APPENDIX A

REVIEW OF SELECTED CITIES' PRACTICES

Bus bulbs were studied as part of a more comprehensive research study of bus stop design and location, which was sponsored by TCRP (*1*). During the course of the study, it was determined that little documentation existed on the operation and design of bus bulb configurations, either in the general literature or within transit agency design manuals. Transit agencies were surveyed to determine the best practices being applied during bus stop design and location decisions. Questions regarding the use and design of bus bulbs were a part of this comprehensive study.

Relatively few transit agencies responding to the mail-out survey indicated use of bus bulbs. These agencies included those in Charlotte, North Carolina; Grand Rapids and Lansing, Michigan; Orlando and West Palm Beach, Florida; Portland, Oregon; San Francisco, California; and Seattle, Washington. The cities of Portland and San Francisco provided guidelines on bus bulb design and placement as part of their responses. Experience from the previous TCRP project (*1*) indicated that the actual definition of a "bus bulb" was interpreted in many different ways. For example, some responding agencies that indicated the use of bus bulbs were merely noting pedestrian curb extensions or "nubs" at intersections that happened to be near a bus stop. The buses did not or could not stop at the curb extension because it was not long enough to accommodate boarding and alighting activities.

Several large cities in the Pacific Northwest, however, are exploring the use of bus bulbs as one of many strategies to deploy a transit preferential program. Researchers visited four transit agencies in the West and Northwest that were known to use bus bulb configurations (Figure A-1). To observe and document existing and planned bus bulb configurations, the research team visited San Francisco, California; Portland, Oregon; Seattle, Washington; and Vancouver, British Columbia. The cities were previously identified in the aforementioned TCRP project, and further contact with the transit agencies revealed that bus bulbs now receive serious consideration at several existing stops. Each of these cities has a strong pedestrian and bicycle program to augment transit operations in the region.

The methodology used during the regional visit was similar to the one employed during the previous TCRP project. Each individual on the trip was responsible for his or her area of expertise. Site visits of existing bus bulbs were conducted prior to meeting with transit and city representatives. It was critical for the team to observe how sites were operating before interviewing knowledgeable staff. During the site visits, notes were made about site layout and facility characteristics, and observations were made regarding transit, vehicle, and pedestrian operations. Still photography was also used to capture site layout, neighborhood setting, and site details (e.g., placement of traffic control measures, drainage, and bus arrival activities).

While in the city, the research team met with transit and city representatives (e.g., city planners, pedestrian and bike program operators, and mobility coordinators) to discuss issues associated with bus bulb design and placement. Issues discussed during the meeting included

- The history of bus bulbs in the area;
- The impetus for considering the use of bus bulbs (e.g., high transit ridership in a corridor, re-entry problems for buses during peak vehicular times, the need for separating transit and pedestrian activities on a sidewalk; and the need for installing additional transit amenities);
- The typical characteristics for sites that would be and for sites that would not be good candidates for bus bulbs (e.g., traffic volumes, transit ridership, high pedestrian use, and roadway operating speeds);
- Experiences or "lessons learned" to date with bus bulb installation;
- The costs of constructing bus bulbs (e.g., retrofit versus new); and
- The development of design standards in the area.

The following pages document the findings from the regional visit. A general summary is presented for each city by a review of the following topics:

- Width and length of bulbs,
- Parking,
- Americans with Disability Act (ADA) wheelchair lift deployment,
- Drainage,
- Bus stop location,
- Pedestrians,
- Bicycles, and
- Cost.

A review of sites visited follows each city summary. Only unique characteristics are discussed for each site. The section on Seattle has a general overview of regional practices,

Figure A-1. Cities with bus bulbs visited.

but it also contains a very detailed review of a bus bulb demonstration project. Similar to Seattle, Vancouver also has a demonstration project underway with two sites near the University of British Columbia campus. Because Vancouver only had two examples at the time of the visit, the general overview and site details are one and the same.

SAN FRANCISCO, CALIFORNIA

The concept or use of bus bulbs in San Francisco dates back to the early 1970s with the adoption of the Transit Preferential Streets (TPS) program in 1973. Under this program, several "transit-first" strategies were identified, which were designed to create a more "transit-friendly" environment within the city of San Francisco, especially within those corridors where there was already a large dependence on transit to move people (*2*). San Francisco, as a city, is unique in North America. The city form is constrained geographically by the Pacific Ocean and surrounding hillsides, which encourages high-density expansion. Neighborhoods are densely built around narrow streets, and there is limited parking throughout the city, either on-street or in parking garages. The population and employment is diversely distributed throughout the city. In fact, San Francisco has the second highest population density in the United States. Because of all of the above factors, there is a heavy reliance on transit and sidewalks for mobility.

The increased emphasis toward pedestrian-oriented types of development within the TPS program and the adopted transit-first policy is to improve transit accessibility within San Francisco. Strategies that were first identified included bus bulbs, signal preemption for transit vehicles, increased parking enforcement at selected locations, exclusive bus-only lanes, and automobile turn restrictions (*2*). The deployment of the program was guided by a number of factors. Among these factors were identifying streets with the highest levels of transit ridership and frequency of service, streets with existing rail and trolley infrastructure, and locations where there was an unacceptable level of auto-to-transit conflicts (*2*). Streets were essentially scored based on these criteria. The higher the score a street receives, the greater number of TPS projects it could receive.

The first bus bulbs in San Francisco were built on Monterey Boulevard, Polk Street, and Stockton Street. The site characteristics for each of these locations are unique and point to the diversity of neighborhoods in the city. Monterey Boulevard is a residential four-lane arterial. Polk Street is a three-lane facility in a well-established mix of commercial and residential development near downtown San Francisco. The Stockton Street bulbs, which are entirely in Chinatown, were constructed to relieve extremely high pedestrian volumes along narrow sidewalks. During this time, there were also bulbs installed in and around Union Square, which is essentially the center of downtown and has high-rise hotels, offices, and commercial shopping buildings.

It was not until two decades later that additional bus bulbs were built within San Francisco proper. In 1996, four bus bulbs were built in the Castro District. Two bulbs are directly located at the intersection of Castro and Market Streets—one farside and one nearside. This intersection serves multiple transit lines, including subway, rail cars, and bus lines. Congestion relief for pedestrians and transferring transit riders was a major objective of the project.

The most recent additions occurred along south Mission Street. A total of nine bulbs were built between Cesar Chavez Street and Cortland Avenue. Mission Street is an historical shopping center with a mix of single-room hotels and small residential living spaces above local businesses. Sidewalks can become inundated with pedestrians, especially after area schools release children in the afternoons and on Saturday mornings when local residents do their weekly shopping. Further adding to the pedestrian demand are the intermittent surges of people created by the boarding and alighting activities of buses. The Mission Street transit volumes are the highest ridership numbers in a corridor west of the Mississippi River.

Another 15 to 18 bulbs are planned, the majority of which are for Mission Street between 20th and 25th Streets. The Mission Street at 20th Street bus stops have the highest number of boardings in San Francisco. Other notable locations are Stockton Street at Geary Street (downtown San Francisco) and Potrero Avenue at 23rd Street near San Francisco General Hospital. The Potrero Avenue site is near the city hospital; however, the most noteworthy item about this site is that it is on a six-lane arterial with posted speeds of 45 mph (72.5 km/h). This is the first bus bulb being considered on a facility with posted speeds greater than 30 mph (48.3 km/h) in the city of San Francisco. Figure A-2 shows the location of bus bulbs that have already been constructed in the city.

