.12$ of 6 trials; 35.3%) [$t(25) = 2.334$, $p < 0.05$]. However, cane intrusions were far more frequent with the 12 inch delineator surfaces ($M = 3.81$ of 6 trials; 63.5%) than with the 24 inch delineator surfaces ($M = 1.88$ of 6 trials; 31.3%) [$t(25) = 4.858$, $p < 0.05$]. The mean number of foot intrusions also appeared higher with the 12 inch delineator surfaces ($M = 0.65$ of 6 trials; 10.8%) than with the 24 inch delineator surfaces ($M = 0.35$ of 6 trials; 5.8%), but the difference was not statistically significant [$t(25) = 1.316$, $p > 0.05$].

Participants' Subjective Evaluations of Surfaces

After completing all tasks, participants were asked if their experience had left them with a clear preference regarding which type of surface ought to be used as the delineator and/or which surface should not be used as the delineator. A summary of the preferences is provided in Table 5.

TABLE 5 Summary of Participant Preferences – Vision Disabled

Measure	No Preference	Trapezoid	Corduroy	Flat-Top Bars	Either Type of Bars
Is there a surface you would like to see used as the delineator?	3.2%	58.1%	6.5% (+ 9.7%)	22.6% (+ 9.7%)	(9.7%)
Is there a surface you believe should not be used as the delineator?	48.4%	19.4%	12.9% (+ 9.7%)	9.7% (+ 9.7%)	(9.7%)

METHOD – MOBILITY DISABLED

The Test Array

The test array was the same as that used for the testing of vision disabled participants (see Figure 15), except that at the time of testing mobility impaired participants only 10' of the corduroy had been installed. Thus the array was 90' long in total. As is described below, the tasks for these participants only required them to cross the surfaces, never follow them or travel along their length, and so the 10' of corduroy was more than sufficient.

Participants – Mobility Disabled

Thirty-three individuals participated in the study while using the following aids: five used manual wheelchairs of a few designs, six used power wheelchairs of a few designs, one used a power mobility scooter , two used rollator walkers (4 wheels), two used walkers with 2 wheels, one used a walker with 4 small wheels, 3 used crutches, and nine used support canes. Four individuals had walking difficulties but used no aid while participating. All participants traveled independently, although the independent travel of some was limited primarily to travel between their origin and destination via a nearby vehicle. Participants varied in age, sex, race or ethnicity and frequency or extent of independent travel. For reasons described in the results section, data from three participants was excluded from the analyses (one power wheelchair user and two participants who used support canes).

Procedure – Mobility Disabled

On arrival at the test site at Pier 38, participants signed the consent form and were given a debit card for $100. All participants then completed the experimental procedure individually. They were accompanied by Linda Myers, Certified Orientation and Mobility Specialist, who gave them instructions, asked for their feedback, and ensured their safety. Alan Scott, PhD, followed closely, recording observed performance, responses to structured questions, and additional feedback. (See Appendix B for the detailed protocol for mobility disabled participants.)

Participants who were mobility disabled were first asked to cross the truncated dome detectable warning surface, over and back, and rate their experience in crossing this surface.

- Did crossing over the truncated domes make you feel at all unstable?
  - If yes: Using scores from 1 to 5, please rate how unstable it made you feel.
    - 1 = just a little bit unstable, up to a score of 5 = very, very unstable
- Did crossing over the Truncated Domes cause you to experience any physical discomfort or pain?
  - If yes: Using scores from 1 to 5, please rate how much physical discomfort or pain you experienced.
    - 1 = just a little discomfort, up to a score of 5 = intense pain
  - If yes: Please describe the physical discomfort or pain.

Participants were then asked to cross each of the other five surfaces two times. Order for crossing the surfaces was counterbalanced across participants. Before being asked to make any crossings, participants were told that if after they saw a surface they did not think it would be safe to cross, they could decline to cross it. They were also informed that if after crossing a surface one time, they found the surface difficult or uncomfortable, they should inform the experimenter and they would not be asked to cross it again. After each back and forth crossing of a surface, they were asked to rate their experience in crossing that surface relative to their experience crossing the detectable warning surface. The following questions and scales were used.

- Did crossing this surface require any more effort than crossing the Truncated Domes?
  - If yes: How much more effort did this surface require?
    - 1 = just a little bit more effort, 2 = a fair amount more, 3 = a great deal more
- Did crossing this surface make you feel any more unstable than when crossing the Truncated Domes?
  - If yes: How much more unstable did this surface make you feel when crossing it?
    - 1 = just a little bit more unstable, 2 = a fair amount more, 3 = a great deal more
- Did crossing this surface cause you any more physical discomfort or pain than crossing the Truncated Domes?
  - If yes: How much more physical discomfort or pain did you feel when crossing this surface?
    - 1 = just a little bit more discomfort, 2 = a fair amount more, 3 = a great deal more

Participants were then asked whether they would be comfortable repeating the procedure. They were offered the opportunity to rest and to have refreshment before beginning again. Two participants were not given the opportunity to repeat the procedure because of insufficient time.

Following all crossings, participants were asked some questions about crossing the surfaces.

- Is there one surface you would most like to see used as a divider?
- Is there one surface you would most definitely not like to see used as a divider?
- For the flat-top bars and the corduroy, you crossed some in which the surface was 12" across, and some in which the surface was 24" across. Did it matter to you whether they were 12 or 24"?
- Do you have any other comments or suggestions?

Measures - Mobility Disabled

In addition to recording the answers to questions about their experiences crossing the surfaces, the following data were recorded for each of the four crossings of each surface.

- Whether participants crossed the entire width of the surface
- Whether participants crossed continuously. Indicators that they did not cross continuously included:
  - they appeared to hesitate before crossing
  - they paused to reposition their device while crossing in a way which was different then how they positioned and repositioned their devise when travelling over the brushed concrete surface
  - Their device appeared to get "stuck" in the surface
- Whether there was any indication of instability of the person or the device while crossing; indicators of instability included:

    - wobble in device
    - decrease in trunk stability
    - apparent adjustment in balance so as to avoid a fall
- Whether participant requested assistance or required intervention to prevent a fall

RESULTS – MOBILITY DISABLED

Analyses
The reported analyses are a series of one-way repeated-measures ANOVAs and dependent t-tests. When the assumption of sphericity was not met for any ANOVA effect, the Huynh-Feldt correction was applied when epsilon was greater than 0.75, and the Greenhouse-Geisser correction was applied when epsilon was less than 0.75 (see Girden, 1992). Post-hoc comparisons were conducted using Bonferroni corrections with the family-wise error rate set at 0.07. In all cases, the "p >/<" statements report the alpha value which was used to evaluate the statistic, thus in the case of Bonferroni corrections this is the adjusted alpha value.

The analysis included data from 30 of the 33 total participants. Two participants completed only half of planned trials before not being allowed to continue due to time constraints (e.g., late arrival and start of one participant combined with the need to start the next scheduled participant on time).They both had crossed all surfaces twice and would have been willing to make additional crossings if time had permitted. One participant asked to stop part way through the second round of trials citing general fatigue and knee discomfort. The participant described needing two knee replacements due to arthritis in both knees. She expressed that this sort of discomfort was typical any time she did a fair amount of walking, and she was one of only four participants to report experiencing pain when crossing the detectable warning surface to which other surfaces were being compared. Not finding any evidence of treatment-related or other systematic reasons for the incomplete data sets of these three participants, and thus following rather standard practices, the incomplete data sets were excluded from the analyses.

Willingness to Attempt to Cross
It was explained to participants that if they ever felt that they could not cross a surface safely, they could inform the experimenter and they would not be asked to cross. It was additionally specified that if after they had crossed the surface the first time, they did not wish to cross the surface again, they could inform the experimenter and they would not be asked to cross. Participants were, in fact, told that if they felt any surface would be unsafe, difficult, or uncomfortable to cross the first time or on any subsequent trial, they should tell the experimenter and they would not be required to cross. Therefore, if a surface required an uncomfortable degree of effort, or caused the participant pain, or made a participant feel unstable particularly to the point that they feared tripping, tipping, and/or falling, it was expected that they would decline to cross the surface. Not once in the 720 trials did a participant request to not cross a surface. See Table 6 for a summary of this and other participant performance measures.

Participants were allowed to ask for assistance or support if that is something that they would often do (e.g., if someone might take the arm of a travel companion) or if they simply wished to cross a surface in the study but felt unsure about doing so without support or assistance. For only 2 of the 720 trials did a participant request such assistance (one participant, on two trials crossing the trapezoid, asked to hold the arm of the experimenter when crossing). Subjectively, aside from those two trials in which the request for support occurred, the experimenters noticed very little if any evidence of reluctance or hesitation by any participant to attempt to cross any of the surfaces.

TABLE 6 Summary of Participant Performance – Mobility Disabled

Measure*	24" Delineators			12" Delineators		
	Detectable Warning	24" Corduroy	24" Flat-Top Bars	12" Corduroy	12" Flat-Top Bars	Trapezoid
Mean # of attempts to cross (0-4 attempts)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)
Mean # of independent attempts to cross (0-4 attempts)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)	3.93 (98.3%)
Mean # of complete crossings (0-4 attempts)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)	4.00 (100%)
Mean # of continuous crossings (0-4 attempts)	3.77 (94.2%)	3.53 (88.3%)	3.67 (91.7%)	3.73 (93.3%)	3.70 (92.5)	3.50 (87.5%)
Mean rating of instability (0-3 scale)	0.01	0.03	0.00	0.00	0.00	0.06
Number of trials in which any instability was noted (120 trials per surface)	1 (0.83%)	3 (2.5%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	6 (5.0%)

** There were no statistically significant differences on any of these measures for performance on the six surfaces.*

Ability to Cross Over the Tactile Surface
If a surface proved to be a barrier to travel for some users, then some participants on some trials were expected to be unsuccessful in independently crossing one or more of the surfaces. Not once in the 720 trials did a participant fail to cross over the entire tactile surface they had attempted to cross.

Ability to Cross Continuously
Using each participant's movement as they travelled over the plain cement as a baseline, observations were made to assess whether the participant was able to cross the surface in a continuous manner; thus were they able to cross without needing to significantly alter their manner of movement, and could they cross without the surface affecting their manner of movement. For example, a participant using a walker may have walked in a rather continuous manner while sliding the walker over the concrete, but then found that the wheels and/or legs of the walker hung up on the surface, requiring them to pause their forward movement, lift the walker over some or all of the surface, step forward, and then possibly repeat. This then would be recorded as a disruption to their progress (i.e., not a continuous crossing), but this might be done in such a manner that the participant showed no signs of instability (instability was evaluated separately). Additionally, this measure on continuity serves to identify instances of

hesitation, or instances in which the participant needed to engage in thoughtful or attentive effort (e.g., pausing in order to prepare for a particular movement).

There were no significant differences between the average number of four crossings of each surface in which participants crossed continuously [$F(1.96, 56.78) = 1.462$, $p > 0.05$]. The observed rates ranged from an average of 3.77 (out of 4.00, thus 94%) crossings of the DWS made in a continuous manner to 3.50 crossings (87.5%) of the Trapezoid made in a continuous manner. In total, participants were observed to cross the surfaces in a continuous manner on 91% of all crossing (657 out of 720).

Experimenter Ratings of Instability

As participants crossed each surface, an experimenter looked for any evidence of instability. The instability was rated using a 3-point scale, with a zero indicating no evidence of any change in stability as compared to when they were travelling on the brushed concrete leading up to the surface, and a 2 being significant instability (e.g., evidence of a near fall while crossing the surface). A score of 1 was used for everything in between (e.g., any noticeable loss of balance, and any visible pitching forward or back, or visible tipping to one side or the other, which was different than any observed when travelling on the brushed concrete leading up to the surface). Averaging each participant's scores for their four trials with each surface, and then averaging all such scores for all participants on each surface, the mean instability score was 0.06 or lower (again, could range from 0 to 2) for all six surfaces. Out of 720 crossings of the 6 surfaces, only 10 times was any instability noted, thus a score other than zero was assigned for fewer than 1.5% of all crossings.

The validity of a repeated-measures ANOVA to assess if differences in rated stability existed for the crossings of the different surfaces is challenged by having three conditions with no variability (all instability scores were zeros for 12" corduroy, 12" flat-top bars, and 24" flat-top bars). Ignoring such concerns, the ANOVA did not reveal any significant differences between the average instability scores for any of the six surfaces [$F(1.37, 39.72) = 2.365$, $p > 0.05$]. Because of the challenges to the validity of the ANOVA, and in order to further investigate these ratings, single-sample t-tests were used to consider whether the observed non-zero means for detectable warning, 24" corduroy, and trapezoid were in fact significantly different than zero. None of these tests was statistically significant at alpha = 0.05 [detectable warning, $t(29) = 1.000$: 24" corduroy, $t(29) = 1.795$: trapezoid , $t(29) = 1.756$]. Thus in considering all of the results, it suggests that the stability ratings for the six surfaces did not significantly differ from each other, nor did any of them significantly differ from zero (i.e., no statistical evidence of increased instability which can be attributed to any one of the tested surfaces).

With 720 total crossings of these tactile surfaces, there were zero falls and zero instances of experimenter intervention which prevented what would have likely been a fall. Of the 10 instances in which instability was noted, 9 were instances of momentary instability which the participant rather quickly corrected.

There was one instance of a near fall. One participant who used a manual wheelchair, sat leaning way forward and pulled the chair with his feet (never using his hands to propel the chair). By leaning forward in such a manner, the center of gravity was out over the small front wheels, and as those wheels contacted the front tapered surface of the trapezoid, they were so weighted as to not allow them to travel up the beveled edge. As a result, the wheels stopped when they made contact, and the participant's momentum caused the chair to tip significantly forward;

however, the participant was able to regain his balance without assistance. It seems worth noting that this occurred on his first-ever attempt to cross the trapezoid. He made three additional crosses of the trapezoid throughout the remainder of the study, one rather immediately after this first, and then two more a bit later in the study session. He never asked not to cross the surface, and he made all additional crossings in a rather continuous manner and without any evidence of instability.

Subjective Participant Assessments

After crossing over the detectable warning surface two times, participants were asked whether crossing the surface caused them to feel at all unstable, and whether it caused them any pain. A score of zero was recorded if they answered “no,” and if they answered “yes,” they were asked to rate how unstable/painful it was from 1 to 5. Thus the resulting scale was a 6-point scale from 0 to 5. Participants crossed the detectable warning twice at each of two different points in the study, and they were asked these two questions after each pair of crosses. Their answers to each question at these two points in time were then averaged to obtain final self-assessment scores for instability and pain. In considering all 30 participants, the mean score for instability was 0.25 and the mean score for pain was 0.10.

After crossing over each other surface two times, participants were asked whether crossing the surface required any more effort than it took to cross the detectable warning, whether crossing the surface made them feel any more unstable than they felt when crossing the detectable warning, and whether crossing the surface caused them any more physical discomfort or pain than they experienced when crossing the detectable warning. A score of zero was recorded if they indicated no more effort/unstable/discomfort, and if they indicated that it was more, they were asked to rate how much more 1 to 3 (a little bit more, a fair amount more, a great deal more). Thus the resulting scale was a 4-point scale from 0 to 3. Participants crossed each surface and width twice at each of two different points in the study, and they were asked these three questions after each pair of crosses. Their answers to each question at these two points in time were then averaged to obtain final self-assessments for the comparative amount of effort, instability, and discomfort in comparison to crossing the detectable warning.

There was evidence to suggest that the responses being provided in many cases were not valid with respect to the descriptors participants were asked to use (i.e., a little bit more, a fair amount more, or a great deal more). For example, a participant would confidently walk across a surface, would do so quickly and with no evidence of any disruption to their normal travel, nor any observed evidence of instability or discomfort. However, in some such instances, participants would then respond to questions by indicating that the surface caused them a "great deal more discomfort or pain than that caused by the detectable warning" or made them feel "a great deal more unstable" or required "a great deal more effort." Experimenters judged that in a significant number of cases, the subjective assessments did not seem to reflect what they had observed. Note that despite participants reporting that certain surfaces caused them “a great deal more pain” or made them feel “a great deal more unstable,” every participant who was asked to cross the same surface at a later point in the study did so with no observed hesitation. Having no way to objectively judge valid from invalid responses, all ratings provided by participants were included in the analyses reported herein, and thus the means are likely inflated relative to the descriptive terms. It may well be that participants were doing some degree of comparative rating and thus differences in how they rated their experiences with different surfaces is likely informative; however, caution should be used in interpreting the numbers relative to the descriptors (i.e., a little bit more, a fair amount more, a great deal more). Table 7 provides a summary of these comparative ratings.

TABLE 7 Summary of Participant Ratings in Comparison to Crossing the Detectable Warning Surface – Mobility Disabled

Measure	12" Corduroy (a)	24" Corduroy (b)	12" Flat-Top Bars (c)	24" Flat-Top Bars (d)	Trapezoid (e)
Mean rating of how much more effort it took to cross the surface compared to effort needed to cross the DWS (0-4 scale)*	0.37 - b,e**	0.67 - a	0.45 - e	0.65	1.13 - a,c
Mean rating of how much more unstable participants felt when crossing the surface compared to when crossing the DWS (0-4 scale)*	0.45 - e	0.62 - c,e	0.35 - b,e	0.62	1.22 - a,b,c,e
Mean rating of how much more discomfort or pain the participants experienced when crossing the surface compared to when crossing the DWS (0-4 scale)	0.23	0.35	0.23	0.37	0.55

** Significant differences were present between some treatments (p < .05), see text for details.*
*** For a given measure, letters in individual cells indicate those conditions against which performance significantly differs [e.g., mean rating of effort with 12" Corduroy (b,e) significantly differs from the rate for 24" corduroy (b) and the rate for trapezoid (e)].*

Effort
The amount of additional effort reported to cross each surface as compared to what it took to cross the detectable warning did significantly differ for the various surfaces/widths [$F(2.27, 65.70) = 8.134$, $p < 0.05$]. The mean scores in each condition are shown in Table 7 [the scale includes 0 (no more effort to cross the surface than was needed to cross the detectable warning), 1 (a little more effort), 2 (a fair amount more effort), and 3 (a great deal more effort)]. Those differences which are significant are between the 12" and 24" of corduroy [$t(29) = 3.674$, $p < .007$], and between the trapezoid and both the 12" of corduroy and 12" of flat-top bars [$t(29) = 3.776$ and $t(29) = 3.371$, respectively; $p < 0.007$].

Instability
The amount of additional instability reported when crossing each surface as compared to what was experienced when crossing the detectable warning did significantly differ for the various surfaces/widths [$F(1.93, 55.86) = 11.669$, $p < 0.05$]. The mean scores in each condition are shown in Table 7 [the scale includes 0 (no more unstable crossing the surface than when crossing the detectable warning), 1 (a little more unstable), 2 (a fair amount more unstable), and 3 (a great deal more unstable)]. Those differences which are significant are between the trapezoid and all other surfaces: 12" corduroy, 24" of corduroy, 12" of flat-top bars, and 24" of flat-top bars [$t(29) = 4.446, 3.095, 4.521$, and 2.983, respectively; $p < 0.007$], and between the 12" flat-top bars and 24" corduroy [$t(29) = 3.002$, $p < 0.007$].

Discomfort or Pain
The repeated-measures ANOVA suggests a significant difference may exist for the various surfaces/widths between the amounts of additional discomfort or pain reported when crossing each surface as compared to what was experienced when crossing the detectable warning [$F(2.43, 70.33) = 3.246$, $p < 0.05$]. However, when using the Bonferroni procedure to address concerns of family-wise error, no comparisons meet the threshold for significant difference. The mean scores in each condition are shown in Table 7 [the scale includes 0 (no more discomfort crossing the surface than when crossing the detectable warning), 1 (a little more discomfort), 2 (a fair amount more discomfort), and 3 (a great deal more discomfort)].

Summary of Participants' Subjective Assessments
Except for only two measures of a single surface, the trapezoid, the mean rated effort, stability or discomfort was less than 1 (i.e., on average, less than "a little more" effort, instability, or discomfort than when crossing the detectable warning surface). The mean ratings for both effort and instability with the trapezoid were significantly higher than those for some other conditions; however, the mean ratings of effort and instability for trapezoid were less than 1.25. Thus while statistically significant differences exist between mean ratings of effort and instability between those for the trapezoid and for some other surfaces, it is questionable whether those differences are of practical significance. Also, recall that the means are likely to be inflated relative to the actual experiences of participants as they relate to the specific descriptors participants were asked to use (i.e., 1 = a little more, 2 = a fair amount more, 3 = a great deal more).

Final Participant Evaluations of the Surfaces
After completing all tasks, participants were asked a few questions regarding their feelings about the flat-top bars, corduroy, and trapezoid, and were also asked about the different widths of the treatment installations. When asked if there was one surface they would most like to see used as a divider, or if they had no specific preference, 37% had no preference, 27% selected the corduroy, 23% selected the flat-top bars, and 13% selected the trapezoid. When asked if there was one surface they hope would not be used as a divider, or if they thought any of them were fine, 23% said any of them would be fine, 7% selected corduroy, 7% selected flat-top bars, and 63% selected the trapezoid. Participants were also asked whether, for the flat-top bars and the corduroy, they had a preference for 12" or 24" for the width of the dividing surface. 27% had no preference, while 37% preferred 12" and the other 37% preferred the 24". See Table 8 for a summary of these preferences.