The following pages provide a general overview of practices and experiences with bus bulbs in San Francisco. Individual site descriptions follow.

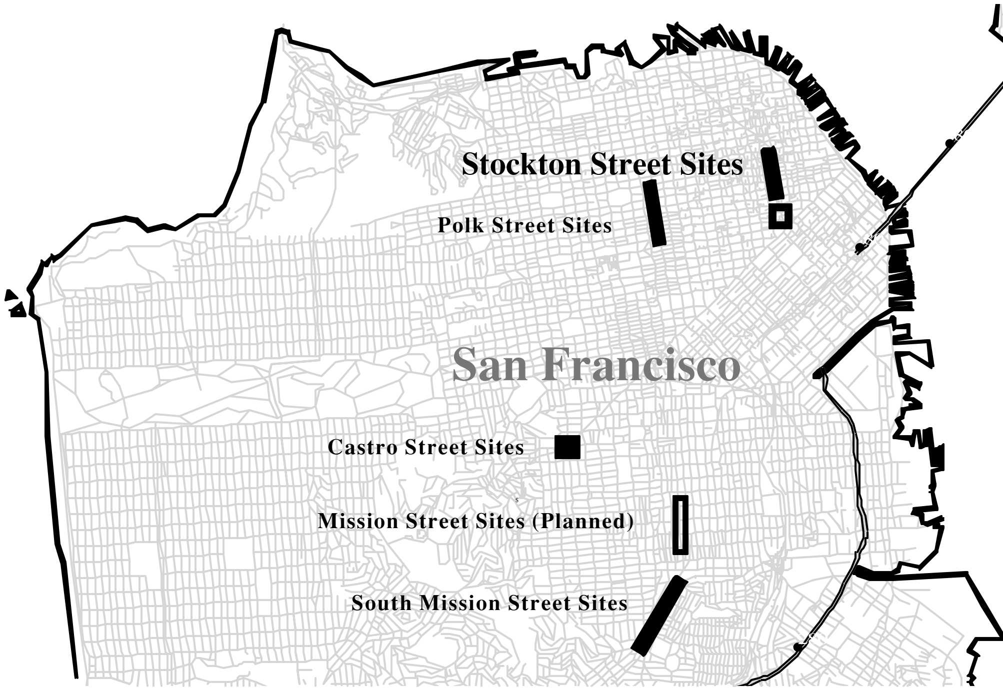


Figure A-2. Location of bus bulbs in San Francisco.

Overview of Practices and Experiences

Width and Length of Bulbs

The current standard width of bus bulbs in San Francisco is 6 ft (1.8 m), depending on any unique site characteristics. The additional distance provided by the bus bulb allows the San Francisco Municipal Railway (Muni) to move transit shelters off of the sidewalk and onto the bulb. Vending machines, benches, and trash receptacles are also moved onto the bulbs, which helps relieve pedestrian congestion along the adjacent sidewalk.

The standard length of a bus bulb is 140 ft (42.7 m). The length was expanded from 60 to 70 ft (18.3 to 21.4 m) in recent years to better accommodate the simultaneous arrival at the site of two articulated buses. Prior to the installation of bulbs, it was difficult for two articulated buses to completely stop in the bus bay at the same time. Figure A-3 is an example of a bus bay that is inadequately sized to handle multiple articulated buses at the same time.

On several occasions, it was not unusual for the research team to observe three buses arriving at a bus stop at the same time (sometimes referred to as "bunching," see Figure A-4). In these instances, even the greater length of the bus bulb is inadequate. Similar to the curbside arrangement, the third or last bus would either board and alight on the street or wait for the first two buses to depart. When the third bus waits for the first two buses to depart, the bus causes additional delay to any vehicles queued behind the bus.

Transit Vehicle Travel Time and Dwell Time

The foremost reason for installing the bulbs along Mission Street is the bus re-entry problem associated with bus bay stops. Bus drivers are extremely positive toward the construction of bus bulbs. Prior to the construction of bulbs, certain routes would experience delays, which were directly blamed on the bus re-entry problem. Drivers had a problem with staying on schedule along routes where the buses interacted with high vehicular volumes. Figure A-5 is an example of a bus on Mission Street during heavy vehicular volumes.

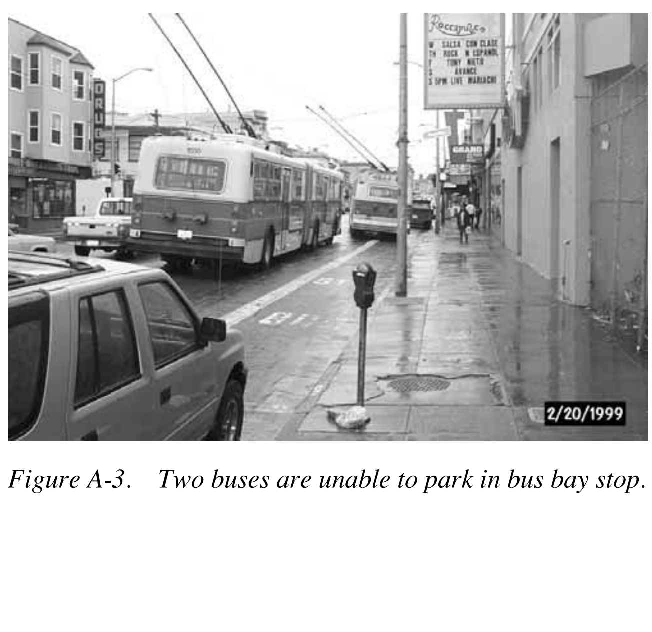


Figure A-3. Two buses are unable to park in bus bay stop.

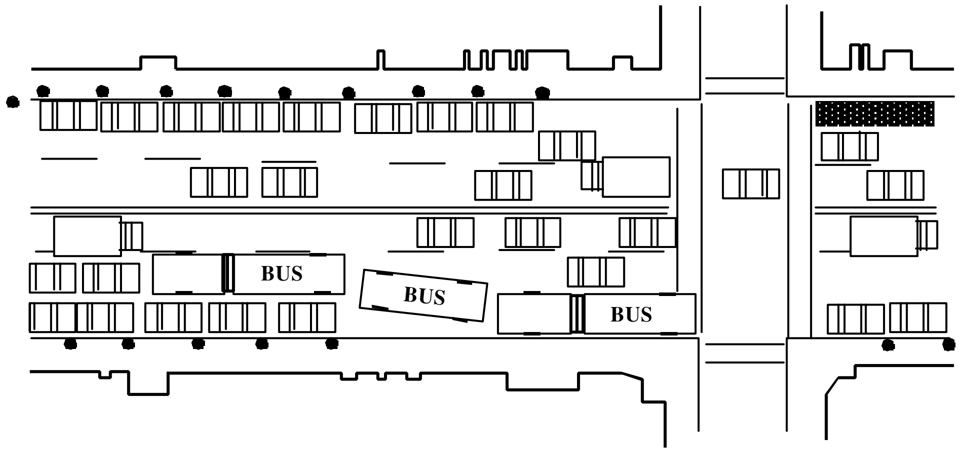


Figure A-4. Example of transit vehicle "bunching" at bus bay.