TABLE 8 Summary of Participant Preferences – Mobility Disabled

Measure	No Preference	Corduroy	Flat-Top Bars	Trapezoid	12"	24"
Specific preference for one of the three surfaces?	37%	27%	23%	13%	NA	NA
Specific desire to not see one of the three surfaces used?	23%	7%	7%	63%	NA	NA
Preference for 12" or 24" surfaces?	27%	NA	NA	NA	37%	37%

Unsolicited comments from several participants with mobility disabilities were that they "don't care what the surface would be, as long as it truly discourages cyclists from riding on the sidewalk." "Bikes scare me because I can't move out of the way fast enough." "Bikes scare me because I can't hear them coming."

In conclusion, although more than 50% of participants preferred that the trapezoid not be used for a delineator, there is no evidence that any of the surfaces would be a barrier to crossing by people with mobility disabilities. The small observed magnitudes of the differences between participants' mean ratings of effort, instability, and discomfort or pain, combined with how those mean scores relate to the underlying scale, call into question the practical significance of any of the observed differences. There was also no meaningful difference in their willingness to cross the surfaces when given an alternative of not crossing, or in their actual independent crossing of the surfaces, continuity of crossing, or observed stability. All 30 participants readily crossed each surface four times.

DISCUSSION

The City of San Francisco's goal for this research was to evaluate potential delineators to be used between the pedestrian and cycle sides of the separated bicycle lane (SBL) at sidewalk level designed for Better Market Street. The necessity for having a good delineator was especially indicated by the fear of bicycles on the sidewalk expressed in unsolicited comments from participants with disabilities.

The delineator needs to be something other than the detectable warning surface (DWS) used in San Francisco, but needs to be at least equivalent to that DWS in detectability by vision disabled pedestrians. The delineator also needs to be crossable by people with mobility disabilities, and it should be as narrow as possible.

Considering detection by either long cane or foot, all of the three alternative surfaces (flat-top bars, corduroy, and the trapezoid) were as detectable to participants with vision disabilities as DWS, regardless of width. It is appropriate to put primary emphasis on detection by cane <u>and foot</u> because a large majority of pedestrians having vision disabilities do not use a long cane, relying on foot detection or low vision to detect changes in walking surfaces. All three surface alternatives, as well as the DWS, were on average detected on more than 94% of trials by visually disabled participants. There was no significant difference between the mean rates of detection by cane or foot for the different surfaces at the tested widths.

In addition, all surfaces were crossed four times, with no observed hesitation or reluctance to cross, by all participants having mobility disabilities, although the trapezoid was generally not their preferred surface for use as a delineator. So any of the surfaces could be selected as a delineator for SBLs at sidewalk level on the two broad criteria of detection by long cane or foot and crossability by people with mobility disabilities.

Prior research on detectability of DWS has primarily been based on 90 degree approaches, yet, in the context of use on a SBL, it is extremely important that when encountered at an angle, the delineator is easily detectable and identifiable as a delineator. Pedestrians with vision disabilities usually will be intending to walk on the sidewalk, parallel with the bicycle lane, and will encounter the delineator only when they accidently veer toward the bike lane. In this case, it is an unpredictable encounter, and it will be important for them to recognize the delineator as indicating that there are bicycles on the other side, and that it is not a place to cross. An unexpected encounter with DWS would usually mean they had arrived at a place to cross. So high detectability when approached from an angle, and accurate identification of the surface as a delineator and thus discriminability from DWS, are very important considerations. Considering detection by either long cane or foot, narrow angle approaches resulted in higher rates of detection than perpendicular approaches.

Dog guide users have only foot information to detect and identify walking surfaces. While the small number of dog guide users makes it inappropriate to consider their performance as more than exploratory, their results for detection of the surfaces are generally in the same direction as those for participants using long canes. In many cases the dog guide users, using the Juno system in which a skilled dog guide trainer holds the dog's harness and guides the handler who is vision disabled, announced that they had detected a surface and came to a stop after they had stepped beyond it into what would be the bicycle lane. This was probably because, on average, dog guide users travel faster than long cane users and so in the time between contacting the surface, recognizing it as a unique tactile surface, and then announcing that they detected it, they covered more distance on average than the cane users. So for the dog guide users it is most appropriate to compare the means for trials on which the surface was not detected. There were no significant differences between the rates of failing to detect the different surfaces i at the tested widths.

With regard to identification of the surfaces, recall that participants were only asked to identify each surface as "domes," "bars," or "trapezoid," and not to distinguish between the two raised bar surfaces. Participants were significantly more accurate in identifying the trapezoid (mean identification accuracy was 98.8%) than in identifying the other three surfaces. DWS and bars were often confused with each other. Participants were also significantly more successful in identifying flat-top bars as bars than identifying the corduroy as bars; and given the patterns of errors, this means that the corduroy bars were more often indistinguishable from the truncated domes of DWS. Ratings of confidence in identification closely paralleled the performance accuracy.

This research included a unique measure of cane or foot intrusion into the bicycle lane. This is an especially important consideration for selection of a delineator for SBLs. Any sort of intrusion introduces the possibility of collisions, and because bicycles are essentially inaudible, pedestrians with vision disabilities who are in a bicycle lane may make no attempt to avoid conflicts or crashes. In addition to intrusions in which a pedestrian is physically in the bike lane, the intrusion of a long cane into bicycle spokes is very likely to cause the cyclist to crash, and the cane itself may also injure the vision disabled user. While any amount of cane intrusion does introduce the possibility of such conflicts, it was considered that when a cane tip is in contact with the ground and only one or two inches into the bike lane, the risk may be rather low. Thus cane intrusions were defined in this research as instances in which the tip of the cane extended 6 or more inches past the far edge of the delineator surface.

There were significantly more cane intrusions on approaches to 12 inch wide surfaces than to 24 inch wide surfaces. There were also significantly more cane intrusions on 90 degree approaches than 25 degree approaches. The pattern was the same for foot intrusions by cane users, but no significance was achieved because of the lower overall rates of foot intrusions. The rates of intrusions were much higher for dog guide users (using the Juno system), probably because they had only foot information available and because of their generally faster rate of travel. However, no significant differences attributable to surface were found for dog guide users when considering total detection rate (i.e., detection with feet, announced while feet were in contact with the surface or just after crossing to the other side). There was some observed differences in the rates, and the lack of statistically significant differences may well be because of the low sample size.

In locations where there is no furnishing zone between pedestrians and bicycles on a SBL at sidewalk level, it is quite likely that pedestrians who are vision disabled, especially those having little or no vision, will use an SBL delineator as a guidance surface once they have encountered it. There are limited areas in the design of Better Market Street in which there is no furnishing zone between pedestrians and bicycles; however, in the design it does occur regularly at the beginning and end of blocks. Therefore a test of following the surfaces was conducted. The primary issues related to choice of a delineator surface in this case are whether one surface is easier to follow than another and whether there are more intrusions when following one surface than another.

Participants very seldom lost contact with any of the surfaces. There was no difference in rates of successfully following the surfaces for 40' attributable to the surface type or the width of the surface. However, there was a difference in cane intrusions. Cane intrusions were significantly more frequent with the 12 inch surfaces than with the 24 inch surfaces, so if a 12 inch wide surface is selected, more conflict with bicycles can be expected than with a 12 inch wide surface.

A majority of all participants having vision disabilities preferred the trapezoid as a delineator (58.1%). Flat-top bars were the second-most selected surface (22.6%, with an additional 9.7% indicating a preference for either type of bars (flat-top or corduroy)). When asked if there was a surface which they believed should not be used as the delineator, nearly 50% expressed not having specific opposition to any of the surfaces. For those who did identify a surface to which they were somewhat opposed, corduroy was most often indicated, though the rates were relatively equal for all three surfaces.

With regard to whether the surface is a barrier to crossing by people having mobility disabilities, there were no significant differences in their willingness to cross the surfaces (they always had the option to not cross), or in their independence when crossing the surfaces, continuity of crossings, or observed stability. There were also no meaningful differences between participants' mean ratings of comparative effort, instability, and discomfort or pain (compared to when crossing DWS) between the different delineator surfaces. There were a few statistically significant differences, but the magnitudes of those differences were small and all mean ratings for all measures and all surfaces were at 1.22 or lower on a scale in which a 1 indicated "a little bit more" effort/instability/discomfort. Although more than 50% of mobility disabled participants preferred that the trapezoid not be used for a delineator, there is no evidence that any of the surfaces would be a barrier to crossing by people with mobility disabilities. All participants readily crossed each surface four times.

CONCLUSION / RECOMMENDATION

The Recommended Surface Based on Human Factors Testing is a Raised Trapezoid

The trapezoid tested in this research was 10.08 inches (256.03mm) wide at base, 6.33 inches (160.78mm) wide at top, and 0.75 inches (19.05mm) high measured from the base surface, on 12" wide tiles, as tested in this research.

The mean rates of detection by either long cane or foot were not significantly different for any of the surfaces, and all were at or above 94.8%, so <u>all of the surfaces tested meet the criterion of detectability equal to DWS.</u> While detection of the trapezoid by cane was more difficult than detection of other surfaces, a difference which is almost entirely due to greater difficulty with detection by cane when approaching from 90°, detection by cane *or foot* was excellent for either angle of approach. The mean rates of detection of the trapezoid and the 24" wide flat-top bars were equivalent when considering detection by cane or foot, but the mean rate of detection was significantly higher for the 24" flat-top bars (24" FTB) than the trapezoid when only cane detection is considered. However, the advantage of the flat-top bars for cane detection was not seen in the 25° approaches, which are most relevant to the travel pattern on SBLs as a traveler who is vision disabled might accidently veer towards the bike lane while intending to walk on the sidewalk parallel to the delineator.

On surface detection trials, the occurrence of cane intrusions beyond 6" into what would be the bike lane were also noted, as were any degree of foot intrusion. The ideal case for a SBL delineator would be that the delineator would be detected early enough by either cane or foot to avoid the cane or foot intruding into the bike lane. The rate of cane intrusions on approaches to the 24" FTB was significantly lower than the rate for such intrusions with the trapezoid. Foot intrusions followed the same pattern as cane intrusions, but occurred far less frequently overall, and the differences between rates of foot intrusions for the different delineator surfaces were not statistically significant.

In addition to the detection task, all participants (cane users and dog guide users) performed a surface identification task. Participants stepped onto and off of each surface eight times, each time being allowed to explore the surface underfoot for only a couple of seconds. Participants stepped onto the surfaces from various directions, and each time, they were asked to identify the within three categories – domes (the DWS), bars (either the corduroy or the flat-top bars), or trapezoid. The mean rate of correct identification of the trapezoid was 98.8%, a rate which is significantly better than for any other surface, including the 24" FTB (87%) and DWS (79.4%). Every time a participant identified a surface, they were also asked to rate their confidence in their identification on a 3-point scale (1=not at all confident; 2=somewhat confident; and 3=very confident). Confidence ratings matched accuracy for identification. Thus the <u>trapezoid was quickly and confidently identified</u> as the trapezoid, and thus not mistaken for the DWS or any kind of bars. Accuracy of identification was also high for the 24" FTBs, but it was significantly lower than for the trapezoid.

Participants with mobility disabilities were asked to cross each surface four times, and to compare crossing it with crossing the DWS for amount of effort, instability, and discomfort or pain. They were given the opportunity to <u>not cross</u> any surface that looked like it would be unsafe, or to not cross it again if, after the first crossing, they did not want to cross again because it was difficult or made them feel uncomfortable. Certainly, participants could elect to not cross any surface for any reason.

All participants crossed all surfaces four times, with little observable difference in their travel as compared to how they travelled over brushed cement. However, participants' ratings of crossings for effort, instability and discomfort or pain, in relation to crossing the DWS, indicated a small difference from the DWS. When asked if there was one surface they would most like to see used as a delineator, or if they had no specific preference, 37% had no preference, 27% selected the corduroy, 23% selected the flat-top bars, and 13% selected the trapezoid. When asked if there was one surface they hoped would not be used as a delineator, or if they thought any of them were fine, 23% said any of them would be fine, 7% selected corduroy, 7% selected flat-top bars, and 63% selected the trapezoid. Thus, while <u>no surface could be considered a barrier to crossing by people having mobility disabilities,</u> the trapezoid was least preferred.

There was nothing outstandingly positive about the corduroy surface, considering both the objective and subjective measures for the various user groups. Performance with the corduroy was quite good on some measures, but in consideration of all measures and all user groups, behaviors and ratings with the corduroy tended to be as good or worse than with the flat-top bars. Therefore, of the two bar surfaces, the flat-top bars appear to be more effective and preferred, and thus corduroy is not receiving further consideration.

Thus the two best-performing surfaces for vision disabled participants were the 24" FTB and the trapezoid. The trapezoid was the most preferred surface for vision disabled participants. In considering the objective measures used in the research, both the 24" FTB and the trapezoid performed very well in many ways, including both surfaces leading to excellent overall detection rates (detection by cane or foot) which were statistically equivalent. This was true for cane users, and also in the more limited sample of dog guide users. On some other measures, the 24" FTB led to better outcomes (e.g., higher rate of detection by cane, lower rate of cane intrusions), while on other measures, the trapezoid led to better outcomes (e.g., higher rate of identification accuracy, and greater confidence when identifying it). There are then a number of additional reasons why we recommend the trapezoidal surface, as tested in this research, instead of the 24" FTB surface:

- The significantly more accurate discrimination of the trapezoid from either the DWS or bars is an important indicator of the trapezoid's likely success when in use as a delineator. The delineator needs to be readily identifiable as a surface that means to any pedestrian that they should not cross this surface because they will be at risk of colliding with a bicycle.
- It is likely that a FTB surface will be recommended as a guidance surface in the US as it already is internationally. If the delineator is also FTBs, it would not have a clear meaning. The delineator needs to be interpreted as "don't go here," while the guidance surface should be interpreted as "this is a safe path for you to travel; it is OK to cross it and walk on either side; both sides are intended for pedestrians."
- Because the trapezoid is three times as high as the 24" FTB, it "looks" more like a barrier though it is not a barrier even to people having mobility disabilities. It is expected that the trapezoid will be more likely to discourage both pedestrians and cyclists from crossing the delineator.
- The 12" width of the trapezoid (width of tile) means that it will require half as much right-of way, and the cost of installation and maintenance will be less than for 24" FTBs.
- There is a down side to the adoption of the trapezoid as the delineator—cane intrusions into the cycle lane are more likely to occur than with the 24" FTB. However, there are numerous possibilities for markings or other treatments on a narrow portion of the cycle track adjacent to the trapezoid that might discourage cyclists from riding immediately beside the delineator.

Toward a California and U.S. Standard for a Delineator for Separated Sidewalk-Level cycle tracks

Because the raised trapezoid has been demonstrated to be highly detectable from various angles of approach, and it is highly discriminable from the guidance surface that is most commonly used in the U.S. as well as from truncated dome DWS, it is appropriate to seek standardization for the raised trapezoid for use as a delineator for sidewalk-level SBLs. It will be a unique and highly recognizable surface indicating to pedestrians that they should not cross because they risk collision with bicycles (or other micro-mobility devices) on the opposite side.

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Appendix A

Better Market Street Project Protocol—Vision Disabled

The participant will be met by an experimenter on arrival, and the three experimenters introduced, Linda Myers, Alan Scott, and Beezy Bentzen. The experimenter will confirm that the participant has read the consent form, and answer any questions. If the consent has not been read, the experimenter will read it to the participant. The participant will be asked to sign the consent which includes an optional permission to take photos or video.

The participant will then be given an honorarium in the form of a debit card for $100.

If there is or may be an observer present, the participant should be asked whether they are comfortable being observed. The observer will be introduced to participant either before or after the experiment—not in the middle. If the participant is not comfortable being observed, the observer will be requested to leave. Observers will be asked to remain at a good distance from participants, and not to interact with them during the experiment and debriefing.

The experimental set-up will be explained to the participant.

As part of Better Market Street re-development project the bicycles will move out of the street onto the sidewalk. We want to make sure there is a divider between pedestrians and bicycles that is detectable to vision disabled pedestrians and distinguishable from truncated dome detectable warning surfaces.

We will have you do five tasks today. To test how detectable each surface is we will have you locate a surface and stop. To test if the surfaces are distinguishable from the truncated domes we will have you step onto a surface and identify it and the last task will be to follow the surfaces.

There are four different tactile surfaces. First I want you to have a chance to get familiar with each of these four tactile surfaces so you can see what they feel like under your feet. I'll guide you to each one. You should explore it both under foot and with your cane to see whether you can tell whether it is domes, bars of some kind, or the trapezoid. [They may explore it with a hand if they want to.]

One is a truncated dome detectable warning surface that is found at found at the the bottom of many curb ramps and at the edge of transit platforms. Show DWS

Are you familiar with this warning surface? The truncated dome detectable warning surface will continue to be used at ramps and transit platforms and we are looking for something different to be used for the divider.

There are three other surfaces that we are considering recommending for a divider between the pedestrian and bicycle sides of the shared bicycle lane at sidewalk level.

One is a surface that is a single, wide, raised trapezoid. (A trapezoid is a shape that is wider on the bottom than on top and is flat on top.) Show surface.

There are also two types of bars we are testing. One is a surface of flat-topped bars and the other one is a surface of somewhat rounded bars. Show rounded and flat top bars.

Now I'm gong to explain the first task. I will guide you to a starting point. When I tell you you're all set, please walk straight forward until you find one of the surfaces with your

cane or your foot. The surface may be in front of you, or somewhat to your left or to your right, but you will reach it if you travel straight. Use any cane technique you choose and stop just as quickly as you can when you detect a surface; this may mean that if you detect the surface with your cane, but you never actually stop on the surface with your feet. You don't have to know or determine what the surface is.

To summarize, when I say "go", travel straight ahead and as soon as you detect the surface with either your cane or foot, stop and say "I found it." Having heard these instructions, what are you going to do when you detect the surface with your cane or foot?

(stop and say I found it)

Do you have any questions?

Now I'll guide you to the (first) starting point, and make sure you are facing in the direction we need you to walk. [Guide S, check facing direction, give starting cue.] **You're all set.** [1st round of 18 detections. Repeat any that were mis-trials for any reason, taking cue from Alan.]

Now we are going to move on to a second task. We are looking for a surface that is quickly identifiable underfoot.

So, I would like you to try to discriminate between the domes, the trapezoid, or any kind of bars using your feet. Please do not touch the surface with your cane.

I'll first guide you to each one so you can recall what each one feels like. [Guide to each surface-maybe the long samples—and encourage foot exploration, primarily, but not exclusively.]

Now, I'll guide you onto a surface, we will step on together and after a couple of seconds, we will step off. After we step off, please tell me as quickly and accurately as possible whether the surface is domes, bars or the trapezoid. Sometimes it my feel like you are guessing, and sometimes you will probably be wrong, that is okay, just do your best. Wrong answers are just as important to us as right answers.

Then, after you tell me what type of surface you think you were on, I would like for you to rate how confident you are about having correctly named the surface by saying 1, 2, or 3.

[Guide to one of the long surfaces and position for perpendicular approach.]

1 means I'm not at all confident;

2 means I'm somewhat confident;

3 means I'm very confident.

To summarize, you will be guided onto and then off of the surface, you will say Bars, Domes or Trapazoid and then you will say 1, 2, or 3 about how confident you are in being correct.

Having heard these instructions, please repeat back to me the two things you are going to tell me after we step off the surface.

(Name surface as domes, bars or trapezoid;

1 means I'm not at all confident,

2 means I'm somewhat confident;

3 means I'm very confident.)

Okay, Let's practice a couple of times. Please guess if you are not sure.

Now I'll guide you to the first trail.

Rest if needed and then repeat all trials for detection and discrimination.

OK. Before you finish, I'd like you to do one more quick task. I'd like you to try to follow the surfaces. I'll guide you to a starting point, and ask you to just follow the surface, whatever it is, until I tell you to stop. Then we'll do it a little differently a few more times. It will go quickly.

[Guide to one end of the platform] **When I say "Begin," start following the surface on your [right/left]. Use any technique you choose. If you do not contact the surface for about 4 steps, I'll ask you to stop and I will guide you to a new starting position on the next surface.**

[Repeat for both rows of surfaces, following on the side of the cane-using hand, and on the opposite side.]

Is there a surface that you would like to see used as a divider between the pedestrian and bikes? Why?

Is there a surface that you think should definitely not be used for the divider? Why?

Appendix B

Better Market Street Project Protocol—Mobility Disabled

The participant will be met by an experimenter on arrival, and the three experimenters introduced, Linda Myers, Alan Scott, and Beezy Bentzen. The experimenter will confirm that the participant has read the consent form, and answer any questions. If the consent has not been read, the experimenter will read it to the participant. The participant will be asked to sign the consent which includes an optional permission to take photos or video.

The participant will then be given an honorarium in the form of a debit card for $100.

If there is or may be an observer present, the participant should be asked whether they are comfortable being observed. The observer will be introduced to participant either before or after the experiment—not in the middle. If the participant is not comfortable being observed, the observer will be requested to leave. Observers will be asked to remain at a good distance from participants, and not to interact with them during the experiment and debriefing.

The experimental procedure will be explained to the participant.

There are four different tactile surfaces that we will be asking you cross today. One is a truncated dome detectable warning surface that is typically yellow and found at the bottom of many curb ramps. It is also at the edge of transit platforms. Are you familiar with this warning surface? The truncated domes will continue to be used on curb ramps and transit platforms and we are looking for a different surface to be used between bikes and pedestrians on a shared bike lane. There are three other surfaces that we are considering for a divider between the pedestrian and bicycle sides of the shared bicycle lane at sidewalk level that is a part of the Better Market Street re-development project. One is a surface of flat-topped bars, one is a surface of somewhat rounded bars that we call corduroy, and one is a surface that is a single, wide, raised trapezoid. The flat-topped bars and the corduroy will sometimes be 12" wide and sometimes 24" wide. The trapezoid is only one width. So, in all, there are six different things to experience. It is not important that you remember all six because I will tell you the name of the surface you will be crossing.