Further exacerbating the re-entry problem are illegally parked vehicles at the end of the bus stop zone or double-parked vehicles or trucks just beyond the bus stop zone (Figure A-6). Bus drivers must carefully maneuver around these parked vehicles and, at the same time, avoid hitting other vehicles in the travel lanes and oncoming vehicles. If bus drivers are not careful, the catenary connection between the bus and the overhead electrical wires can become dislodged, which causes the bus to stop in its tracks. This can add to the route delay if this event occurs often. The time difference can be quite substantial when bus drivers must slowly re-enter the flow of traffic with these unnecessary obstacles.

To avoid maneuvering around illegally parked vehicles in the bus stop zone or double-parked trucks just at the end of the zone, bus drivers will do one of two things: (1) board and alight the bus from the street (Figure A-7) or (2) partially pull into the zone to avoid the bus re-entry problem around a double-parked vehicle or truck (Figure A-8). Boarding and alighting passengers from the bus onto the street can create hazardous conditions for the patrons and expose the transit authority to liability. Partially pulling into the zone leaves all or a portion of the transit vehicle in the travel lane. When this partial pulling in occurs, the bus bay is functioning as a bulb in terms of blocking a travel lane.

Figure A-5. Bus operating during heavy vehicular volumes.

The bus re-entry problem was not the only source of delay mentioned as a problem for the bus trolley lines. Another source of significant delay is entry into the bus stop zone. Double-parked vehicles can cause changes in how the bus driver approaches the bus stop zone. Double-parking is a significant problem in areas with an abundance of local shops that have limited on-street parking.

During the on-site visit, the fare collection policy and bus dwell time were concerns. The current policy is to have patrons alight from the rear door of the bus and to board in the front of the bus. There are signs to this effect in the bus. However, during extreme crowding, it was observed that all doors were used for boarding and alighting to minimize dwell. If the bus driver did not open all of the doors, long queues would form in and around the bus stop and, in some instances, these queues would interfere with pedestrians on the sidewalk. This interference with pedestrians is especially true for bus stops that do not have bus bulbs. Muni will begin a proof-of-payment system that enables all doors to be open for boarding and alighting while still maintaining appropriate fare collection levels. It is hoped that this system will decrease the amount of time a bus is at a bus stop.

In another effort to improve transit vehicle time, Muni is considering signal preemption on a number of routes. Signal preemption is being installed along Mission Street as part of the street improvement plan. It is hoped that the installation of bulbs, the implementation of a new fare collection system, and the use of signal preemption will improve the end-to-end route travel times by 5 to 15 percent on Mission Street.

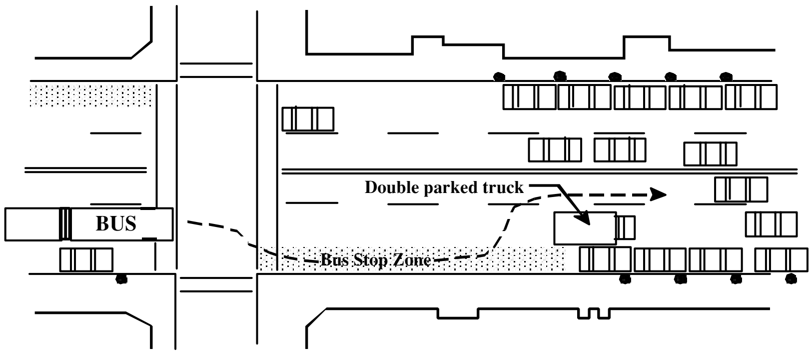


Figure A-6. Transit vehicle path impacted by double-parked truck at end of bus bay.

Parking

Parking is extremely limited throughout the city of San Francisco. On-street parking is typically available on both sides of the street. While the research team was in San Francisco, illegal parking at metered spaces was aggressively monitored. Despite these efforts, illegal parking in the curbside bus bay zone is a significant problem in certain areas of San Francisco. Motorists park in the curbside bus zone when parking spaces are full. Either a passenger or the driver will quickly run errands at local stores while the car is illegally parked. It was not an uncommon event for buses to encounter cars blocking the path into the curbside zone. Bus drivers will usually be forced to stop in the travel lane either completely or partially in order to have enough maneuvering room to return to the traffic stream safely. The bus then blocks the outside lane of travel, and cars either form a queue behind the stopped bus or weave into the inside lane to avoid the queue (Figure A-9).

Double-parking either before or after the zone can also affect the overall travel time of the route. Because of the limited on-street parking, delivery trucks load and unload in the outside lane of travel. If this activity occurs near the bus stop zone (either before or after), the bus driver must adjust the path of travel dramatically to maneuver around the double-parked vehicle. Muni believes that bus bulbs are a self-enforcing parking design. Bus bulbs highly discourage any motorists from temporarily parking in the bus stop zone because of the amount of traffic the illegally parked vehicle would block.

Bus bay stops are clearly marked with signage on posts and red paint along the curb over the entire bus stop zone. The curbside zone is also marked with Bus Stop and a large white box that defines the zone on the pavement. The bulbs have the same signage on posts and red curb markings, but the street does not have any markings. Figure A-10 shows downstream parking near a bus bulb on Mission Street.

The construction of the bus bulbs on Mission Street did not remove any parking spaces from the parking lanes. However, in this case, perception is greater than reality. A few of the local store owners made it a point to tell the research team during the data collection efforts about how the bus stops removed parking in front of their respective stores. The bulbs, in this regard, were not well received by these local business owners.

Figure A-7. Buses board and alight on street to avoid parked vehicle.

Figure A-8. Bus partially pulls into bus stop to avoid bus re-entry problem.

Figure A-9. Illegally parked car affects bus and general-purpose movement.

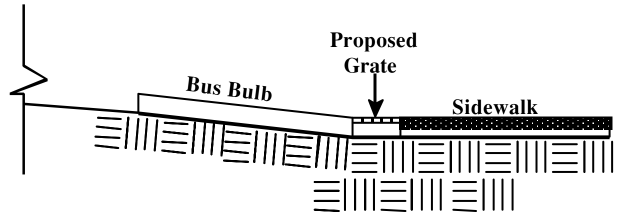


Figure A-11. Proposed drainage system.

Drainage

Drainage is a major contributor to increasing the cost of a bus bulb project. Because bus bulbs have been constructed in San Francisco since the 1970s, the city has more experience with overcoming design problems associated with constructing what essentially amounts to curb extensions. Most of the cost is associated with regrading the street to accept the extension. The Mission Street bus bulb project was part of an overall road reconstruction project. Consequently, retrofitting a bus bulb to existing grades was not as much of an issue as it might have been at other sites.

The greatest design issue is how to connect the curb extension to the existing grades of the sidewalk and roadway while maintaining proper drainage to storm gutters. The earliest approach was to place a covered drain between the existing curb and the bulb (Figure A-11). However, this approach was abandoned for numerous reasons—mainly, maintenance of the covered drain.

The street gradient on Mission Street is fairly strong, and the city could rely on gravity to propel water around the bulbs. Where the grade was fairly shallow, the city did install some grates to handle runoff from the street and from intersecting streets that were draining downhill toward Mission Street (Figure A-12).

General-Purpose Traffic

Bus bulbs, as previously mentioned, are one of many strategies that can be implemented under the TPS program. Obviously, in these corridors, the emphasis is placed on the people-

Figure A-10. Example of defined curbside parking near a bus bulb.

Figure A-12. Drainage detail.

carrying capacity of buses rather than on automobiles. The 14 Line on Mission Street is the single heaviest surface line west of the Mississippi River with 80,000 patrons per day. Although vehicular volumes are fairly active throughout the day along Mission Street and other corridors, the roads are not overly saturated with automobiles, and by no means do the number of people moved on the roads compare with the number of people moved in the corridor by transit. Traffic volumes and speeds play an obvious role in the decision-making process, but it is as much a recognition of policy as it is a design decision.

Mission Street has always been viewed as a street designated primarily for transit. Despite this, there were concerns that the bulbs could be viewed as traffic-calming measures and that some traffic would divert to Valencia Street, which is a parallel alternative to Mission Street. The issue is more acute at the intersection of Mission and 30th Streets, which has a farside and nearside bus bulb that are directly across from each other. The new reduced street cross section could conceivably be perceived as a traffic-calming measure (Figure A-13).

Stockton Street is a two-lane facility. During congested periods drivers either move to another road or wait through the delays caused by a bus stopped at the bulb. Similar to Mission Street, there are a tremendous number of people being moved aboard transit and on sidewalks through Chinatown.

For the Polk Street bus bulbs, Van Ness Boulevard is a more attractive alternative for vehicles than is Polk Street. There may have been some regular drivers of Polk Street who diverted to a parallel facility, but this was not mentioned as an issue observed by Muni. Drivers may have simply accepted any delays the buses represented as a normal activity associated with the facility. Prior to the installation of the bulbs on Mission Street, the bus bays essentially operated like bus bulbs during peak vehicular times. Bus drivers avoided leaving the travel lane because of concerns with the bus re-entry problem. Vehicles either queued or changed lanes prior to encountering the stopped bus (Figure A-14). Figure A-15 is an example of the traffic queue and "tie-up" behind a bus that has partially pulled into the bus bay. Bus stop spacing on Mission Street is approximately every block or every other block. Consequently, stopped buses are not an uncommon event for drivers, and, in most instances, drivers anticipated encountering a stopped bus and avoided using the outside travel lane.

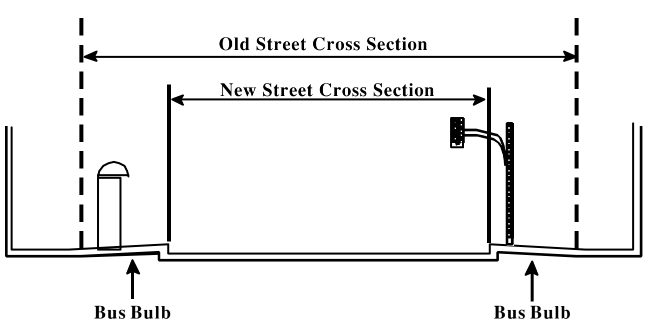


Figure A-13. Is this traffic calming (Mission and 30th Streets)?

Another bus–auto interaction concern is right-turning vehicles from intersecting streets. The problem may be heightened by the addition of a bulb near the intersection (Figure A-16). When a bus completely pulls into the bus bay stop, there is a clear travel lane for a vehicle turning right from the minor street onto the major street. However, a bus stopped at a bus bulb can block the path of a right-turning vehicle into the outside lane. The problem can also occur with bus bays during peak hours. Figure A-17 is an example of a right-turning vehicle encountering a stopped bus that has not completely pulled into a bus bay stop.

Bus Stop Location

San Francisco does not appear to have a preferred bus stop location. Any combination of farside, nearside, and midblock stops can be found on almost any route. Bulbs have been built at all three location types within San Francisco.

Pedestrians

A major impetus for installing bus bulbs in the San Francisco area is pedestrian crowding in and around bus stops. Pedestrian volumes can cause sidewalks to reach saturation levels in some areas of the city, especially in areas in which there is a mix of residential and commercial land uses. Pedestrian crowding can also occur at the street corners when surges of transit patrons board and alight from a vehicle.

Pedestrian crowding on sidewalks is highly variable in San Francisco and is extremely dependent on the neighborhood and its characteristics. Not unlike vehicular peak periods, most pedestrian crowding revolves around business hours of operation. The downtown bus stops are no exception to this rule. The periods before and after working hours have the highest pedestrian and transit volumes.

However, neighborhoods within San Francisco are extremely diverse in culture and in characteristics. Along Mission Street, the peak period for pedestrians during the weekday is between 2:30 P.M. and 4:00 P.M., when elementary and high school students are walking home from school. The highest pedestrian volumes, however, occur on Saturday morning when local residents shop in the many different businesses that are located on Mission Street. Figure A-18 is an example of the pedestrian crowding that occurs on Saturday mornings on Mission Street.

Like Mission Street, Stockton Street experiences its largest pedestrian volumes on Saturdays. Because people are walking to and from the shops, they are carrying their purchases. Waiting patrons who are carrying multiple bags require more room than pedestrians who are not carrying bags. The combination of shoppers and tourists in Chinatown tends to

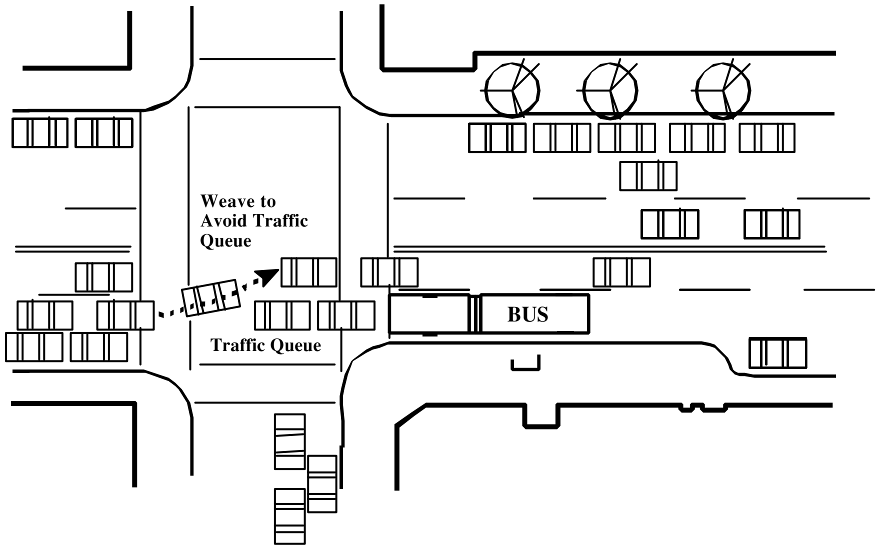


Figure A-14. Examples of driver behavior when encountering a stopped bus.

overwhelm the limited capacity of the sidewalks in this area of San Francisco.