We would like you to cross each surface 4 times but we will start with crossing each twice. The first thing you will cross will be a truncated dome detectable warning surface. It is important that you know how it feels when you cross the warning surface, because after you go back and forth across each of the other surfaces, we'll be asking you to rate how much effort it took compared to the truncated domes, whether you felt unstable while crossing, and whether you felt any discomfort while crossing. Then we'll move to the next surface and do the same thing.

Linda Myers will be walking with you, telling you which surface is next, and asking you questions. Alan Scott will be following along, writing down what he observes as you cross, and recording your answers to questions.

You don't have to cross any surface that you think would not be safe for you to cross. Just let Linda know if a surface looks like it would be unsafe for you. Or if you make one crossing and it is particularly difficult or uncomfortable for you, you can say that you'd rather not cross it again.

We would like you to go back and forth across all the surfaces, and then go around again, going back and forth across each surface, for a total of 4 crossings of each surface. But you can rest any time you would like to, or have a drink of water or a snack. Do you think you're likely to be able to go around two times? [This is just to give the experimenter an idea what to expect.]

Linda will guide the participant to the detectable warning surface.

This is a detectable warning surface made of truncated domes. Have you crossed these domes many times and are familiar with how they feel?

[If the answer is yes] **I'd like you to go across and turn around and come back. Then I'll ask you a couple of questions.**

Did crossing over the truncated domes make you feel at all unstable? Please rate how unstable it made you feel 1 2 3 4 0r 5.

- **If yes: Using scores from 1 to 5, please rate how unstable it made you feel.**
    - **1 means that it made you feel just a little bit unstable, up to a score of 5 which means it made you feel very, very unstable.**

Did crossing over the Truncated Domes cause you any physical discomfort or pain?

- **If yes: Using scores from 1 to 5, please rate how much physical discomfort or pain you felt.**
    - **1 being just a little discomfort, 5 being intense pain.**
- **If yes: Please describe the physical discomfort or pain.**

[If the answer is anything other than yes] **I'd like you to cross back and forth across the Truncated Domes several times, so you have a really good idea of what this is like for you. When you cross the other surfaces, I'll ask you to rate crossing that surface in relation to how it felt crossing the truncated domes, so it's important that you have a very clear idea about how crossing the truncated domes feels to you.** [Have participant cross as many times as seems to be needed. Then ask the questions above.]

Now I'd like you to cross the [12" or 24" wide; flat bar surface/corduroy surface/ raised trapezoid surface]. **Cross over and back in the way that's most comfortable to you.** [Give participant an opportunity to say it looks unsafe, both before starting, or between the two crossings.]

Now I'd like you to answer some questions about crossing the [12" or 24" wide; flat bar surface/corduroy surface/ raised trapezoid surface].

I'm going to ask you to compare how it felt to cross this surface to how it felt crossing over the Truncated Domes. Ok?

- **Did crossing this surface require any more effort than crossing the Truncated Domes?**
    - **If yes: Crossing this surface required how much more effort?**
      A little more (1), a fair amount more (2), or a great deal more (3)?
- **Did crossing this surface make you feel any more unstable than when crossing the Truncated Domes?**
    - **If yes: Crossing this surface made you feel how much more unstable?**

A little more (1), a fair amount more (2), or a great deal more (3)?

- **Did crossing this surface cause you any more physical discomfort or pain than crossing the Truncated Domes?**
  - **If yes: Crossing this surface caused you how much more physical discomfort?**

    A little more (1), a fair amount more (2), or a great deal more (3)?

Continue, until participants have been asked to cross all surfaces two times.

Would you be OK with crossing all the surfaces again, just like we did this time? [If “No,” move to final questions. If “Yes,” continue.]

Would you like to sit for a few minutes, and perhaps have a drink of water or a snack before going around again?

Begin again when participant is ready, starting again with the detectable warning, and continuing in the same order as previously.

Following all crossings, invite the participant to sit while they are asked some questions about crossing the surfaces. (See debriefing on first data sheet.) Offer them water and a snack.

I would like you to think about the three different surfaces you crossed – Flat-top bars, Corduroy, and the trapezoid:

Is there one surface you would most definitely <u>not like</u> to see used as a divider, or would you be fine with any of these?

Is there one surface you would most like to see used as a divider?

For the flat-top bars and the corduroy, you crossed some in which the surface was 12” across, and some in which the surface was 24” across. Did it matter to you whether they were 12 or 24”?

Do you have any other comments or suggestions?

Thank participants for their time and assistance, and facilitate their connection with transportation.

Appendix B – Bollard Separation Report

Bollard separation for detection by pedestrians who are blind

Prepared by Robert Wall Emerson, PhD

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Department of Blindness and Low Vision Studies

When a pedestrian zone and a vehicle zone are to be separated not by a change in elevation (e.g., a curb) but by bollards or posts, there exists the possibility that some pedestrians will walk between the bollards and, lacking a level change as a cue, not realize that they have passed from a pedestrian to a vehicular zone. This is especially true for pedestrian who are blind. A critical question, therefore, is what the optimal separation is for bollards that will allow for ease of detection by pedestrians who are blind using a long cane while also allowing an ease of movement of pedestrians and cyclists between zones demarcated by the line of bollards. While there is no direct research on the optimal separation between bollards for detection by pedestrians who are vision disabled, research on size of detected objects, and on average arc width, can be used to predict optimal separation between bollards or objects such as posts or planters, for likely detection by pedestrians who are blind. At the end of this report, a range of separation between 1200 mm (47.24in) and 1500 mm (59.05 in) is recommended.

When beginning to determine optimal placement of bollards, the first consideration is the detection of a single obstacle by a person using the long cane. A series of studies from Western Michigan University investigated factors impinging on detection of obstacles with diameters of 2 inches, 6 inches, 10 inches, and 14 inches and heights of 1 inch, 3 inches, 5 inches, and 7 inches. These studies found that cane length and cane arc width did not significantly impact detection of these obstacles (Kim, Wall Emerson, & Naghshineh, 2017). They did find, however, that how a person wielded the long cane and what tip was used had a significant impact on detection of these obstacles. Using a long tip that extended the cane tip forward horizontally (called a "bundu basher" tip) led to significantly better obstacle detection over use of a marshmallow tip (see figure 1). Use of a standard constant contact technique (where the cane tip is not lifted off the ground) led to significantly better obstacle detection than a modified technique that moved the entire cane laterally rather than by sweeping the tip left and right (Kim & Wall Emerson, 2018). It was also found that obstacles positioned more to the center of a person's walking path were detected more often than those slightly off to the side.

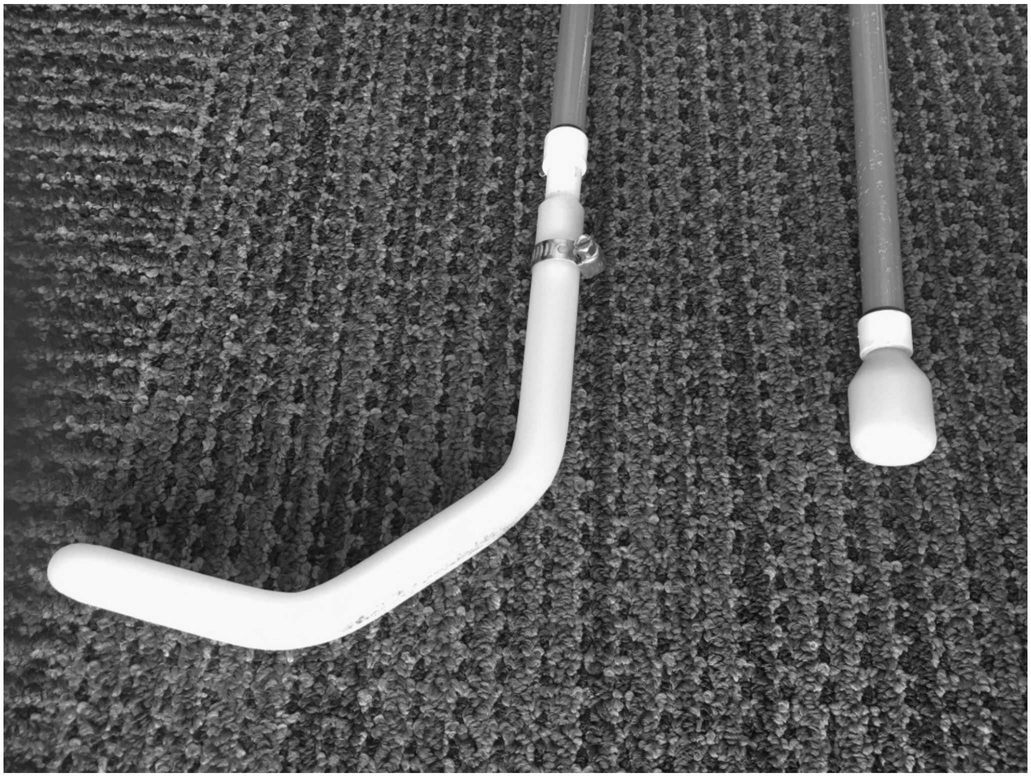

Figure 1

Bundu basher tip (left) and marshmallow tip (right)

To look more closely at physical factors that might impact obstacle detection, a dataset containing 10,069 trials of people walking using a long cane was explored. Within this dataset, the average arc width was 831.6 mm (32.7 in) with a standard deviation of 230.24 mm (9.1 in). Across all participants and all trials, although there was a tendency to have the hand holding the cane an average of 141.96 mm (5.6 in) off of midline, cane arcs were generally centered so the cane previewed participants' path of travel 85.59% of the time.

In looking at detection of single obstacles within the relevant portion of this dataset, a binary logistic regression was used to determine significant physical predictors of obstacle detection over 5,510 trials. The obstacles referred to in this dataset were the obstacles previously described: disks with diameters of 2 inches, 6 inches, 10 inches, and 14 inches and heights of 1 inch, 3 inches, 5 inches, and 7 inches. For these trials, participants correctly detected an obstacle in 3,245 trials and failed to detect an obstacle in 2,265 trials. Failure to detect an obstacle could mean that a participant did not contact the obstacle with the cane or that they did contact the obstacle but did not recognize that they had done so. The most significant predictor of obstacle detection was hand off set from the center of the body, followed by cane tip height, walking speed, and body coverage by the cane. In the final model, hand off set accounted for .8 % of the variability in the obstacle detection measure (Nagelkerke R square = .008), cane tip height accounted for an additional .3 % of the variability in the obstacle detection measure (Nagelkerke R square = .011), walking speed accounted for an additional .4 % of the variability in the obstacle detection measure (Nagelkerke R square = .015), and body coverage equal to or greater than the width the cane tip covered accounted for an additional .2 % of the variability in the obstacle detection measure (Nagelkerke R square = .017).

This analysis was then repeated, but only for obstacles that were 7 inches high and 6 inches in diameter (most “pole like”). For 673 trials, participants correctly detected an obstacle in 438 trials and incorrectly in 235 trials. The most significant predictor was hand off set, followed by whether the arc was centered, and being in step (in standard techniques of using the long cane to preview the path of travel, the tip of the cane is on the side opposite the forward foot). In the final model, hand off set accounted for 1.1 % of the variability in the obstacle detection measure (Nagelkerke R square = .011), arc centeredness accounted for an additional .7 % of the variability in the obstacle detection measure (Nagelkerke R square = .019), and being in step accounted for an additional 1.1 % of the variability in the obstacle detection measure (Nagelkerke R square = .03).

The result of these analyses and the previous research suggests that cane length and arc width do not significantly affect obstacle detection but the type of cane tip used, whether the cane arc is centered on a person's body, and whether the obstacle is centered on a person's path are more predictive of whether the obstacle will be detected. However, even these factors do not account for what appears to be a modest rate of detection. The modest rate of detection is likely attributable to inconsistent cane technique by many participants.

Proceeding from the detection of single obstacles, we need to consider how well people using a long cane can identify a gap between obstacles. This ability is one of perceiving relative distance and accurately estimating that distance through the exploration of the environment with a hand held cane. Distances reachable, as perceived by a person using a cane to explore the environment, have been shown to be governed by the principal moment of inertia of the hand and cane around an axis of rotation (Yosef Solomon & Turvey, 1988). This finding suggests that a longer cane or a wider separation between objects would lead to a larger moment of inertia and therefore better detection. Barac-Cikoja and Turvey (1991) explored this idea more fully. Objects spaced apart by 5 cm (1.97 in), 10 cm (3.94 in), and 15 cm (5.91 in) were explored with a hand held rod at distances of 15 cm (5.91 in), 30 cm (11.81 in), and 45 cm (17.72 in) by blindfolded participants. Perceived distance between objects decreased with increasing distance from the participant. Distances between objects felt more similar the further they were from the participants. Barac-Cikoja and Turvey also found that exploring a space between two objects with the end of a cane rather than the portion closer to the hand led to a better perception of the distance between them. These findings suggest that in order for the distance between two objects to be reliably detected, that space needs to be as wide as possible within the bounds of reasonably being detected by a person wielding a long cane.

An inventory of shared spaces in the Netherlands indicated that none of the shared spaces investigated used vertical barriers such as bollards to demarcate zones or differential spaces within the shared space (Havik, Melis-Dankers, Steyvers, & Kooijman, 2012). However, the London Department for Transport cites a requirement of 1100 mm (43.31 in) as the space required for a person with a cane or dog to walk through while a wheelchair user requires 1200 mm (47.24 in). In guidance for erecting barriers between different forms of traffic, the London Department for Transport suggests bollards at least 1000 mm (39.37 in) high separated by at least 1200 mm (47.24 in) (to allow wheelchairs users to pass but to discourage bicycle riders from weaving through) and not attached to each other by chains or rope (London Department for Transport, 2005). Other elements of good bollard design in relation to pedestrians who are blind include a height of at least 1 meter (39.37 in), a bollard color that stands out from the background, a band of contrasting color around the neck of the bollard, and illumination of the bollard at night (Hersh & Johnson, 2008).

Within the large dataset discussed earlier, the average long cane arc width was 831.6 mm (32.74 in) and the average walking speed was 893.94 mm/sec (35.19 in/sec). This means that participants within that dataset were walking forward approximately the distance of their arc width in a second. If it can be assumed that people using a cane are walking while swinging in cadence with their footsteps (as is good practice) the cane tip will be at the extreme left and right side of the person's body each second. If bollards are separated by 1200 mm (47.24 in), a person whose cane arcs to one side just after a bollard will likely encounter the next bollard within a second, even if they are veering through the line of bollards at the time. If the next bollard is more than 1700 mm (66.9 in) away, it is very possible for a pedestrian using a long cane to miss one bollard and veer through the line of bollards, missing the next bollard, even using standard cane technique. Thus, to meet requirements for passage between bollards for all users and maximize detection by pedestrians using a long cane, a separation of 1200 mm (47.24in) at a minimum and 1500 mm (59.05 in) at a maximum is recommended. The lower end of the range will increase the likelihood of detection by pedestrians using long canes and allow for them to tactually follow the line of bollards more easily than if they were separated by a larger distance.

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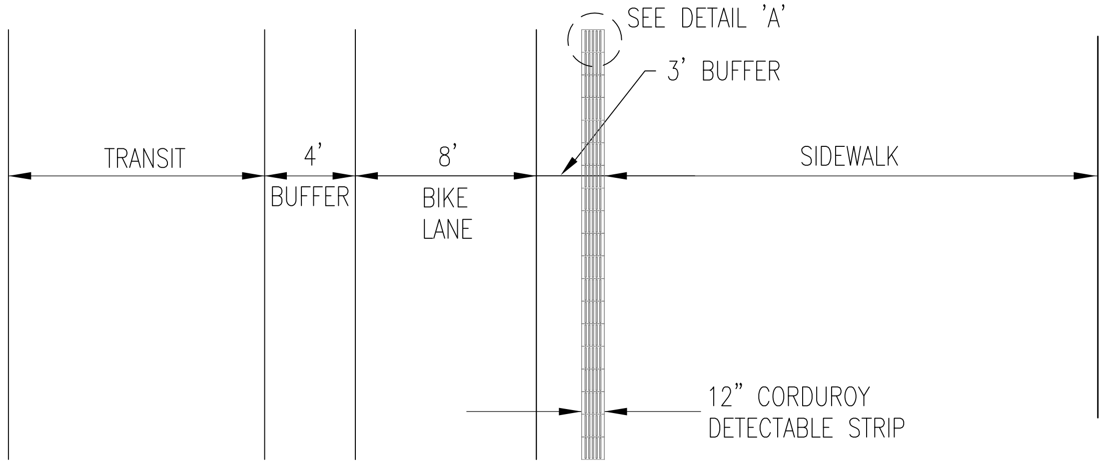
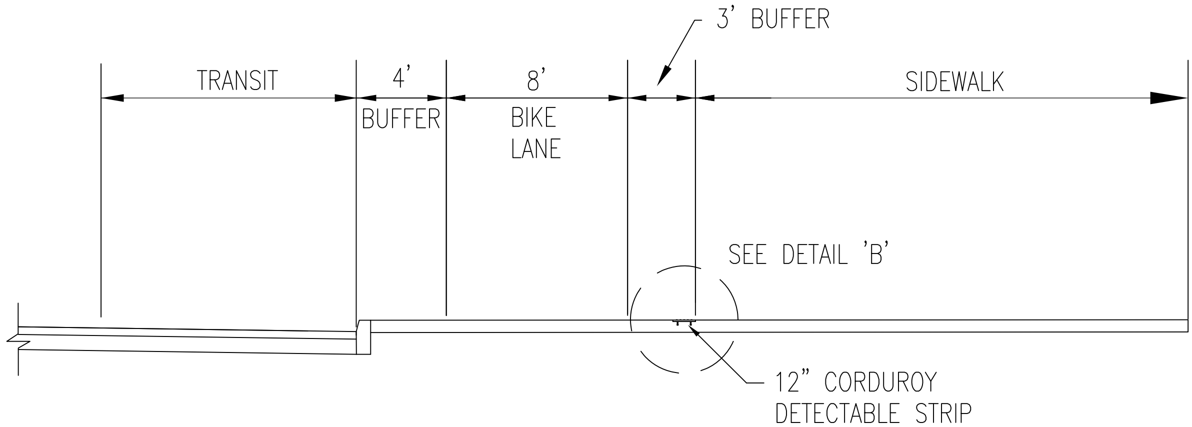
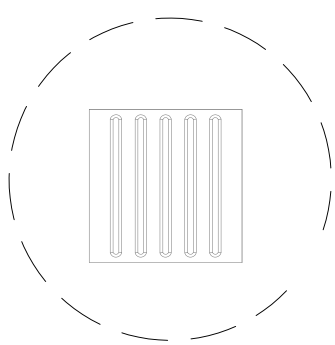
Appendix C – Surface Layout Drawings







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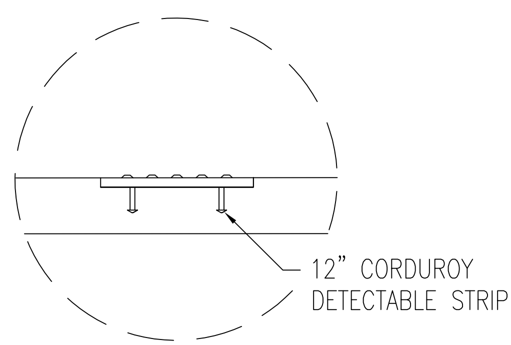

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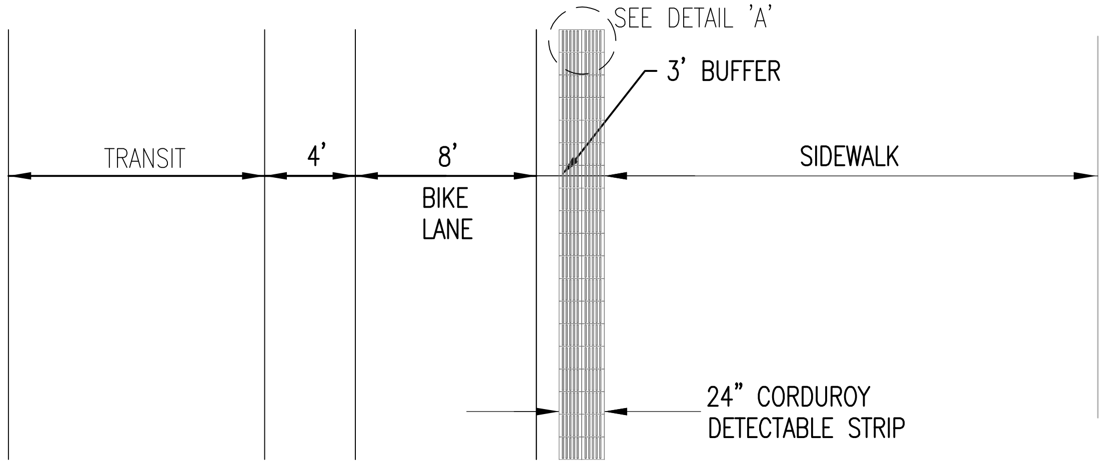