Sidewalks are often crowded with street furniture (e.g., light poles, fire hydrants, benches, trash receptacles, trees, and vending machines). In the Mission District, it is not uncommon for sidewalk vendors to set up impromptu operations on the sidewalk. This is especially true on the weekends when pedestrian and transit patronage is the highest. Local businesses also extend displays beyond the storefront (e.g., fruit stands or hanging clothes). All of these local factors reduce the available walkway width in and around bus stops.

These same types of activities also occur near the Stockton Street sites. In Chinatown, local merchants selling food receive fresh shipments throughout the morning. Merchants load and unload directly in front of their stores. Used crates and boxes are discarded in parking stalls or are stacked along the sidewalk in front of the stores. These storage areas serve as choke points for pedestrians and transit patrons. The bulbs help to segregate waiting patrons from passing pedestrians and shoppers.

Figure A-15. Traffic queue behind stopped bus.

Bus stops with bus shelters can also serve to reduce the walkway width that is available for passing pedestrians. Muni moved shelters off the sidewalk and onto the bulbs to create additional room on the sidewalk. Queues of bus patrons can also crowd the adjacent sidewalk at curbside bus stops. The bus bulbs provide an additional 6 ft (1.8 m) of sidewalk width in and around the bus stop zone; this extra width appears to be the greatest source of relief for pedestrian crowding.

The addition of bus bulbs reduces pedestrian exposure time in crosswalks. The city of San Francisco does not plan to change signal timing at any of the intersections for additional benefits to either pedestrians or vehicles. The extra time is given to the pedestrian at locations with bulbs. The bus stops at nearside and farside locations can cause intermittent surges of pedestrians at the street corner during boarding and alighting activities. Figure A-19 shows an example of the surge of pedestrians at a corner created by the presence of the bus. Bus bulbs at these locations provide additional room for pedestrians at the street corner.

Another interesting item associated with bus bay stops is the level of pedestrian–transit vehicle interaction and pedestrian safety. In most cases, regardless of whether there is a double-parked vehicle or an illegally parked vehicle in the bus stop zone, bus drivers provide some room between the side of the bus and the back-face of the curb. Drivers park away from the curb to avoid hitting waiting patrons and to avoid hitting pedestrians with the vehicle's side mirrors. Muni keeps a record of these incidents, and one of the items the agency is interested in comparing between bus bays and bus bulbs is pedestrian safety. Are the bus bulbs safer than bus bays in this regard? Muni believes that these types of incidents will decrease at sites with bus bulbs.

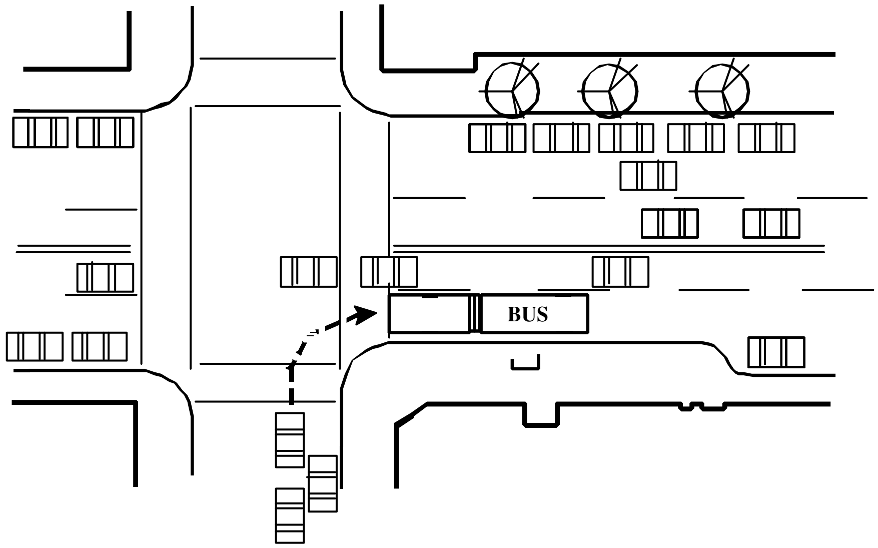


Figure A-16. Right-turn conflict at bus bulbs.

Bicycles

Defined bike lanes were not present on any of the observed examples of bus bulbs in San Francisco. Because vehicular volumes are so heavy and the streets are so narrow, it is rare to see bicyclists on any of the heavy transit routes. Because the bulbs do not encroach on the vehicular lanes, there is no impact on bicyclists, according to Muni. The width of the bulbs is essentially the same as the width of the parking lane. Therefore, bicyclists must share the travel lanes with motorists and transit vehicles alike.

Figure A-17. Car encountering stopped bus.

Cost

The nine Mission Street bus bulbs cost approximately $500,000 to design and construct. The bus bulbs were included in a roadway reconstruction project and were not a stand-alone project. The neighborhood specifically requested that the bulbs be built during the road reconstruction to reduce the overall construction time in front of neighborhood storefronts. The total cost of the project was approximately $2,000,000.

Figure A-18. Pedestrian crowding on a Saturday morning along Mission Street.

Figure A-19. Surge of alighting patrons at crosswalk.

Figure A-20. Midblock bus bulb on Polk Street.

The first phase of the reconstruction effort was relocating the overhead electric wires for the buses. Because the buses would no longer be pulling into and out of a bus bay, the wires could be relocated into better positions to avoid having the catenary hook slip off the wire. It is unclear whether this would have been done without the reconstruction of the road.

A major portion of the cost of the Mission Street bulbs was relocating fire hydrants, street lights, and traffic lights. Muni signs were also relocated, but this was minor in comparison. As was discovered in other regions, drainage is a challenging and costly portion of the overall bill for bus bulbs. Of major concern was the connection between the bulb and the existing sidewalk. The curbside channel for storm water is effectively blocked by the curb extension. Muni initially allowed a covered channel between the curb and the bulb for curbside drainage. This channel is present on some of the older bulbs. However, because the road was being reconstructed and regraded, the Mission Street bulbs were built without the channel. Storm water street grates were added before and after the bulbs to handle on-street drainage.

Polk Street Sites

Polk Street is a mix of residential and established local businesses and restaurants adjacent and parallel to Van Ness Boulevard. Polk Street has a medium level of transit ridership. The sidewalks, however, are used heavily throughout the day by local residents and shoppers.

Polk Street is a three-lane facility—two lanes in the southbound direction and one lane in the northbound direction. The bulbs were built on only one side of the street in the southbound direction. A majority of the bulbs were built at the intersection's nearside. There is one midblock stop between Sacramento and Clay Streets and a farside stop at Pine Street. Figure A-20 is a picture of the midblock stop at Polk Street. Figure A-21 is a plan view of the midblock bus bulb.

The bulbs at the intersections (both farside and nearside) provide much needed space at the intersection for crossing pedestrians. The capacity of the sidewalk to handle pedestrians and waiting transit patrons is clearly improved with the addition of the bulbs. Although the bus bulbs were not created or intended to be used in this fashion, the bulbs have become a storage haven for the large numbers of vending machines that are present on Polk Street. Figure A-22 is a plan view of the farside bus bulb at the intersection of Pine and Polk Streets.