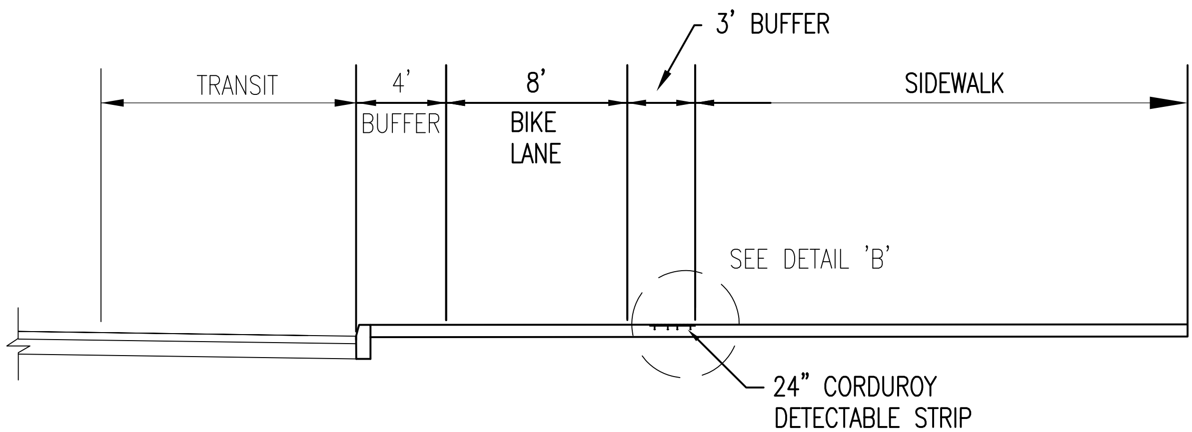

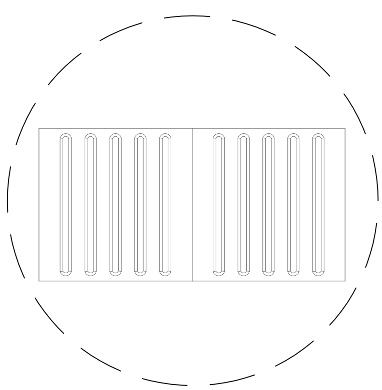

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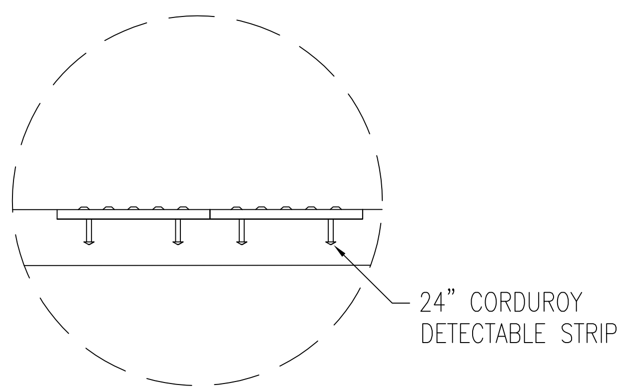

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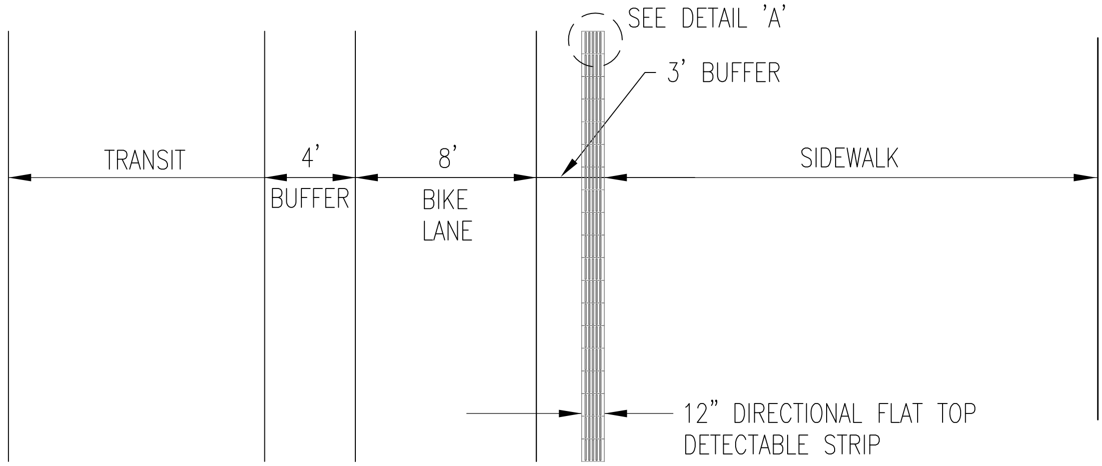

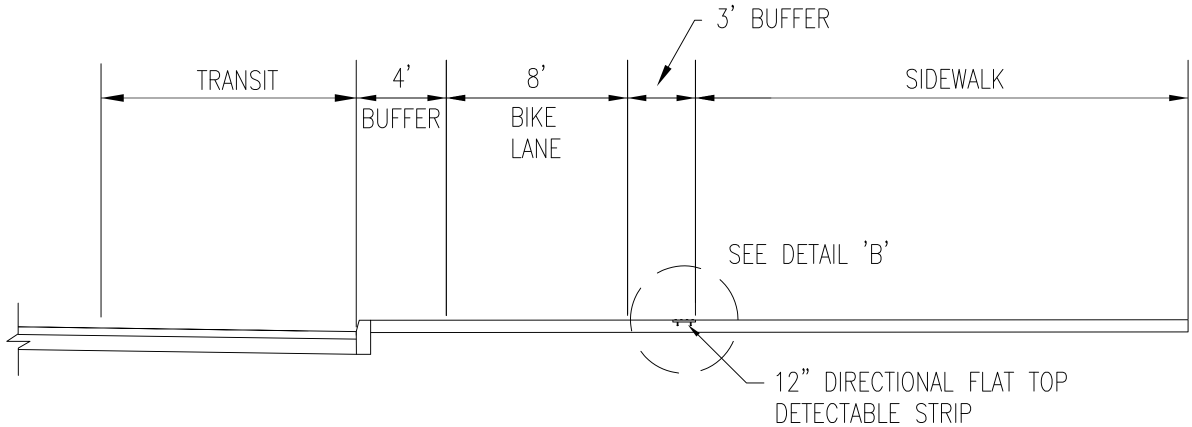

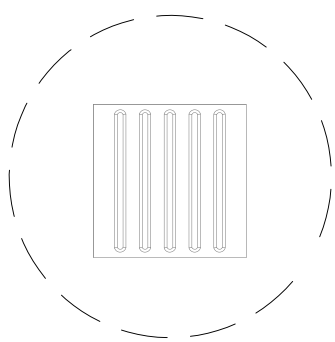

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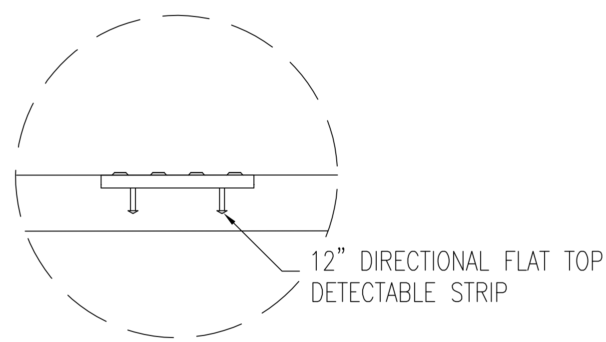

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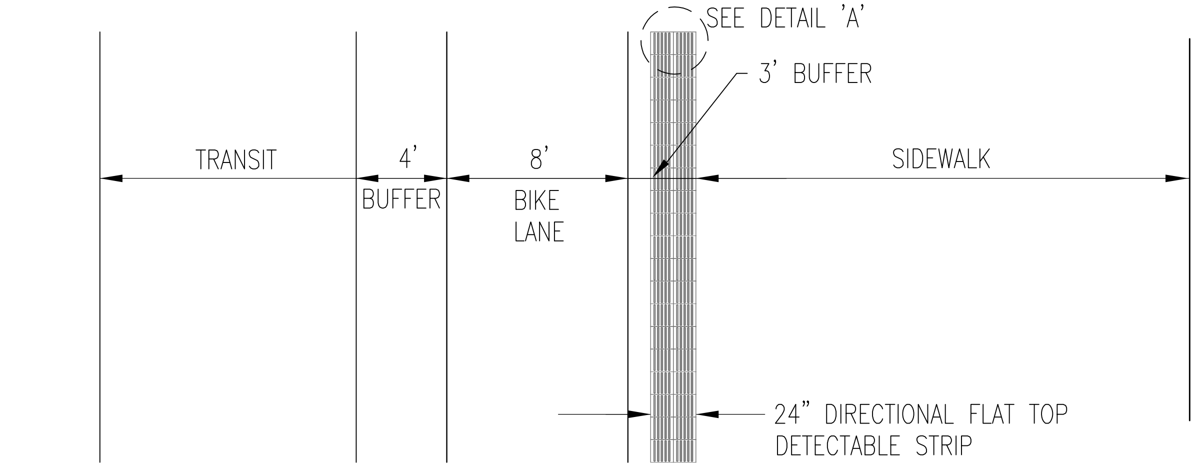

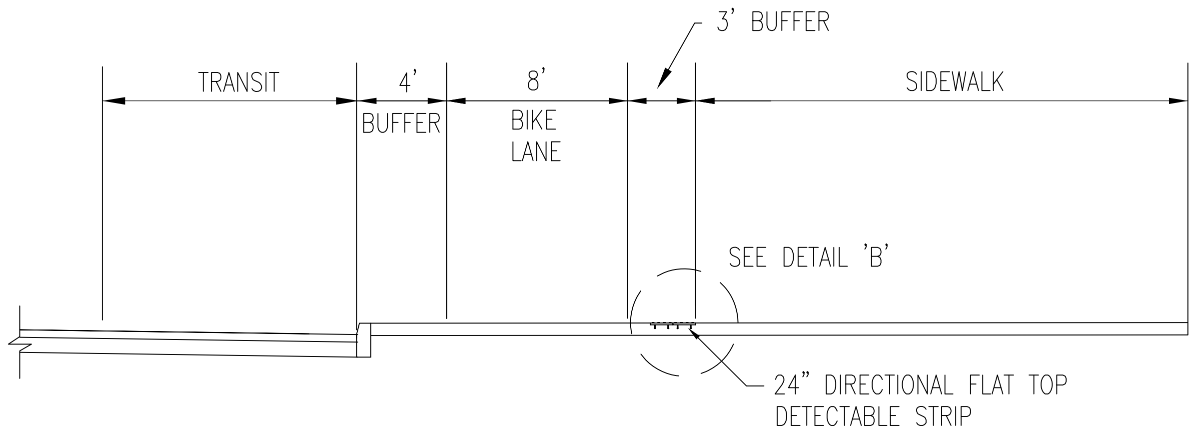

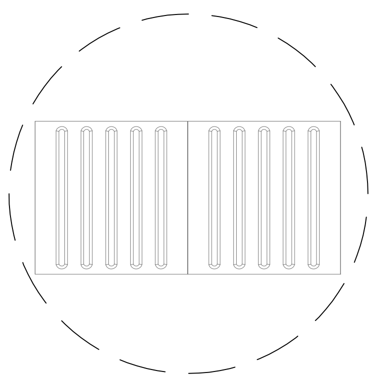

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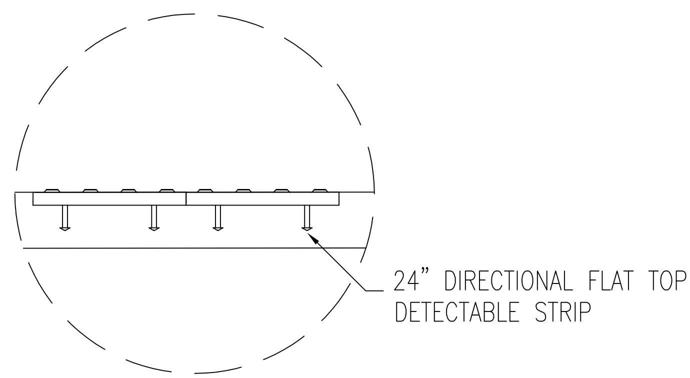

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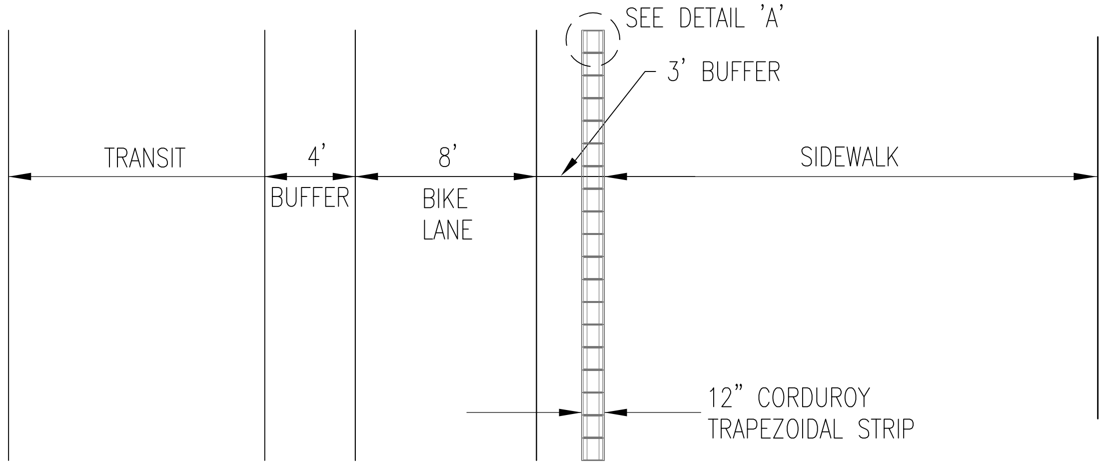

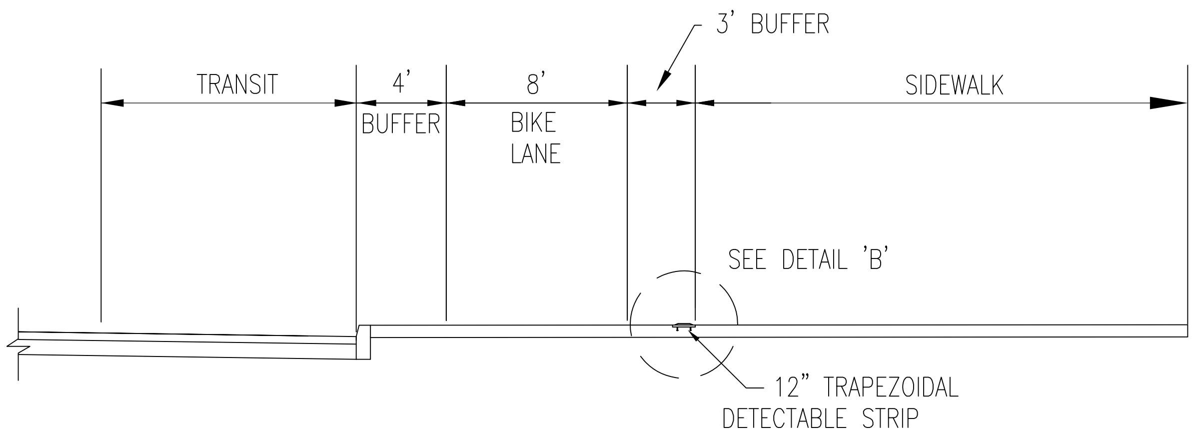

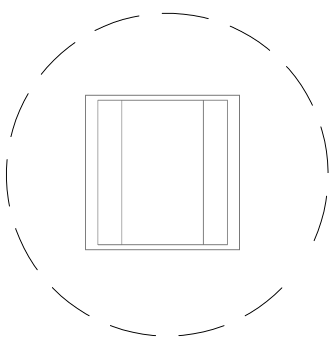

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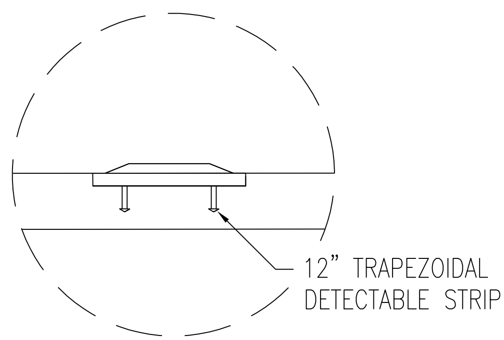

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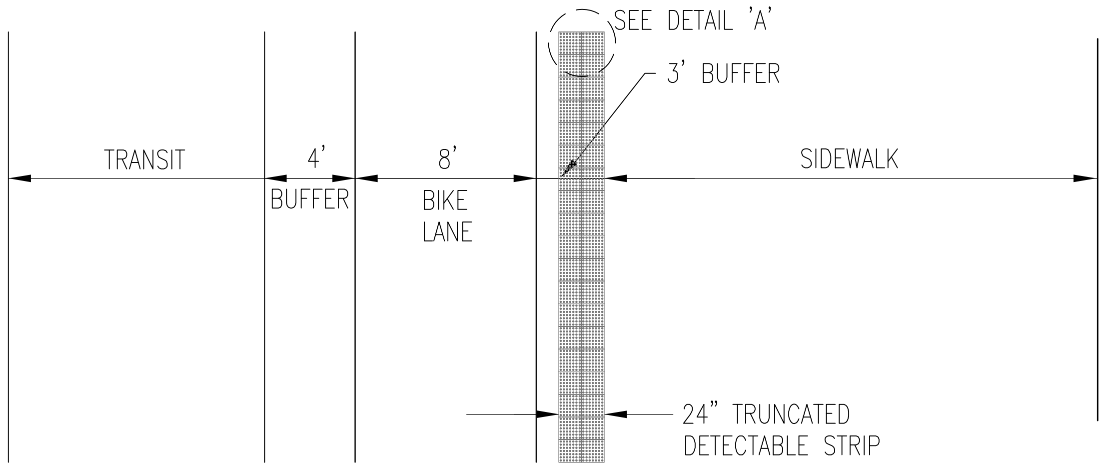
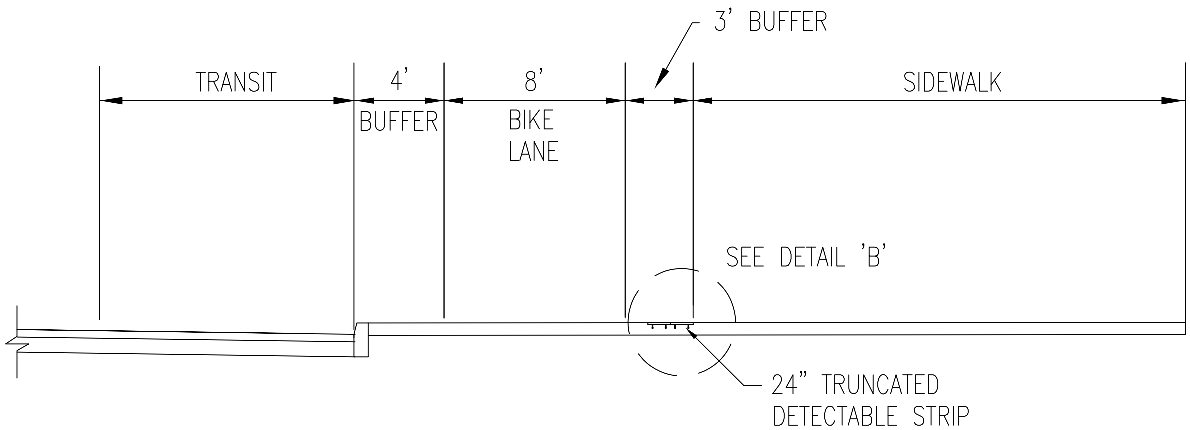
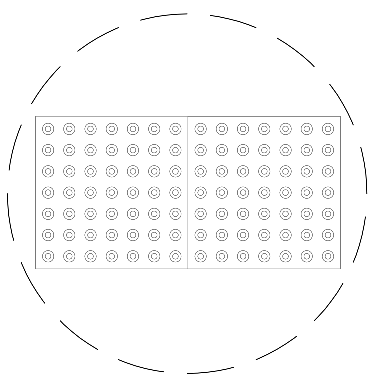
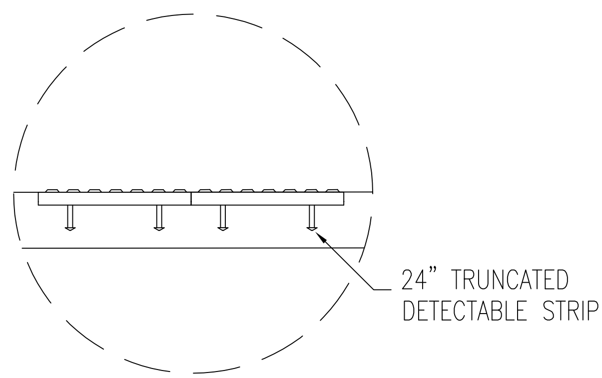






DETAIL 'A'



DETAIL 'B'