Stockton Street Sites

Like Polk Street, Stockton Street is a three-lane facility—two lanes in the southbound direction and one lane in the northbound direction. Stockton Street is the main thoroughfare through Chinatown, and it eventually transitions into North Beach (Little Italy). Consequently, the sidewalk is congested with local residents and tourists alike. Transit volumes in this neighborhood are extremely high, especially on Saturday mornings when residents do their weekly shopping. The sidewalks are very narrow in relationship to the number of pedestrians who move through the corridor. Street vendors, storefront displays, and discarded boxes from local stores all serve to reduce the available space on the sidewalk.

The bus bulbs were created for the purpose of providing storage for waiting transit patrons. Prior to the installation of the bulbs, the bus stops would create bottlenecks for pedestrian movement because of the number of transit riders waiting for their next available bus. Only the bus bulb on Stockton Street at Sacramento Street has a bus shelter. For maximum storage area, the other bus bulbs in this neighborhood are devoid of any street furniture. The bulbs obviously serve their intended purpose of relieving choke points on the sidewalk. Figure A-23 is an example of a bus boarding and patrons alighting at the intersection of Stockton and Sacramento Streets.

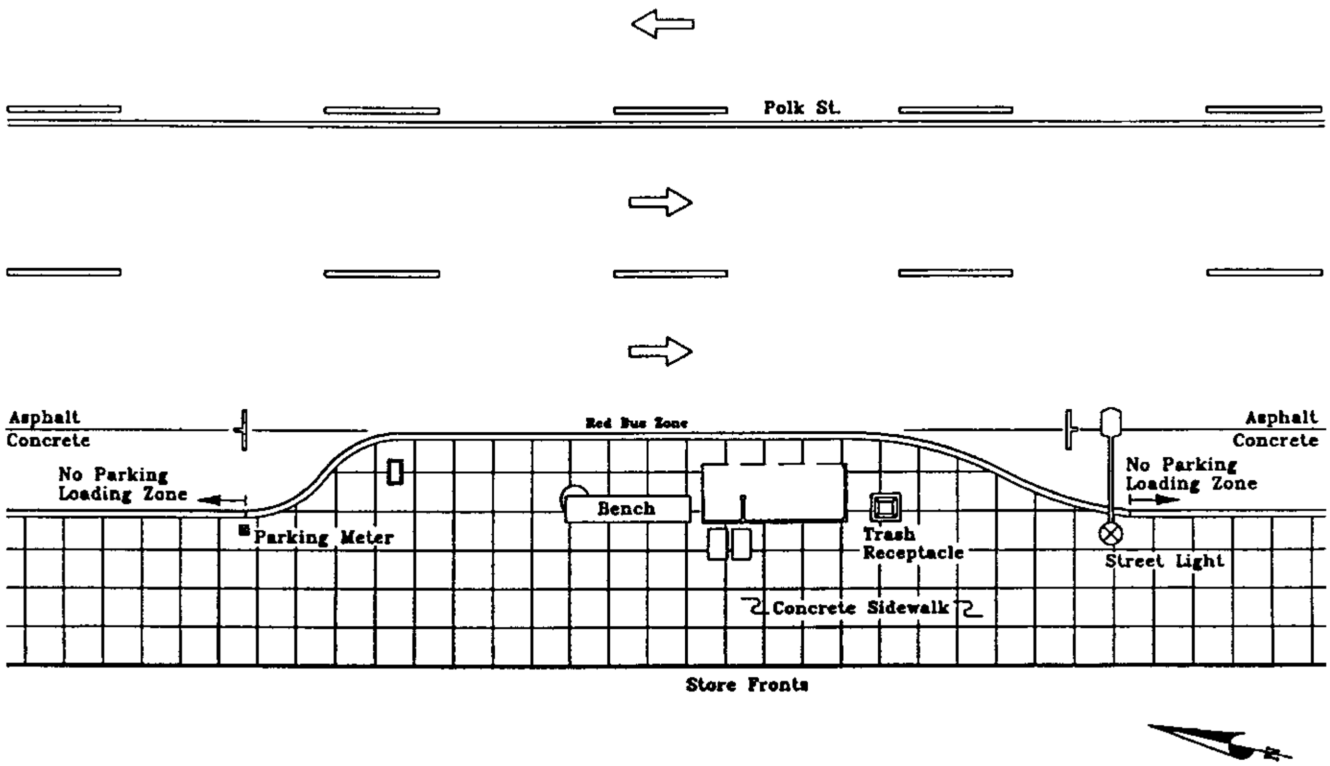


Figure A-21. Plan view of midblock bus stop on Polk Street.

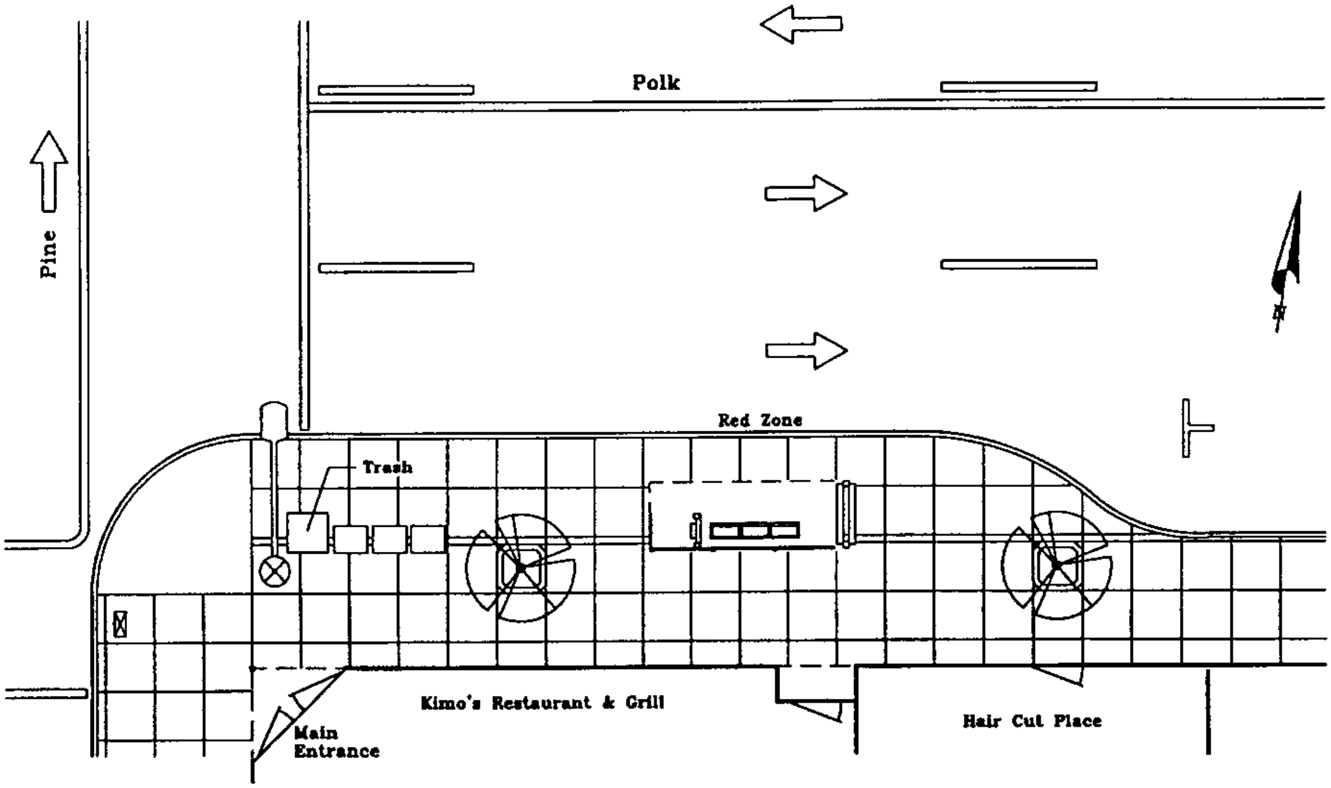


Figure A-22. Plan view of farside bus bulb at Pine Street.

Figure A-23. Bus bulb on Stockton Street.

Figure A-25. Sidewalk congestion at the Castro and Market Streets bus bulb.

Castro Street Sites

The Castro Street sites were installed in mid-1996 because more room was needed for pedestrian movement and waiting passengers. A total of four bulbs were built—two bulbs at the intersection of Market and Castro Streets and two bulbs at the intersection of 18th and Castro Streets. Each pair of bulbs consists of one nearside and one farside stop. Figure A-24 is a picture of the farside bus bulb on Castro Street at the intersection of Market Street. This configuration helps reduce the crossing time for pedestrians using the crosswalks. Castro Street is a three-lane facility with designated left-turn bays. Curbside parking is available on either side of the street.

The bus stop sites at the corner of Market and Castro Streets are transfer points for people trying to move between the bus lines and the Muni subway station nearby. Because of these transfer points, the stops sometimes serve a tremendous number of transit riders during peak travel hours (Figure A-25). The sidewalks are used heavily in this area of San Francisco because the Castro District is a popular shopping and dining location. The district also has a mix of multilevel row housing. Residents either use curbside parking or park in small at-grade garages.

The addition of the bulbs permitted Muni to move the bus shelters and other pedestrian furniture and amenities (e.g., vending machines) off the sidewalk and onto the bulbs, thereby increasing the effective sidewalk width at the corner of Market and Castro Streets. Figure A-26 shows waiting patrons using the bulb and the shelter to wait for the next available bus. Figure A-27 shows how the bus shelter and vending machines at the nearside 18th Street and Castro Street site are no longer impeding the sidewalk because the items were moved onto the bulb.

Figure A-24. Farside bus bulb on Castro Street at Market Street.

VANCOUVER, BRITISH COLUMBIA

The transportation mission statement of Vancouver, British Columbia, is to emphasize transit movement rather than vehicle movement. The City Council, based on a recommendation from an administrative report, has adopted a transit-first policy. Therefore, no more construction or expansion of freeways is planned, and the city has placed greater emphasis on increased bus service. At this time, bus bulges, as bus bulbs are called in Vancouver, have been identified as a potential transit priority measure. Bus bulges, it is assumed, will increase bus travel-time savings by allowing the bus to stop in the travel lane rather than to have to exit and re-enter the stream of traffic. Bus bulges are also viewed as traffic calming and pedestrian improvements.

The city of Vancouver is currently studying the effect of two demonstration bulges near the University of British Columbia on west 10th Avenue. The city is planning to install additional bus bulges at locations with high bus volumes to improve transit service and to improve the pedestrian environment. At the locations being considered for new bus bulges, the buses do not stop in the travel lane; rather, buses stop

Figure A-26. *Waiting patrons on bulb.*

Figure A-27. *Vending machines on bulb.*

along curbside stops within defined parking lanes. More than Can$650,000 has been set aside in the city budget for future bus bulges. Currently, there are no warrants or guidelines developed for the installation of bus bulges. The city hopes that the 10th Avenue sites will yield good information on the operation of bus bulges.

West 10th Avenue at Sasamat Street Demonstration Bus Bulges

The city of Vancouver currently has a total of two bulges. They are located, as a pair, on opposing sides of west 10th Avenue at the farside of the Sasamat Street intersection (Figures A-28 through A-31). West 10th Avenue is a four-lane facility (two lanes in each direction) with parking lanes on either side. The location is near the University of British Columbia and is the approximate center of the shopping district on west 10th Avenue. The bulges were installed in May and June 1998. The site was selected as the candidate for demonstration because of the unique conditions associated with this site. While the University is in session, the area has high pedestrian volumes and transit ridership. An express bus route is also being added to 10th Avenue, which will stop at the 10th Avenue and Sasamat Street bus bulge location. The stop location will provide a quick ride to the University from the surrounding community. The corridor has moderate traffic volumes and 24-hr curbside parking that is used heavily.

Width and Length of Bus Bulges

The width of the bus bulges is constrained by the narrowness of the facility. The actual width of 10th Avenue is only 52 ft (15.9 m). Because of this, the width of the bulge was restricted to 6.5 ft (2 m) to minimize the potential of having a stopped bus encroach on the second travel lane. Another concern is having enough room to pass the stopped bus without sideswiping the stopped vehicle or encroaching on the opposing lane. The city of Vancouver is also concerned with vehicles striking the curb edge of the bulge. The return S-curve radii was motivated by the desire to limit vehicles from striking the curb face while parking. Unlike San Francisco, the S-curve radii

Figure A-28. Westbound bus bulge: west 10th Avenue at Sasamat Street.

Figure A-29. Eastbound bus bulge: west 10th Avenue at Sasamat Street.

was not initiated by the need to have the street cleaner equipment successfully navigate along the bus bulge curb return.

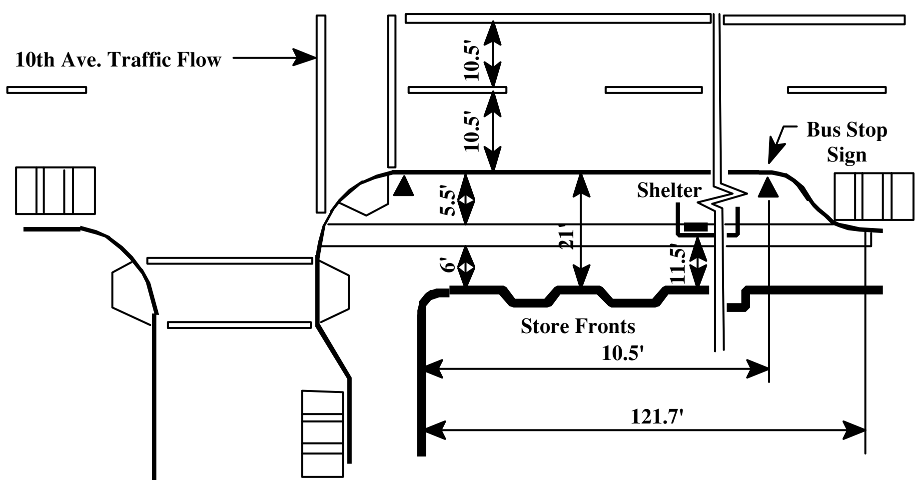
The length of the curb bulge is approximately 105 ft (32 m). The length of the bus bulges was determined by the need to accommodate more than one transit vehicle arriving and stopping at the site: Articulated (60 ft) (18.3 m) + Trolley (40 ft) (32 m). Vancouver transit, however, does not use all three doors on an articulated bus to board and alight. Therefore, the overall length of the bulges is not influenced by the number of doors used to board and alight from the transit vehicle—a policy similar to that of Portland, Oregon.