24" TRUNCATED DETECTABLE STRIP

Arden Way Complete Streets - Phase 1 Bicycle Facility Update

Heather Yee

May 18, 2022

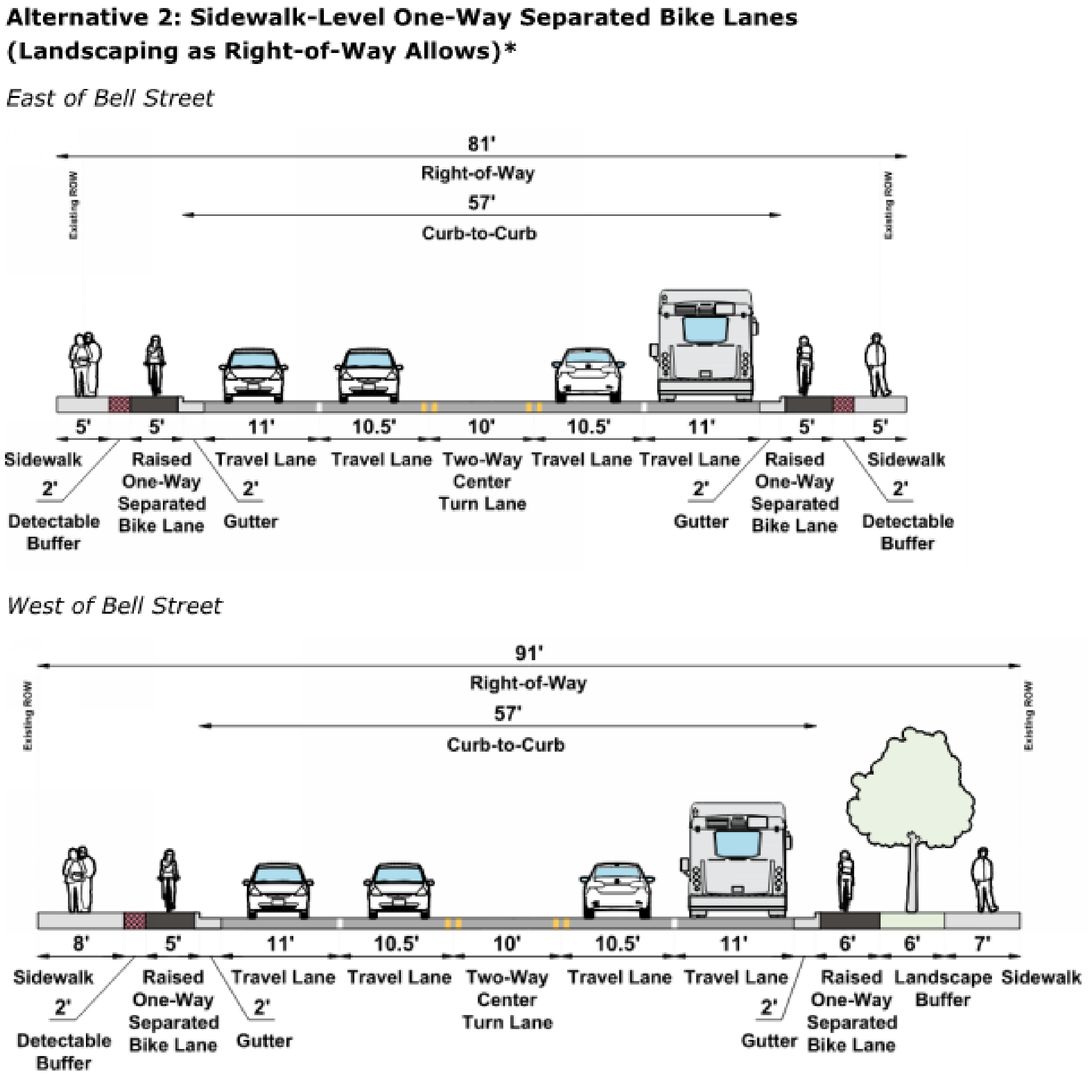
Vicinity Map

NOT TO SCALE

Arden Way Complete Street Improvement Project - Phase 1: Morse Avenue to Watt Avenue

Complete Streets Master Plan:
Arden Way between Howe Avenue and Morse Avenue

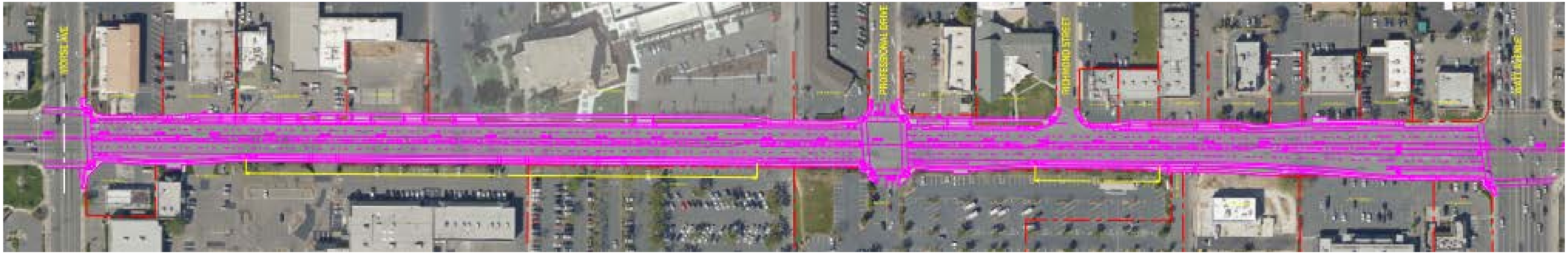
Arden Way – Complete Street MP Concept Alternatives



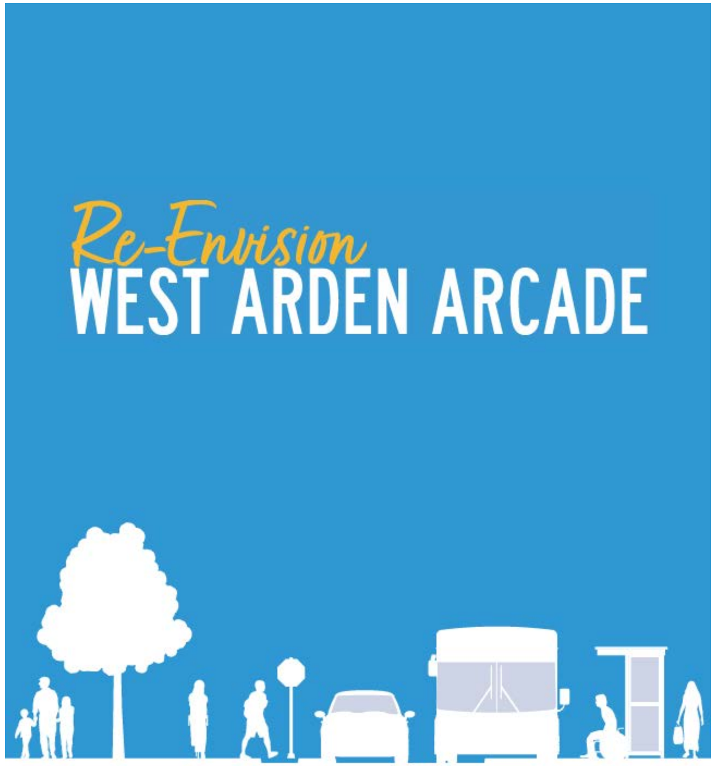
- Exhibit C
- Concept of a physically separated bike facility was taken to the Supervisor for conceptual approval.
- He liked it so much, he asked that it be implemented into the Phase 1 project

Arden Way Phase 1 Project Plan

Exhibit B in packet:



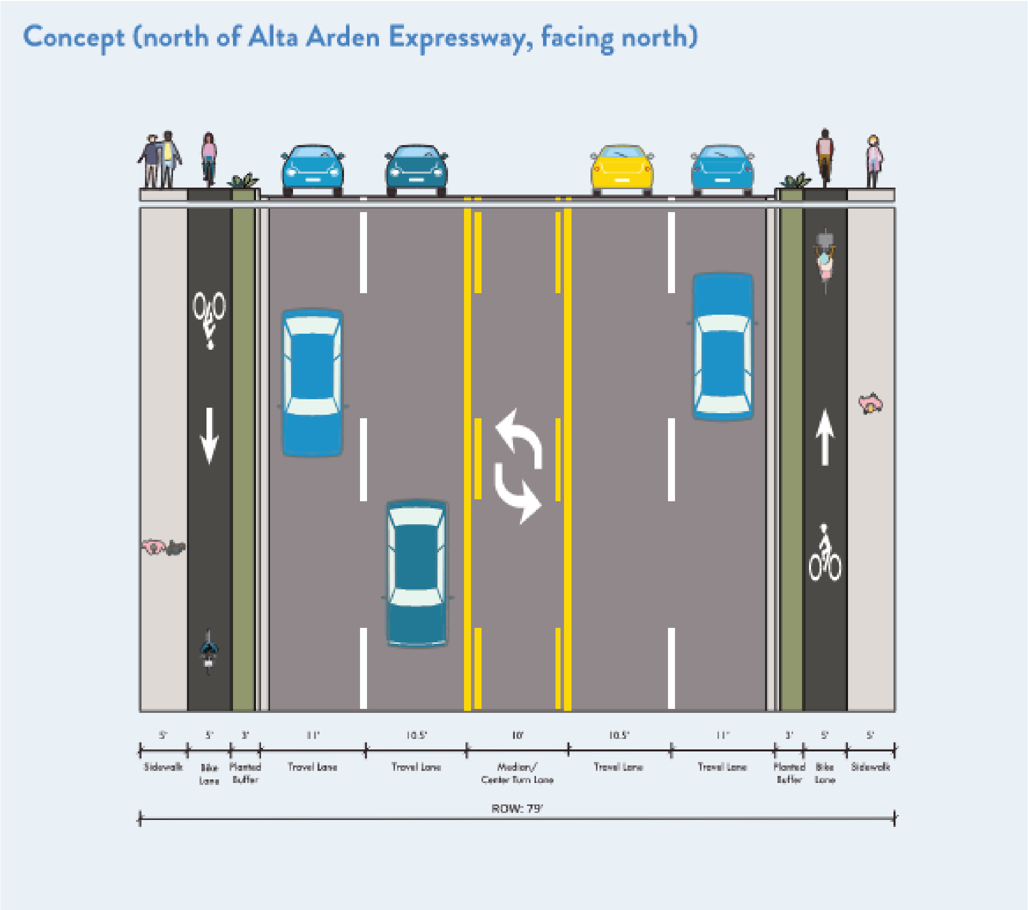
REWAA concept
Re-Envision West Arden Arcade



SACRAMENTO COUNTY

- Planning Document that reviewed the Arden Arcade area
- Community Engagement

Shared Bike-Ped Facility, presented to the Disabled Access Committee



Guidance/ BMPP for the Visually Impaired

Planning and Designing Streets to be Safer and More Accessible for People with Vision Disabilities

A Toolkit for Montgomery County and the Metropolitan Washington Region

First Edition
October 2021

- Fairly recent document
- There is a difference between a **Guidance Strip** and a **Delineator**

Guidance Surface

When guidance strips need only be detected by people with vision disabilities walking parallel to the guidance strip, they should be a minimum of 12” depth

Figure 13: Example of a detectable guidance surface.

Do Not Use as an Edge Treatment

Guidance strips should not be used to define the edge between pedestrian space and vehicular lanes and should be offset as noted above. Guidance strips should also not be used to define the edge between a pedestrian comfort zone and the shared zone in a shared space design.

Figure 14: Example of guidance strips used to direct pedestrians with vision disabilities to a floating bus stop in the Netherlands.

Delineator

Delineator strips should be considered for the following designs:

- Flush streets
- Shared spaces
- Parallel flush pedestrian and bicycle facilities

When used to indicate the boundary between parallel flush pedestrian and bicycle facilities, delineator strips should ideally be 24”wide, although a minimum 12” wide delineator strip is acceptable if the pedestrian path of travel is parallel to the bicycle facility.

Parallel Flush Pedestrian and Bicycle Facilities

- When used as part of a parallel flush pedestrian and bicycle facility design, delineator strips can be placed between the pedestrian and bicycle facility.

Delineator Strip?

Figure 19: In New Zealand delineator strips (center of photo) are placed between the pedestrian access route and the furniture zone in shared space designs. This toolkit recommends that in a shared street design delineator strips be placed at the edge of the shared zone used by vehicular traffic and, unlike what is shown here, that they contrast visually with adjacent surfaces.

Research on Adjacent Bicycle + Pedestrian Facilities

TRR

Research Article

Transportation Research Record
1–12

DOI: 10.1177/0361198120922991
journals.sagepub.com/home/trr
SAGE

Delineator for Separated Bicycle Lanes at Sidewalk Level

Billie Louise (Beezy) Bentzen[1], Alan C. Scott[2], and Linda Myers[3]

Abstract

The City and County of San Francisco sponsored research to identify a delineator for separated bicycle lanes at sidewalk level that is at least as detectable as truncated-dome detectable warning surface (DWS) by pedestrians with visual impairments, and that is not a barrier to pedestrians with mobility impairments. Tested as potential delineators were a 12-in. wide continuous raised trapezoid (0.75 in. high), and 12- and 24-in. wide installations of relatively wide flat-top bars (FTBs) and of a "corduroy" surface of narrower bars spaced more closely together (both 0.2 in. high). Thirty-one visually-impaired participants detected all five surfaces in addition to DWS, a total of six times each, from 90° and 25° approaches, with mean detection accuracies better than 90% for all surfaces (no significant differences). The long white cane intruded into the cycle track significantly less frequently with 24-in. wide surfaces. In a counterbalanced manner, participants also briefly stepped onto each surface eight times, each time identifying it as "domes,""bars," or "trapezoid." They identified the trapezoid significantly better (mean rate of correct identification = 98.8%) than all other surfaces. A majority of participants with vision disabilities preferred the trapezoid. Thirty participants with a variety of mobility impairments, using a variety of aids, crossed each surface four times with little significant difference from the DWS in effort, instability, and discomfort or pain. No surface was found to be a barrier to crossing. The trapezoidal surface was recommended as the delineator, although the 24-in. FTBs also performed very well.

Exhibit D

San Francisco Public Works

Better Market Street Delineator

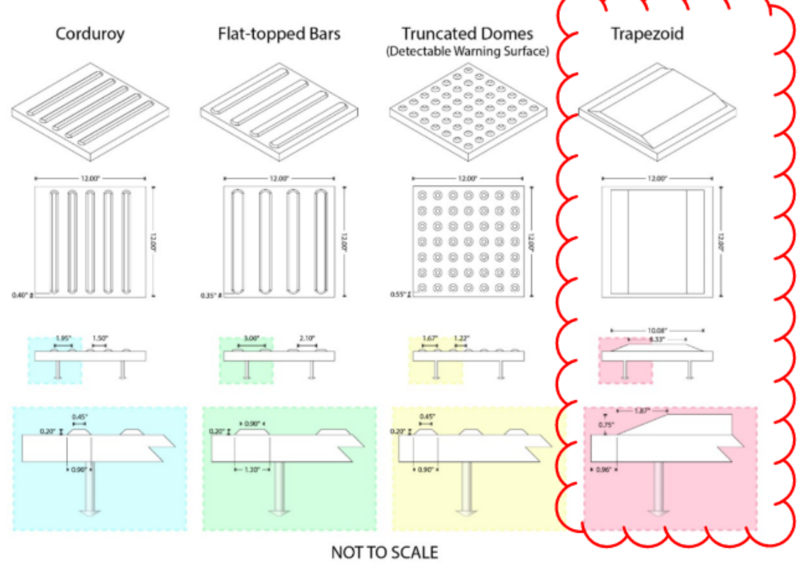
Summary Report

Issue | October 26, 2020

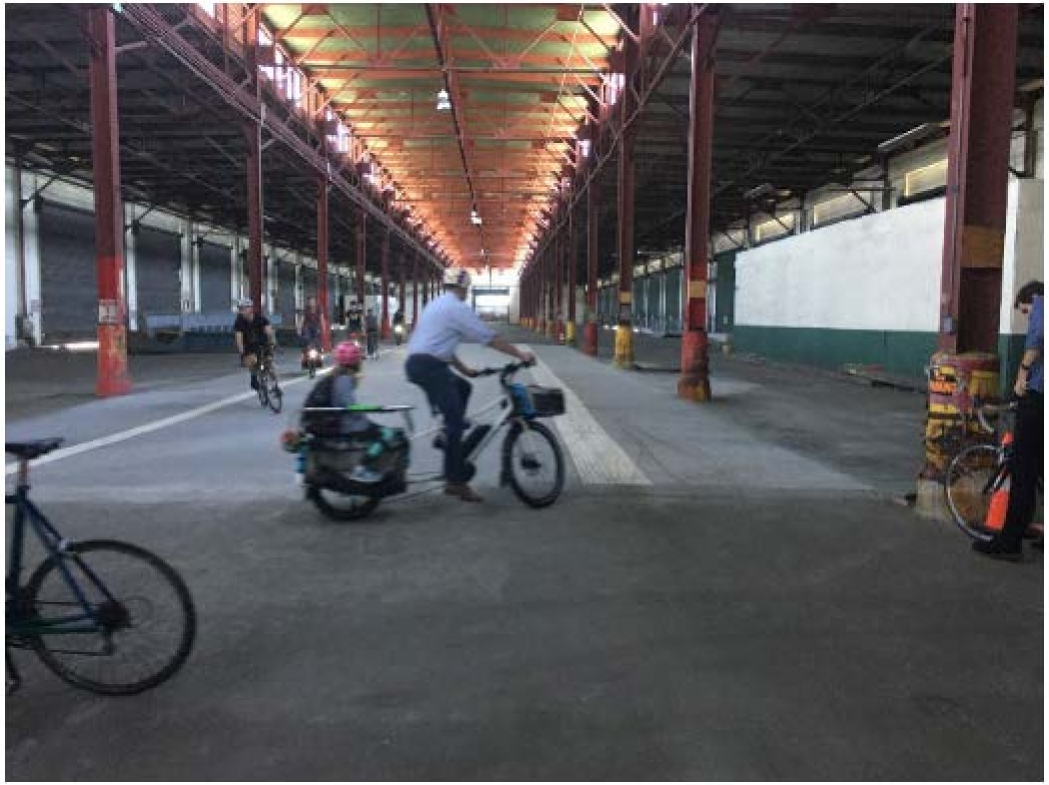
Exhibit E

Delineator Testing

Figure 5 – Tested surfaces



Better Market Street Delineator Study. Examples of surfaces that were tested by vision- and mobility-impaired users as well as bicyclists.



Tested at Pier 38 in San Francisco by both Visually Impaired and Bicyclists

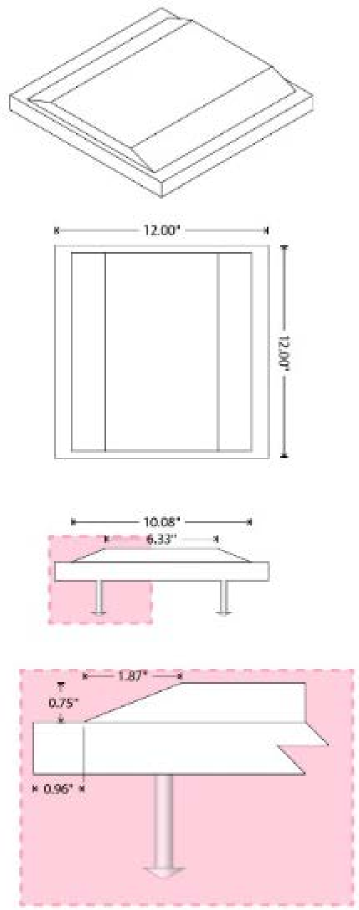
Implemented?

Treasure Island, San Francisco. Installation of trapezoidal shaped delineator, not used as a delineation between bicycle and pedestrian facility.

Delineator Concepts

Strong Go – Tek Way

Trapezoid



Vanguard

Strong Go / TekWay

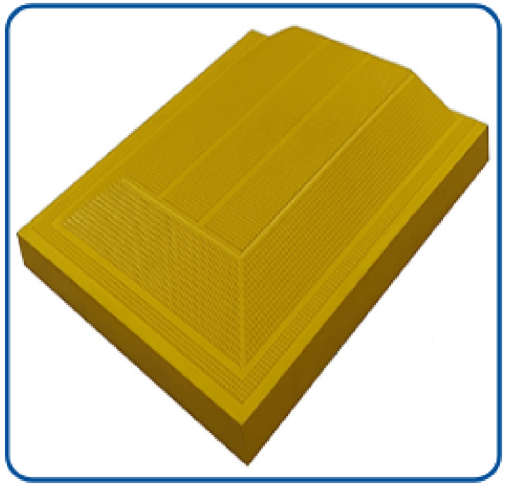
TekWay® HIGH PERFORMANCE DELINEATORS

TekWay® Delineator Tiles

An increasing number of City Planners across the United States are incorporating Separated Bicycle Lanes at sidewalk level.

Trapezoid Delineator Tiles are designed and tested to safely separate the visually impaired pedestrians from cyclists on separated bicycle lanes at sidewalk level. These delineators are intended for areas such as city centers, parks and universities or any area where the two paths would be adjacent on the same level.

Note:
Delineator Tiles should not be confused with Navigational Bar Tiles. Navigational Bar Tiles are only used as a way-finding device for the Visually Impaired.



Will be visiting SacDOT on Wednesday May 25th at 1:00 pm and 2:30 pm

Available Sizes in:

12" x 12"

12" x 48"

Available Colors in:

- Natural Colors
- Federal Color Standard #595
- Custom Colors

Industry leading TekWay Delineator Tiles are long-lasting and reliable devices for separating the visually impaired pedestrians from cyclists on separated bicycle lanes at sidewalk level. They are fully detectable for those with low to no vision and do not impede safe movement for the mobility impaired.

May 12, 2022

California Transportation Commission
1120 N Street, MS 52
Sacramento, CA 95814

RE: Bell Street Safe Routes to School

The Sacramento County Bicycle Advisory Committee supports the Sacramento County Active Transportation Program (ATP) Cycle 6 application for the Bell Street Safe Routes to School project.

This project will construct bicycle and pedestrian improvements and implement bicycle education programs around and for three schools and two parks: Dyer Kelley, Encina High/Greer Elementary, Howe Community Park, and Santa Anita Park. The project improves 2.4 miles of Bell Street from Hurley Way to Edison Avenue. The project also builds upon recent speed tables constructed on Bell from Rainbow Avenue to Church Avenue near Dyer Kelley Elementary.

The Sacramento County Bicycle Advisory Committee strongly supports this ATP application. The project will support ongoing efforts to provide transportation equity, enhance safety and security for all travel modes including safe routes to school along Bell Street, and reduce reliance on vehicle travel.

Sincerely,

____________________________	____________________________
Sue Schooley	Jack Wursten
SacBAC Chairperson	SacBAC Vice Chairperson

Cc: Benjamin Rady, Associate Transportation Planner, Sacramento County Department of Transportation

May 12, 2022

California Transportation Commission
1120 N Street, MS 52
Sacramento, CA 95814

RE: Elkhorn Boulevard Complete Streets

The Sacramento County Bicycle Advisory Committee (SacBAC) supports the Sacramento County Active Transportation Program (ATP) Cycle 6 application for the Elkhorn Boulevard Complete Streets project on Elkhorn Boulevard from Watt Avenue to Don Julio Boulevard.

This project will construct a one way Class IV bikeway for 1.8 miles on the north and south sides of Elkhorn Blvd from Watt Ave to Don Julio Blvd within the existing pavement sections. The project will also construct sidewalk infill and make bicycle, pedestrian and ADA improvements at several signalized intersections

The Sacramento County Bicycle Advisory Committee strongly supports this ATP application. The project will support ongoing efforts to provide transportation equity, enhance safety and security for all travel modes, and reduce reliance on vehicle travel.

Sincerely,

______________________________	______________________________
Sue Schooley	Jack Wursten
SacBAC Chairperson	SacBAC Vice Chairperson

Cc: Benjamin Rady, Associate Transportation Planner, Sacramento County Department of Transportation

May 12, 2022

California Transportation Commission
1120 N Street, MS 52
Sacramento, CA 95814

RE: Stockton Boulevard Complete Streets

The Sacramento County Bicycle Advisory Committee supports the Sacramento County Active Transportation Program (ATP) Cycle 6 application for the Stockton Boulevard Complete Streets project.

This project will seek funds for Project Approval/Environmental Document phase for bicycle and pedestrian improvements along Stockton Boulevard from Florin Road to Mack Road/Elsie Avenue.

The Sacramento County Bicycle Advisory Committee strongly supports this ATP application. The project will support ongoing efforts to provide transportation equity, enhance safety and security for all travel modes, and reduce reliance on vehicle travel.

Sincerely,

______________________________	______________________________
Sue Schooley	Jack Wursten
SacBAC Chairperson	SacBAC Vice Chairperson

Cc: Benjamin Rady, Associate Transportation Planner, Sacramento County Department of Transportation

Active Transportation Program Grant Writing
Bell Street Safe Routes to School
Updated 5/10/2022

Funding Program:
California Transportation Commission Active Transportation Program, Cycle 6

Project Description
The Bell Street Safe Routes to School Project – Medium Application

Project Limits
Bell Street from Hurley Way to Edison Avenue.

This project will construct bicycle and pedestrian improvements and implement bicycle education programs around and for three schools and two parks: Dyer Kelley, Encina High/Greer Elementary, Howe Community Park, and Santa Anita Park. The project improves 2.4 miles of Bell Street from Hurley Way to Edison Avenue. The project also builds upon recent speed tables constructed on Bell from Rainbow Avenue to Church Avenue near Dyer Kelley Elementary.

Infrastructure
- Construct sidewalk on Bell between Edison and Hurley (Sacramento County Draft ATP Sidewalk Gap Projects: Bell-3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14) and at 2419 Wyda Way.
- Determine feasibility of removing one lane of traffic in each direction on Bell from Arden to Alta Arden. Add a bicycle lane in both directions. (Please note that DOT will be seeking input from Caltrans District 3 on any road diet.)
- Upgrade curb ramps to current ADA standards at non-signalized intersections
- Intersection enhancements for pedestrian needs will be made at the following intersections:

Description	Street 1	Street 2
Straighten the southern crosswalk (pushing back the stop bar at the south approach); build a curb ramp and connect area to existing landing for the eastern crosswalk (verify that the intersections still has good line of sight). Consider constructing a curb extension to better define and increase the accessibility of the southeast corner. Upgrade Audible Pedestrian Signal (APS) and Push Buttons to current ADA standards. Add any missing bicycle detection.	Bell	Edison
Construct a pedestrian signal, include audible feature and push buttons to current ADA standards. (Two curb ramps and crosswalk are being constructed in summer 2022.)	Bell	Encina High (780’ south of Arden Way)
Add curb ramp on NE corner. Upgrade Audible Pedestrian Signal (APS) and Push Buttons to current ADA standards. Add any missing bicycle detection.	Bell	Alta Arden

Add second curb ramps on NE and SE corners, straighten out southern crosswalk, add detectable warning surface. Push out four corners, if necessary, to accommodate bike lane north of Arden. Upgrade Audible Pedestrian Signal (APS) and Push Buttons to Current ADA standards, Add any missing bicycle detection.	Bell	Arden
One curb ramp on west side	Bell	Hood
2 Curb ramps - NW corner, ped bulb out	Bell	Hurley

Non-Infrastructure

- Implementation of non-infrastructure programming for the West Arden neighborhood, including Encina High, Greer Elementary, and Dyer Kelley Schools.

Active Transportation Program Grant Writing
Elkhorn Blvd Complete Streets Project Scope of Work
Updated 5/10/2022

Funding Program
California Transportation Commission Active Transportation Program Cycle 6

Project Description
Elkhorn Blvd Complete Streets Project – Medium Application

Project Limits
Elkhorn Boulevard from Watt Ave to Don Julio Blvd

Infrastructure
Construct a one way Class IV bikeway for 1.8 miles on the north and south sides of Elkhorn Blvd from Watt Ave to Don Julio Blvd within the existing pavement sections. Construct 1,065 feet of detached 8' wide sidewalk infill, including landscaping, between Watt and Larchmont on the north side (Elkhorn-16). Make improvements at the following signalized intersections: Elkhorn/Watt, Elkhorn/Cantel Way, Elkhorn/Thomas Dr., Elkhorn/Larchmont Dr., Elkhorn/Walerga, Elk Horn/ Sprig Dr., Elkhorn/Don Julio which could include the following: signal modifications/video detection, ADA improvements (curb ramps, push buttons, and audible), and extend bike lanes to intersection. Upgrade bus stop at Elkhorn Blvd east of Watt on the south side to an ADA accessible stop with shelter. Add bus turnouts with quarter mile spacing: one WB bus turnout just west of the Jimboys on the northwest corner with Thomas Dr and another WB bus turnout on the existing shopping center property just west of the Cantel Way intersection.
Slurry and restripe roadway and bikeway. Ensure pedestrian connectivity along Elk Horn Boulevard through existing sidewalks along frontage roads or on Elk Horn itself and ADA curb ramp replacements.

Non-Infrastructure
See Excel spreadsheet attached for draft non-infrastructure programming plan.

Active Transportation Program Grant Writing
Stockton Blvd Complete Streets Project Scope of Work
Updated: 5/10/2022

Funding Program
California Transportation Commission Active Transportation Program Cycle 6

Project Description
Stockton Blvd Complete Streets Project – Large Application

Project Limits
Stockton Boulevard from Florin Road to Mack Road/Elsie Ave (The west side of the road is in the City of Sacramento between from Mack Road to 0.25 mile to the north.)

Infrastructure
Seek funds for Project Approval/Environmental Document phase for the following project:

- Construct a Class IV separated bikeway for 1.5 miles on east side of Stockton Blvd from Florin Road to Mack Road.
    - Option A: A one way Class IV on both sides using the future number three lane in both direction.
    - Option B: A two way Class IV on the east side with a general plan amendment to change the ultimate from 6 to a 4 lane facility.
- Construct sidewalk infill (Stockton-6, 7, 8, 9, 10 and E. Stockton-1).
- Signalize the off-set intersection at Stockton/Pomegranate Ave/Walter.
- Slurry and restripe roadway/bikeway.

Exhibit 25-R ATP Non-Infrastructure Project Work Plan

Fill in the following items:

Date: (1)	
Implementing Agency Name: (2)	Sacramento County Department of Transportation
Project Number: (3)	1
Project Location(s): (4a)	
" " (4b)	
" " (4c)	
" " (4d)	
Project Description: (5)	

Enter information in each Task Tab, as it applies (Task A, Task B, Task C, Task C, etc.)

For Department use only
You will not be able to fill in the following items. Items will auto-populate once you've entered all "Task" tabs that applies:

Task Summary:

Click the links below to navigate to "Task Details" tabs:

Task	Task Name	ATP Cost	Non-ATP Cost
Task "A"	Engagement for Elkhorn Boulevard Complete Streets Project	$ -	$ -
Task "B"	Equity for Elkhorn Boulevard Complete Streets Project	$ -	$ -
Task "C"	Education and Encouragement for Elkhorn Boulevard Complete Streets Project	$ -	$ -
Task "D"	Evaluation for Elkhorn Boulevard Complete Streets Project	$ -	$ -
Task "E"	Safe Routes to School Programs	$ -	$ -
Task "F"		$ -	$ -
Task "G"		$ -	$ -
Task "H"		$ -	$ -
Task "I"		$ -	$ -
Task "J"		$ -	$ -
	ATP Total:	$ -	
	Non-ATP Total:		$ -
	GRAND TOTAL	**$ -**	

TASK "A" DETAIL

Task Name (5a):	**Engagement for Elkhorn Boulevard Complete Streets Project**
Task Summary (5b):	This task will focus on establishing a stakeholders committee for the purpose of authentically engaging with the community about needs, opportunities, and challenges related to the project.

	Start Date	End Date	Task Activities (6a):	Deliverables (6b):
1.			Establish a stakeholders committee	Invitees list
2.			Convene meetings of the stakeholders committee	Presentations, agendas, meeting notes
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Staff Costs (7):

Staff Time (Agency) (7a):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
Party 4 -						
Party 5 -						
Party 6 -						
				Subtotal Agency Costs:	$ -	$ -

Staff Time (Consultant) (7b):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
				Subtotal Consultant Costs:	$ -	$ -
				Total Staff Costs (Agency & Consultant) (7c):	**$ -**	**$ -**

Indirect Costs (8)

Approved ICAP (8a)?	☐	**If Approved ICAP box is checked, provide Rate** (8b):		**ATP Indirect Costs** (8c):	

Task Notes (9):

Other Costs (10):

You will not be able to fill in the following items. The totals for each "Other Costs" category listed below will automatically calculate from information entered in the itemized other costs tab:

		ATP Total $	Non-ATP Total $
To fill out an itemized cost for each "Other Cost", click below: Itemized "Other Costs" Section	Travel (10a):	$ -	$ -
	Equipment (10b):	$ -	$ -
	Supplies/Materials (10c):	$ -	$ -
	Incentives (10d):	$ -	$ -
	Other Direct Costs (10e):	$ -	$ -
	Other Direct Costs (10f):	$ -	$ -
	Total Other Costs (10g):	$ -	$ -
	TASK GRAND TOTAL (11):	**$ -**	**$ -**

TASK "B" DETAIL

Task Name (5a):	**Equity for Elkhorn Boulevard Complete Streets Project**
Task Summary (5b):	As an Equity goal outlined in the Sacramento County Active Transportation Plan, this task will focus on creating accessible and culturally appropriate active transportation opportunities for all people regardless of race, color, national origin, disability, age, sexual orientation, or income to engage in the decision-making process

	Start Date	**End Date**	**Activities** (6a):	**Deliverables** (6b):
1.			Identify equity metrics for non-infrastructure and infrastructure activities	Equity Plan
2.			Translate outreach materials	Translation of outreach materials into Spanish and Russian
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Staff Costs (7):

Staff Time (Agency) (7a):		**ATP or Non-ATP (select one)**	**Staff Hours**	**Rate Per Hour**	**ATP Total $**	**Non-ATP Total $**
Party 1 -						
Party 2 -						
Party 3 -						
Party 4 -						
Party 5 -						
Party 6 -						
				Subtotal Agency Costs:	$ -	$ -
Staff Time (Consultant) (7b):		**ATP or Non-ATP (select one)**	**Staff Hours**	**Rate Per Hour**	**ATP Total $**	**Non-ATP Total $**
Party 1 -						
Party 2 -						
Party 3 -						
				Subtotal Consultant Cost):	$ -	$ -
				Total Staff Costs (Agency & Consultant) (7c):	**$ -**	**$ -**

Indirect Costs (8)

Approved ICAP (8a)**?**	☐	**If Approved ICAP box is checked, provide Rate** (8b)**:**		**ATP Indirect Costs** (8c):	

Task Notes (9):

Other Costs (10):

You will not be able to fill in the following items. The totals for each "Other Costs" category listed below will automatically calculate from information entered in the itemized other costs tab:

		ATP Total $	**Non-ATP Total $**
To fill out an itemized cost for each "Other Cost", click below:	Travel (10a):	$ -	$ -
	Equipment (10b):	$ -	$ -
	Supplies/Materials (10c):	$ -	$ -
Itemized "Other Costs" Section	Incentives (10d):	$ -	$ -
	Other Direct Costs (10e):	$ -	$ -
	Other Direct Costs (10f):	$ -	$ -
	Total Other Costs (9g):	$ -	$ -
	TASK GRAND TOTAL (10):	**$ -**	**$ -**

TASK "C" DETAIL

Task Name (5a):	**Education and Encouragement for Elkhorn Boulevard Complete Streets Project**
Task Summary (5b):	As the Educate and Encourage goals outlined in the Sacramento County Active Transportation Plan, this task will focus on educating and encouraging safe and frequent active transportation.

	Start Date	End Date	Task Activities (6a):	Deliverables (6b):
1.			Conduct one (1) demonstration project	One (1) demonstration project
2.			Hold one (1) "grand opening" community event	One (1) community event
3.			Create social media campaign promoting active transportation	Social media campaign
4.			Create active travel educational content, consistent with Sacramento County standards, for mapboards, kiosks, social media, and others as appropriate in the project area community	Educational content mapboard, kiosk, and social media
5.				
6.				
7.				
8.				
9.				
10.				

Staff Costs (7):

Staff Time (Agency) (7a):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
Party 4 -						
Party 5 -						
Party 6 -						
				Subtotal Agency Costs:	$ -	$ -

Staff Time (Consultant) (7b):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
				Subtotal Consultant Costs:	$ -	$ -
				Total Staff Costs (Agency & Consultant) (7c):	**$ -**	**$ -**

Indirect Costs (8)

Approved ICAP (8a)**?**	☐	**If Approved ICAP box is checked, provide Rate** (8b):		**ATP Indirect Costs** (8c):	

Task Notes (9):

Other Costs (10):

You will not be able to fill in the following items. The totals for each "Other Costs" category listed below will automatically calculate from information entered in the itemized other costs tab:

		ATP Total $	Non-ATP Total $
To fill out an itemized cost for each "Other Cost", click below:	Travel (10a):	$ -	$ -
Itemized "Other Costs" Section	Equipment (10b):	$ -	$ -
	Supplies/Materials (10c):	$ -	$ -
	Incentives (10d):	$ -	$ -
	Other Direct Costs (10e):	$ -	$ -
	Other Direct Costs (10f):	$ -	$ -
	Total Other Costs (10g):	$ -	$ -
	TASK GRAND TOTAL (11):	**$ -**	**$ -**

TASK "D" DETAIL

Task Name (5a):	**Evaluation for Elkhorn Boulevard Complete Streets Project**
Task Summary (5b):	This task will focus on evaluating the use of the new infrastructure as well as the effectives of the other non-infrastructure activities in promoting safe and frequent active transportation.

	Start Date	End Date	Task Activities (6a):	Deliverables (6b):
1.			Identify evaluation metrics for infrastructure and non-infrastructure activities	Evaluation Plan
2.			Implement Evaluation Plan	Evaluation Summary Report
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Staff Costs (7):

Staff Time (Agency) (7a):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
Party 4 -						
Party 5 -						
Party 6 -						
				Subtotal Agency Costs:	$ -	$ -

Staff Time (Consultant) (7b):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
				Subtotal Consultant Costs:	$ -	$ -
				Total Staff Costs (Agency & Consultant) (7c):	**$ -**	**$ -**

Indirect Costs (8)

Approved ICAP (8a)?	☐	**If Approved ICAP box is checked, provide Rate** (8b):		**ATP Indirect Costs** (8c):	

Task Notes (9):

Other Costs (10):

You will not be able to fill in the following items. The totals for each "Other Costs" category listed below will automatically calculate from information entered in the itemized other costs tab:

		ATP Total $	Non-ATP Total $
To fill out an itemized cost for each "Other Cost", click below: Itemized "Other Costs" Section	Travel (10a):	$ -	$ -
	Equipment (10b):	$ -	$ -
	Supplies/Materials (10c):	$ -	$ -
	Incentives (10d):	$ -	$ -
	Other Direct Costs (10e):	$ -	$ -
	Other Direct Costs (10f):	$ -	$ -
	Total Other Costs (10g):	$ -	$ -
	TASK GRAND TOTAL (11):	**$ -**	**$ -**

TASK "E" DETAIL

Task Name (5a):	**Safe Routes to School Programs**
Task Summary (5b):	As outlined in the Sacramento County Active Transportation Plan, this task will focus on education and encouragement for schools within the project area.

	Start Date	End Date	Task Activities (6a):	Deliverables (6b):
1.			Bike Education	Four (4) bike education sessions
2.			Pedestrian Education	Four (4) pedestrian education sessions
3.			Parent/Guardian Education	Four (4) Parent/Guardian education sessions
4.			Walking School Bus	Four (4) Walking School Bus events
5.			Suggested Route Maps	Four (4) suggested route maps for project area schools
6.				
7.				
8.				
9.				
10.				

Staff Costs (7):

Staff Time (Agency) (7a):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
Party 4 -						
Party 5 -						
Party 6 -						
				Subtotal Agency Costs:	$ -	$ -

Staff Time (Consultant) (7b):		ATP or Non-ATP (select one)	Staff Hours	Rate Per Hour	ATP Total $	Non-ATP Total $
Party 1 -						
Party 2 -						
Party 3 -						
				Subtotal Consultant Costs:	$ -	$ -
				Total Staff Costs (Agency & Consultant) (7c):	**$ -**	**$ -**

Indirect Costs (8)

Approved ICAP (8a)**?**	☐	**If Approved ICAP box is checked, provide Rate** (8b):		**ATP Indirect Costs** (8c):	

Task Notes (9):

Other Costs (10):

You will not be able to fill in the following items. The totals for each "Other Costs" category listed below will automatically calculate from information entered in the itemized other costs tab:

		ATP Total $	Non-ATP Total $
To fill out an itemized cost for each "Other Cost", click below: Itemized "Other Costs" Section	Travel (10a):	$ -	$ -
	Equipment (10b):	$ -	$ -
	Supplies/Materials (10c):	$ -	$ -
	Incentives (10d):	$ -	$ -
	Other Direct Costs (10e):	$ -	$ -
	Other Direct Costs (10f):	$ -	$ -
	Total Other Costs (10g):	$ -	$ -
	TASK GRAND TOTAL (11):	**$ -**	**$ -**

COUNTY OF SACRAMENTO
BICYCLE ADVISORY COMMITTEE
FINAL Meeting Minutes
Department of Transportation | Videoconference

Online: https://zoom.us/j/98729158988?pwd=YkY1T3d3VXpjZ0EydlRabnZpTlYxdz09

Dial-in: +1 669 900 6833 US,,98729158988#,,,,*778340#

WEDNESDAY January 19, 2022 - 6:00 p.m.

Members of the public wishing to address the committee on any item not on the agenda may do so at the beginning of the meeting. We ask that members of the public request to speak and keep their remarks brief. Testimony will be limited to a total of ten (10) minutes.

1. **Roll Call / Welcome and Introductions**
   Members: Thomas Cassera, Robert Goss, Sue Schooley, Jack Wursten, Dave Comerchero, Pat Perez, Arlete Hodel
   6:02 p.m.
   Present: Thomas Cassera, Robert Goss, Sue Schooley, Jack Wursten, Dave Comerchero, Pat Perez, Arlete Hodel
   Excused: None
   Unexcused: None

2. **Public Comment on Non-agenda Topics**
   None

3. **Review and Approve Meeting Minutes of December 15, 2021** **Action Item**

   Motion: Approve meeting minutes of December 15, 2021 as is.

   Action: **Motion/Second:** Perez/Wursten
   Yes: Thomas Cassera, Robert Goss, Sue Schooley, Jack Wursten, Dave Comerchero, Pat Perez, Arlete Hodel
   No: None
   Abstain: None

4. **50 Corridor Transportation Management Agency Programming** **Review and Comment**
   Cheryl Croshere, Executive Director, 50 Corridor TMA, (916) 601-2317, execdirector@50corridor.com
   6:20 p.m.
   - Committee expressed support for the use of financial incentives.
   - Members would like survey results to be reviewed, to determine peak motivational factors.
   - Committee is concerned about the use of the term “subsidy”, as this may cause the notion that the program is not sustainable over the long term.
   - Ensuring that communities of all socioeconomic levels are reached through inclusive engagement is a Committee priority.

The meeting facilities are accessible to persons with disabilities. Requests for documents in accessible formats, interpreting services, assistive listening devices, or other accommodations should be made through the County Disability Compliance Office at (916) 874-7642 or (916) 874-7647 (TTY/TDD), no later than five working days prior to the meeting.

- Committee member asked that the program address the possible concerns on unsafe areas and missing trips for tentative new riders.
- Member emphasized that it is important to introduce cycling safety and driver education as the program encourages more people to shift their mode of commuting.
- A collaboration with air quality management districts was suggested.

5. Draft Annual Report from SacBAC to Board of Supervisors **Review and Comment**

Mikki McDaniel, Senior Planner, SacDOT, (916) 875-4769, mcdanielm@saccounty.net
Kiara Movido, Student Intern, SacDOT, (916) 874-3926, movidok@saccounty.net
6:06 p.m.

- Members expressed they would like to see more momentum in the establishment of bike lanes.

6. Draft Active Transportation Plan (2022) **Review and Comment**

Mikki McDaniel, Senior Planner, SacDOT, (916) 875-4769, mcdanielm@saccounty.net
7:08 p.m.

- Committee asked that staff reassess the analysis for the plan due to the rise in telecommuting associated with the COVID-19 pandemic. This may be addressed in a plan amendment.
- Committee emphasized the need for the County to allot a budget towards driver education, as opposed to solely relying on outside grants.

7. Informational Items

- Final Meeting Minutes of November 3, 2021

8. Staff Updates and Reports Back

- SacBAC – Arlete Hodel
- SacDOT Associate Planner
- SacBAC presentation topics
- 311 – Photo Geolocation

9. Future Agenda Items

- Active Transportation Program Cycle 6 Project Candidates

10. Set Next Meeting Dates

a) Next SacBAC meeting: March 16, 2022

Online: https://zoom.us/j/98729158988?pwd=YkY1T3d3VXpjZ0EydlRabnZpTlYxdz09

Dial-in: +1 669 900 6833 US,,98729158988#,,,,*778340#

b) Adjourn SacBAC

Action: **Motion/Second:** Hodel/Wursten
Yes: Thomas Cassera, Robert Goss, Sue Schooley, Jack Wursten, Dave Comerchero, Pat Perez, Arlete Hodel
No: None
Abstain: None
7:47 p.m.

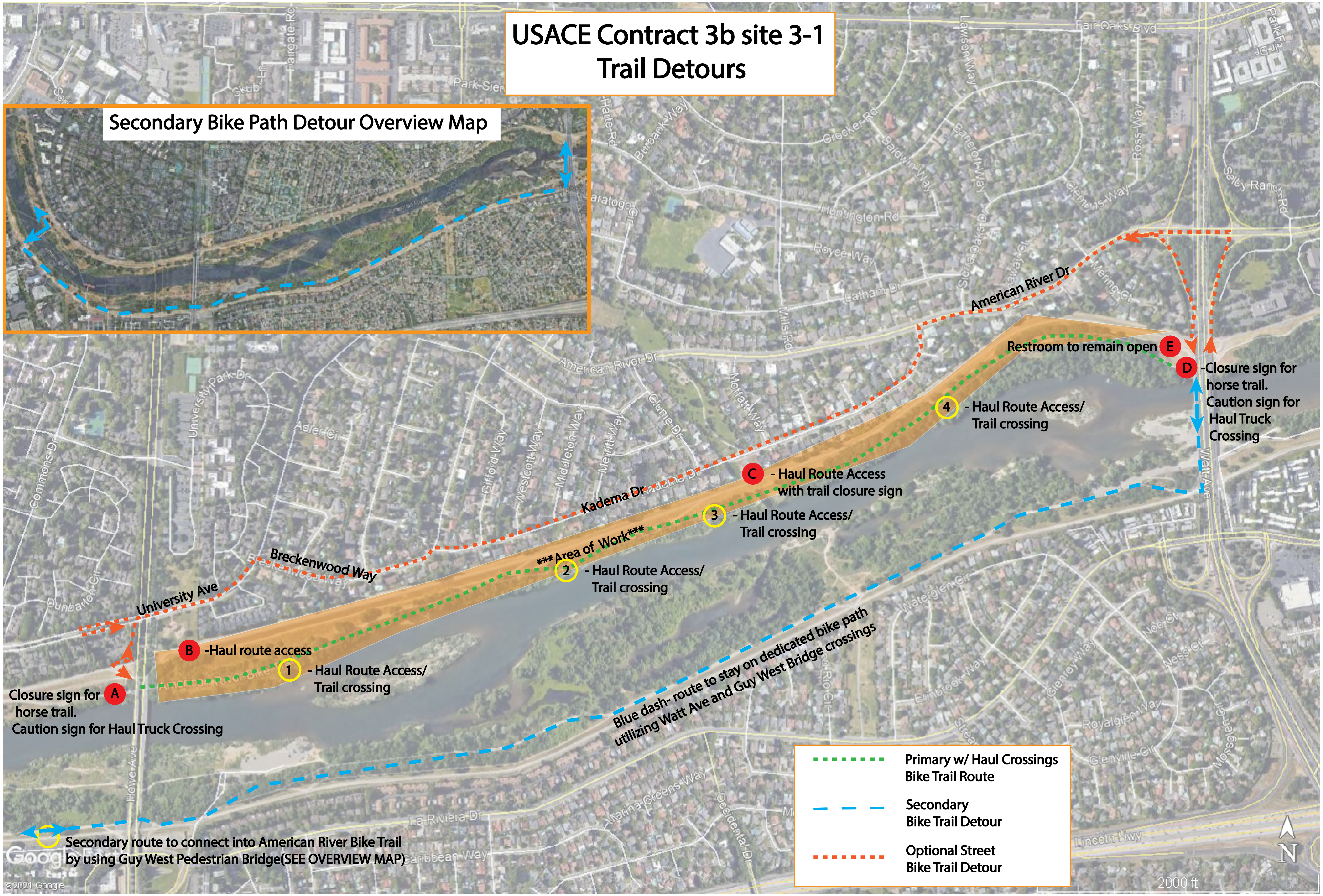
(DRAFT)CONTRACT 3B DETOUR STRATEGY(DRAFT)

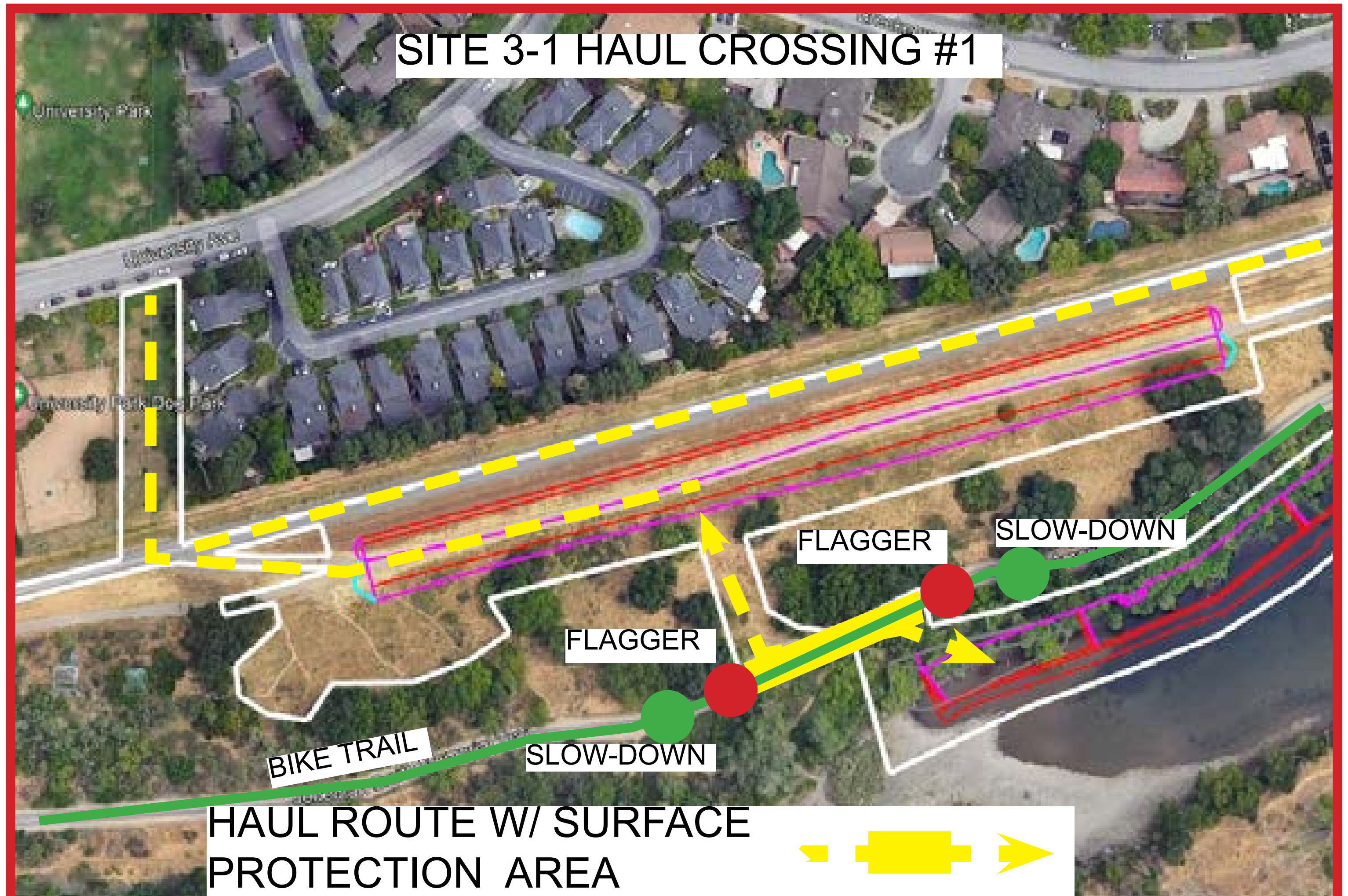
GUIDELINES

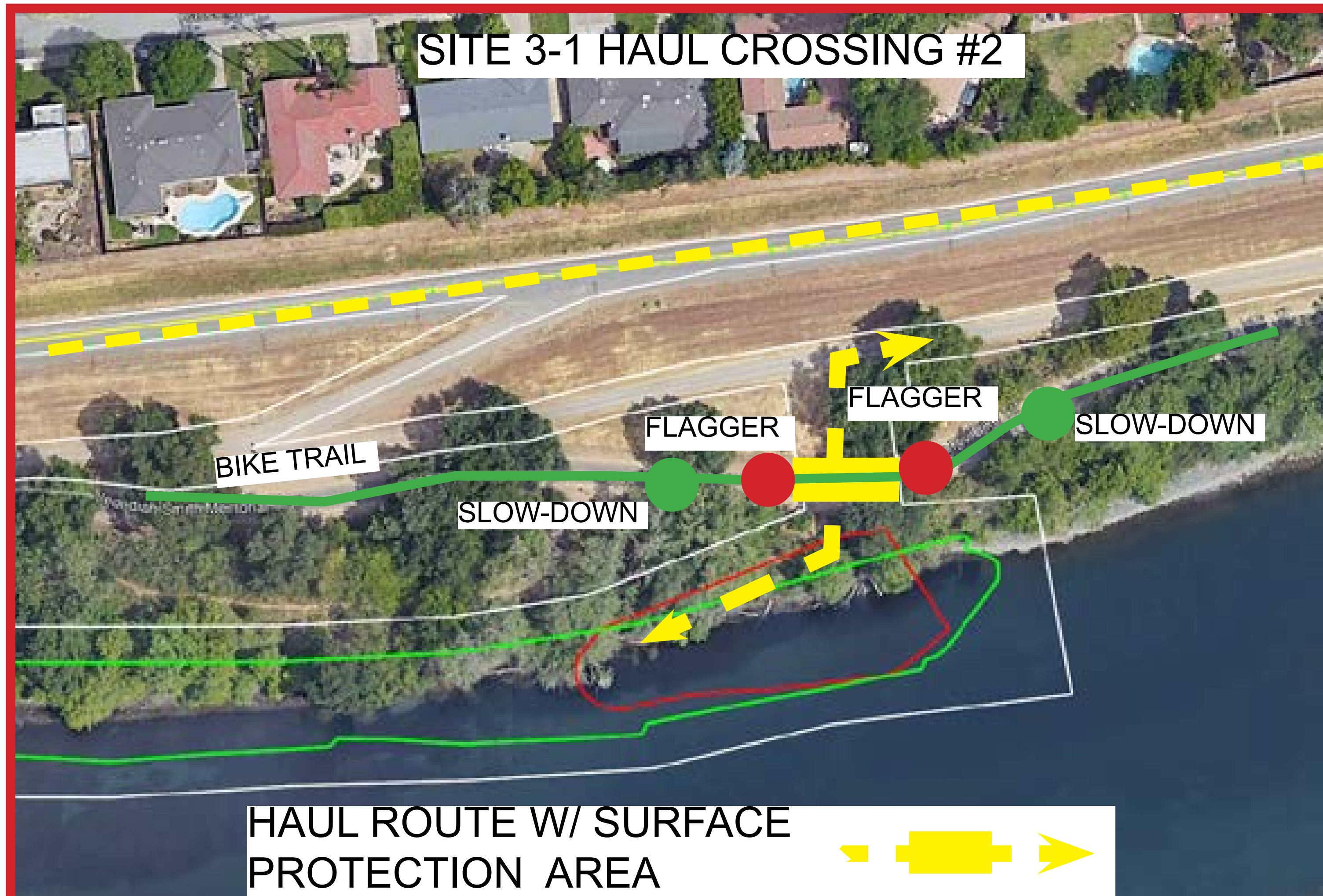
1. Section 3-1 and 4-2 should **never** have primary detours on the city streets at the same time.
2. Trail detours should remain in American River Parkway and must be approved to detour on city streets.
3. Any detour surface must be approved, non-skid surface, hardened, and free of debris at all times.
4. Any crossing of trail by haul trucks will require construction flaggers and haul trucks will have priority to cross trails.
5. Haul truck crossings should be adjusted for bike commuter timelines.
6. Any setup work on the bike trail will require temporary detours to be placed on top of levee

DETOUR PRIORITIES(1-being top)

1. Trail remains open in existing alignments.
2. Trail to detour within the American River Parkway.
3. Trail to detour using top of levee.


USACE Contract 3b site 3-1
Trail Detours
Secondary Bike Path Detour Overview Map
DRAFT
DRAFT
Restroom to remain open
E
D
-Closure sign for horse trail. Caution sign for Haul Truck Crossing
4 - Haul Route Access/ Trail crossing
C - Haul Route Access with trail closure sign
3 - Haul Route Access/ Trail crossing
Area of Work
2 - Haul Route Access/ Trail crossing
B -Haul route access
1 - Haul Route Access/ Trail crossing
A
Closure sign for horse trail. Caution sign for Haul Truck Crossing
Blue dash- route to stay on dedicated bike path utilizing Watt Ave and Guy West Bridge crossings
Secondary route to connect into American River Bike Trail by using Guy West Pedestrian Bridge(SEE OVERVIEW MAP)
American River Dr
Kadema Dr
Breckenwood Way
University Ave
Primary w/ Haul Crossings Bike Trail Route
Secondary Bike Trail Detour
Optional Street Bike Trail Detour
2000 ft
N
©2021 Google





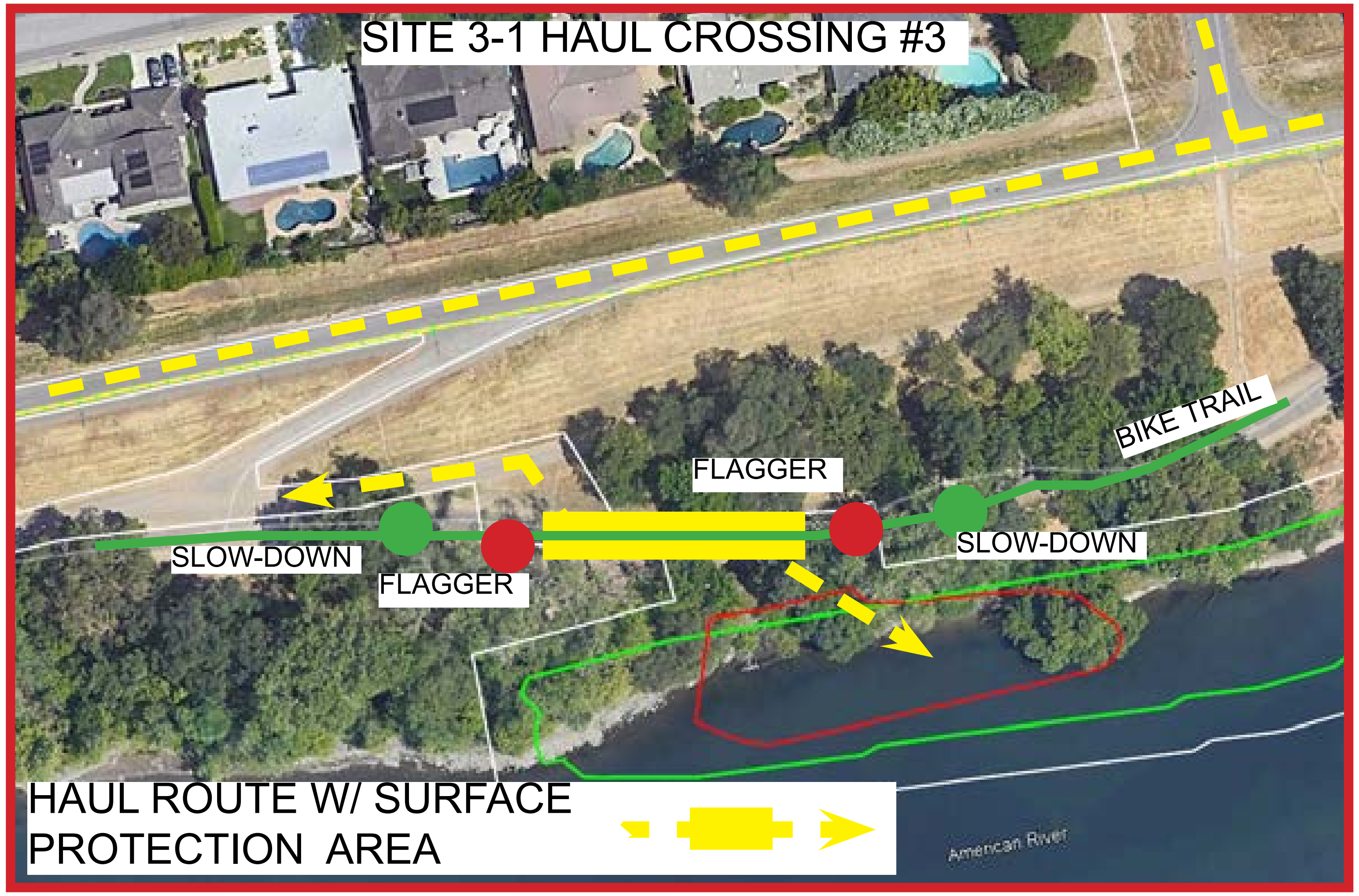
OPTION #1 HAUL CROSSING SURFACE PROTECTION

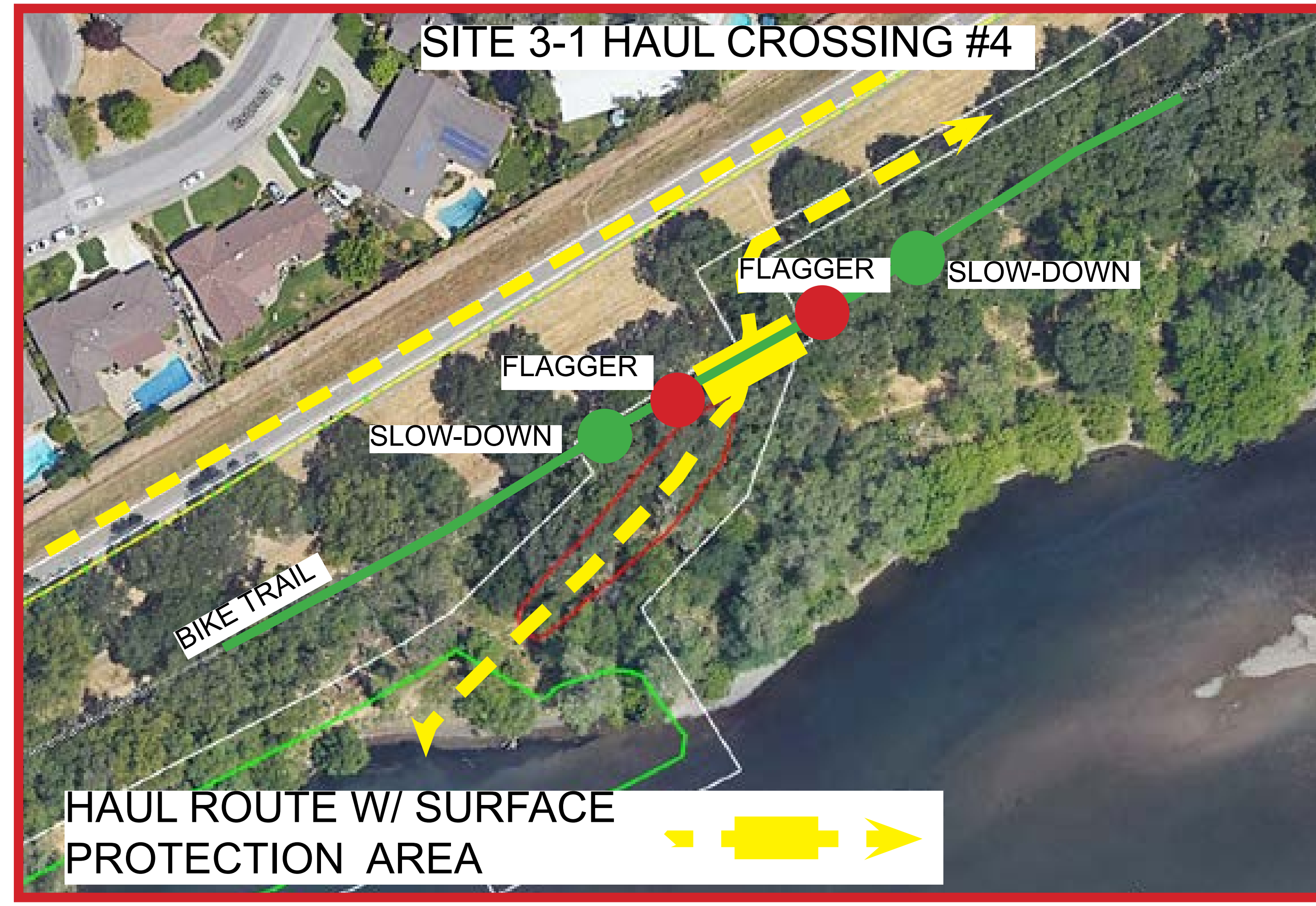
TEMPORARY NON-SKID SURFACE PROTECTION. TRAIL TO BE DETOURED TO TOP OF LEVEE WHILE INSTALLATION OCCURS

OPTION #2 HAUL CROSSING SURFACE PROTECTION

INSTALL FULL-DEPTH AS-PHALT-FOR HEAVY HAUL TRUCKS. TRAIL TO BE DETOURED TO TOP OF LEVEE WHILE INSTALLATION OCCURS. THICKNESS OF PATH-WILL TEMPORARILY INCREASE FOR TRUCKS WEIGHT

6”-12” additional thickness





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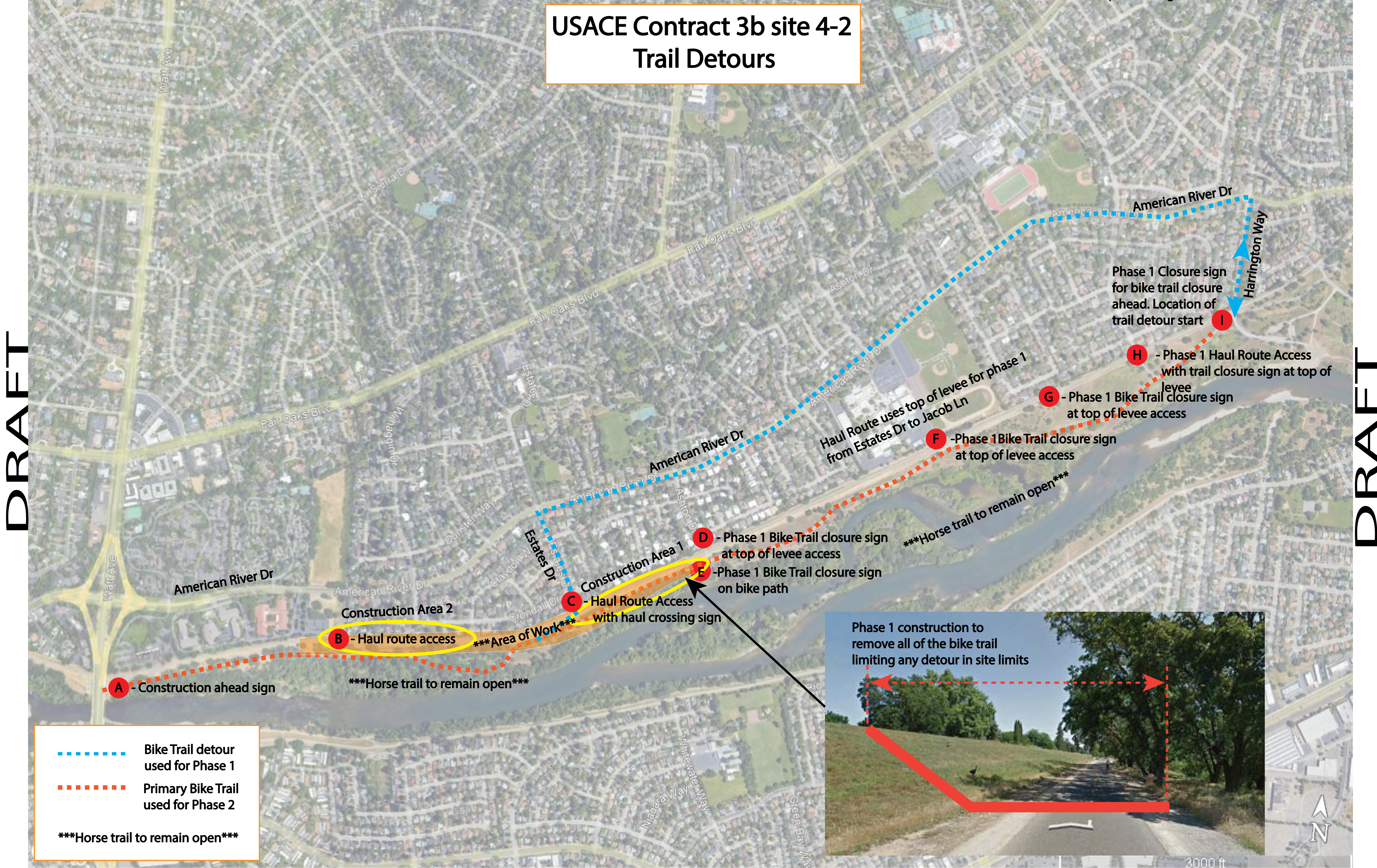


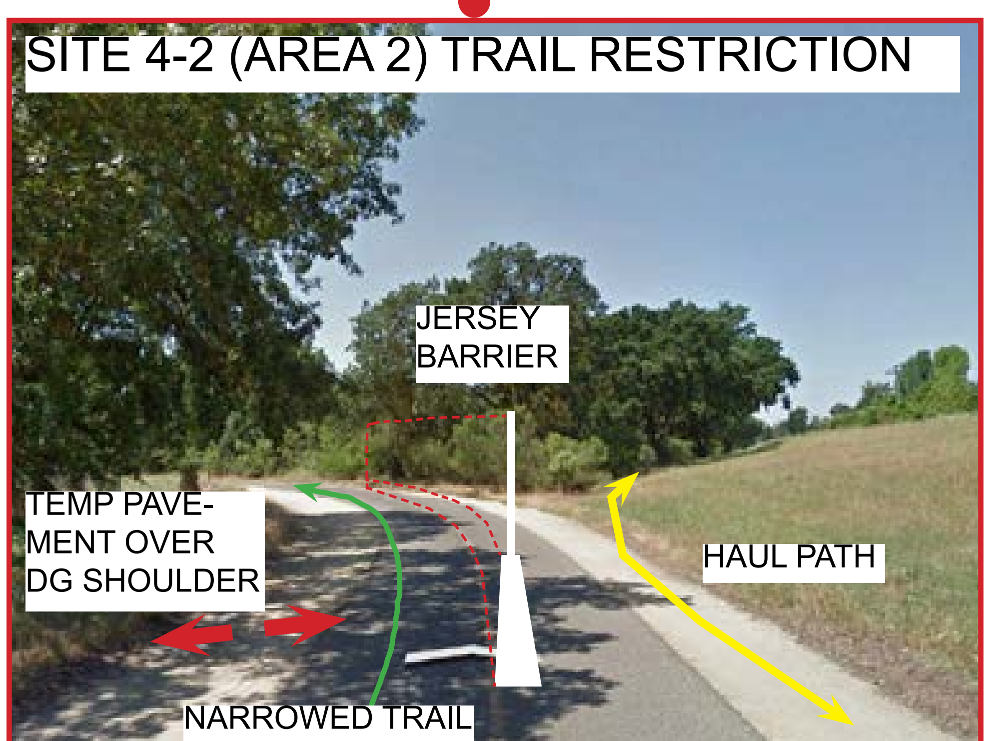
USACE Contract 3b site 4-2
Trail Detours
DRAFT
DRAFT
American River Dr
Harrington Way
Phase 1 Closure sign for bike trail closure ahead. Location of trail detour start
I
H - Phase 1 Haul Route Access with trail closure sign at top of levee
G - Phase 1 Bike Trail closure sign at top of levee access
F -Phase 1Bike Trail closure sign at top of levee access
Haul Route uses top of levee for phase 1 from Estates Dr to Jacob Ln
Horse trail to remain open
American River Dr
D - Phase 1 Bike Trail closure sign at top of levee access
E -Phase 1 Bike Trail closure sign on bike path
Construction Area 1
Estates Dr
C - Haul Route Access with haul crossing sign
American River Dr
Construction Area 2
B - Haul route access
Area of Work
A - Construction ahead sign
Horse trail to remain open
Phase 1 construction to remove all of the bike trail limiting any detour in site limits
Bike Trail detour used for Phase 1
Primary Bike Trail used for Phase 2
Horse trail to remain open
Fair Oaks Blvd
Watt Ave
N
3000 ft

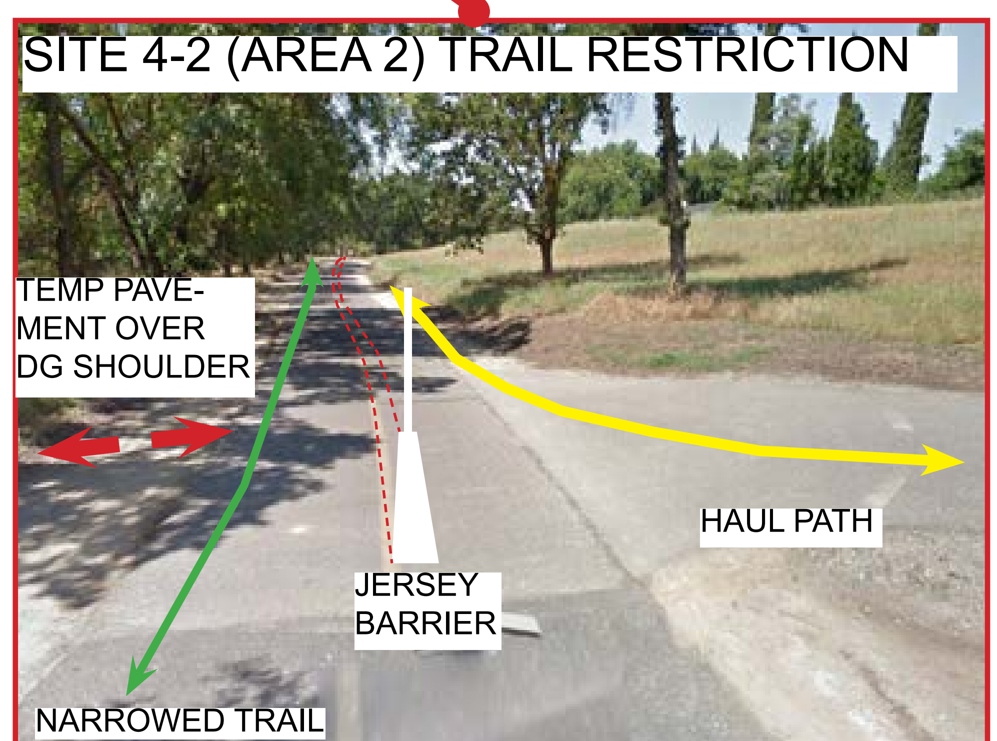
SITE 4-2 (AREA 1) TRAIL DETOUR INTERFACE
Crondall Dr
Estates Dr
Chillam Way
Estates Drive River Access
HAUL PATH
AREA 1
FLAGGER
BIKE TRAIL DETOUR
SLOW-DOWN
Jedediah Smith Memorial Trail
TRAIL CLOSED DURING AREA 1 CONSTRUCTION
JERSEY BARRIER AREA APPROX-380 LF (SEE AREA 2 DETAILS)

SITE 4-2 (AREA 1) TRAIL DETOUR INTERFACE
BIKE TRAIL DETOUR
CLOSED

SITE 4-2 (AREA 1) TRAIL DETOUR INTERFACE
HAUL PATH
BIKE TRAIL DETOUR
JERSEY BARRIER

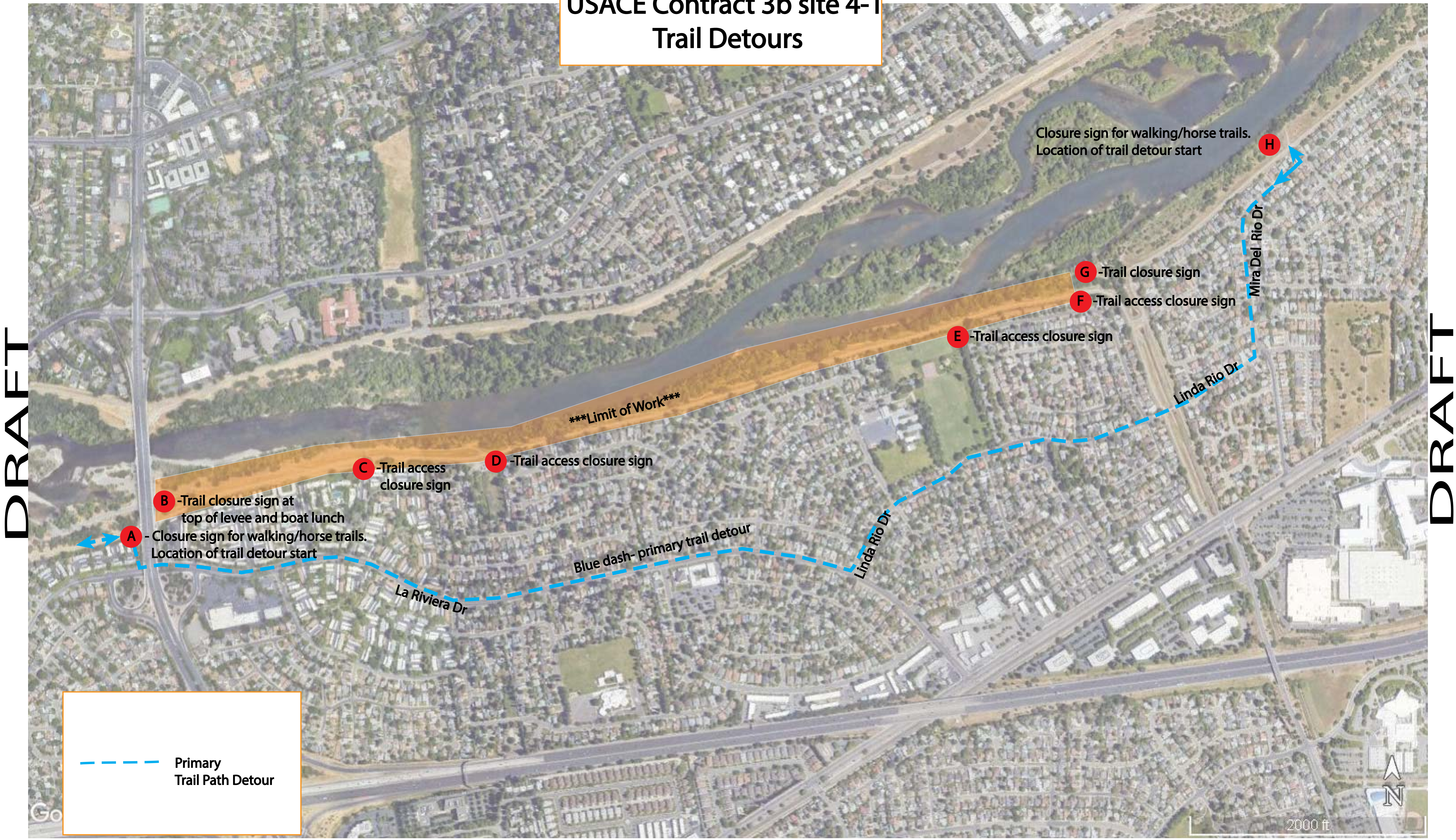

SITE 4-2 (AREA 2) TRAIL RESTRICTION AREA
Crondall Dr
Estates Dr
Estates Drive River Access
AREA 2
HAUL PATH
TRAIL ACCESS CLOSED DURING AREA 2 CONSTRUCTION
SLOW-DOWN
JERSEY BARRIER AREA
APPROX-380 LF
SLOW-DOWN
BIKE TRAIL OPEN DURING AREA 2
CONSTRUCTION


SITE 4-2 (AREA 2) TRAIL RESTRICTION
JERSEY
BARRIER
TEMP PAVE-
MENT OVER
DG SHOULDER
HAUL PATH
NARROWED TRAIL


SITE 4-2 (AREA 2) TRAIL RESTRICTION
TEMP PAVE-
MENT OVER
DG SHOULDER
HAUL PATH
JERSEY
BARRIER
NARROWED TRAIL


PROTECTIVE JERSEY
BARRIER TO SEPARATE
BIKE PATH AND HAUL
PATH INTERFACE

USACE Contract 3b site 4-1 Trail Detours



USACE Contract 3b sites (3-1, 4-1, 4-2)

Trail Detours

Purpose:

The draft trail maps are to collect comments and vet the best routes before providing details in the construction plans. All routes are subject to safety, construction area limits, truck haul routes, and providing a route suitable for recreation transportation.

The recreation routes priority was to keep within the original trail alignments. The trails were only rerouted if it was concluded to be unsafe for trail users and the requirement provide a suitable trail surface.

Site 3-1 detours:

Description: Trail detours are made up of two main routes with a third optional street route. The horse trail will remain closed because crossing truck haul routes and proximity of construction. Signage will be placed at all levee access and parkway corridors access points.

1. Primary Detour- First primary route is to stay on the existing trail which would intersect 4 haul routes in the 3-1 work limits. Trucks would cross the existing bike path to get to work areas along the toe of the riverbank. Each haul route crossing would have a flagger during work hours and surface protection would have to be provided in the shared section of the existing bike trail. The surface protection of the trail would be placed because of the heavy haul trucks causing degradation of the pavement. There would also be the need for periodically sweeping during the construction day to maintain a safe surface for trail users. At each truck crossing there would need to be trail user slow down markers allowing for safe approach speeds in case trucks are crossing.
2. Secondary bike path detour will utilize the dedicated bike path along the south side of the American river. It will cross at Watt Ave bridge and the Guy West pedestrian bridge down by Sacramento State College. The secondary path allows trail users to avoid any vehicle intersections and streets. Vetting of both routes will be required to meet all traffic safety requirements.
3. Lastly, the optional street bike trail detour will be on the north side of the American River utilizing city streets to safely move pedestrians around the work area. This is strictly an optional path and should **not** be the dedicated detour at any time.

Considerations: Site 3-1 has many trail interruptions with construction areas and haul truck routes. Haul routes will be utilizing levee maintenance road, top of levee, and crossing the American river bike trail at 4 locations. The 4 haul route trail crossings will be safety concerns to users because of possible rock debris over crossing, trail degradation, proximity of trucks near trail, and vicinity of active construction equipment. Sections of trail will be opened and brought back to existing conditions as contractors completes sections of work, but it will need to be coordinated and developed further during the final plans.

Site 4-2 detours:

Description: 4-2 section is to be constructed in two areas which changes the bike detours alignments as each area is constructed. Once area 1 is complete the bike trial will not be detoured to the city streets and brought back to existing trail alignment. When area 2 is constructed, the bike trail shown on the map will need to parallel the haul route causing a temporary restriction in width and requiring a section of the trail to utilize a SLOW ZONE for trail users. The horse trail is to remain in use and open during all construction phases.

4. Area 1-
    a. Trail Detour: The bike trail detour will be routed to city streets while construction is taking place. The detour will utilize a shared entrance at the levee entrance on Estates Dr. The bike trail will remain open to the boundary of the construction allowing access along the majority of shoreline from Harrington Way to Watt Ave. Signage will be placed at all levee access and parkway corridors access points.
    b. Haul Route: The Estates Dr access will require a flagger and a barrier to separating the haul trucks from trail detour users. Area 1 construction area will require all access points to be closed at the top of levee from Estates Dr to Jacob Ln for the haul route.
5. Area 2-
    a. Trail Detour: Once Area 1 is completed and the trail will be opened. Work limits will be readjusted for the restricted/narrowing section of the trail(See plans Area 2). Temporary paving over the DG shoulder of the bike trail is recommend for the trail user side allowing for a total width of 9 feet. The trail user will be cautioned with signage of a SLOW ZONE and required to reduce speed in this section. Creating a narrowing of the trail will allow for the trail to remain open without creating new trail in the area or a detour on the city streets.
    b. Haul Route: Trucks will utilize half of the bike trail while trail users will be on the water side half. The separation of the trail will have a jersey barrier with fencing creating a safe barrier for trail users(See 4-2 images provided).

Considerations: The truck haul routes and construction areas create a pinch point for trail access through the site around the Estates Dr levee access area. It was recommend detouring the trail around to the city streets only during Area 1 construction because it will be fully removing the bike trail temporary in the up-stream extents. The top of levee will be used for trucks in area 1 as well.

Site 4-1 detours:

Description: Trail detour of the hiking trail is to be rerouted to city streets while construction is taking place. The trail will exit at a pedestrian access point on Mira Del Rio Dr and along La Riviera Dr(Watt Ave). Signage will be placed at all levee access and parkway corridors access points.

Considerations: Trail detours within or along the levee would be unsafe due to haul routes and construction equipment. Top and toe of levee routes will be utilized to avoid impacting vegetation in the area which will not allow the use the routes for detours within the site.