Transit Vehicle Travel Time and Dwell Times at Stops

A major reason for installing the bus bulges at this location was to eliminate the weaving of buses in and out of the curbside parking lane bus stop. A bus re-entry problem at the 10th Avenue sites exists because of the high vehicular volumes during school months. The city of Vancouver believes that the bus bulges will provide a travel-time savings because they will solve the re-entry problem.

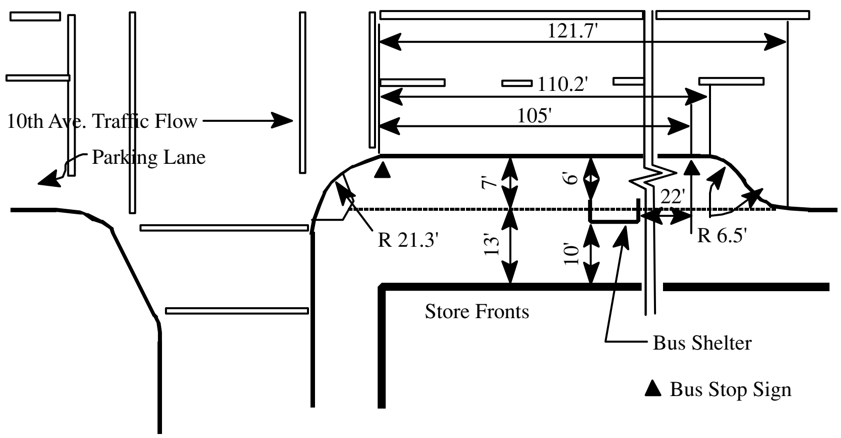
Parking

The curbside parking lane on either side of 10th Avenue is used heavily. The city is admittedly aggressive about ticketing and removing vehicles that are illegally stopped or parked in the travel lane during peak periods. Although illegal parking in the bus stop zone was not mentioned as a problem at this site, the city believed that the other sites being considered for bulges occasionally had problems with cars



1 ft = 0.305 m

Figure A-30. Farside bus bulge, 10th Avenue at Sasamat Street (westbound).



1 ft = 0.305 m

Figure A-31. Farside bus bulge, 10th Avenue at Sasamat Street (eastbound).

illegally parking in the zone, which cause the buses to stop in the travel lane. Double-parking near the bus stop rarely occurs. No Parking signs were attached to the Bus Stop Zone sign to help define the no-parking region in and around the bus bulge. Figures A-32 and A-33 are examples of the signage at the bus bulge.

The construction of the bus bulges removed 1.5 parking spaces from each farside parking lane. Because of the high use of the parking lanes, a pedestrian bulge was not added to the opposing curbs at either bus bulge site. The signals are already timed in favor of crossing pedestrians, and the bulges are believed to have removed at least 1 s of crossing time.

Drainage

Drainage is a major issue in the design and construction of these bus bulges. A noticeable slope adjoining the sidewalk to the bus bulge exists on the University-bound farside stop at 10th Avenue and Sasamat Street. This appears to be the result of retrofitting the bulges to the existing street crown rather than a design decision. Figure A-34 is a cross section of the westbound bus bulge at 10th Avenue and Sasamat Street. Low-floor articulated buses will be added to the transit fleet, which may necessitate changes to curb height at the bulges.

General-Purpose Traffic

General-purpose vehicular traffic experiences some delays caused by the bus stopping in the moving traffic lane (Figure A-35). Because the bus stops are located at the far side of the intersection, there is concern over the potential for the queuing of and increased weaving movements of general traffic at these locations.

As of July 1998, there have been no observed conflicts between vehicles turning right from Sasamat Street onto 10th Avenue and buses at the bus bulge. The city will continue to monitor this issue.

The city believes that the potential exists for the bulges being perceived as traffic-calming devices. Vancouver has several traffic-calming strategies already in place, and the bus bulges are seen as another strategy to discourage traffic flow on the facility. Drivers may see the bulges and switch to a parallel route, thereby increasing the traffic volumes on that facility. The city has received two calls from the public regarding the bus bulges on 10th Avenue, one of which was concerned about the perceived capacity loss caused by the buses stopping in the traffic lane.

The installation of the bus bulges may highlight an already existing problem. The travel lanes are considered too narrow on west 10th Avenue, and a bus passing a stopped bus may have to encroach on the opposing lane. With the implementation of an express route on this corridor, greater potential exists for an express bus to encounter a bus stopped at the bulge. The passing bus may have to encroach on the opposing travel lane in order to navigate successfully around the stopped bus. While at the west 10th Avenue bus bulges, the research team did observe this type of passing behavior.

Bus Stop Location

The city of Vancouver generally locates all bus stops at the far side of the intersection. The two bus bulges on west 10th Avenue are located at the farside intersection of Sasamat Street. Bus bulges at farside locations, it is believed, will further encourage pedestrians to use the crosswalks at the intersections rather than to jaywalk at the midblock of the facility.

Pedestrians

The bus bulges have already improved pedestrian movement along the sidewalks. West 10th Avenue is a significant

Figure A-32. Traffic control sign.

Figure A-33. Traffic control sign detail.

shopping district. Because of the increased sidewalk capacity, local store owners have readily accepted the construction of the bus bulges. The implementation of the bus bulges has allowed the city to move trash receptacles, vending machines, and bus shelters off the sidewalk and onto the bulge, thereby increasing the capacity of the sidewalk (Figure A-36). The reduced width of the west 10th Avenue bulges has limited the number of pedestrian and bus patron amenities placed at that site. The city plans to add additional amenities to other bus bulge sites.

The construction of the bus bulges caused the removal of two existing street trees, which have not been replaced. A clear space of at least 9 ft (2.7 m) between the storefront edges and the beginning of the bus bulges was created on the sidewalk. A bike rack was placed adjacent to the bus shelter on the bulge.

The signal timing at 10th Avenue and Sasamat Street was not changed by the implementation of bus bulges at this intersection. The bus bulge has reduced the crossing distance by approximately 7 ft (2.1 m), which could result in the addition of about 1 s to pedestrian crossing time. However, the reduced exposure in the intersection and greater crossing time are seen as added pedestrian benefits. The area also has several older citizens, and the increased crossing time will benefit them. Additional pedestrian bulges were not added to the opposing curbs because of the need to maintain parking.

Bicycles

Because of the narrowness of the travel lanes and the presence of a well-defined bicycle lane on a parallel facility two blocks north, minimal attention was given to bicyclists at this site. Many of the bicyclists traveling to and from the University use the bikeway close to 10th Avenue. Bike racks are present on both bus bulges.

Cost

The cost of the bus bulges was Can$48,000 for the pair. The city has set aside an additional Can$650,000 for future bus bulges.

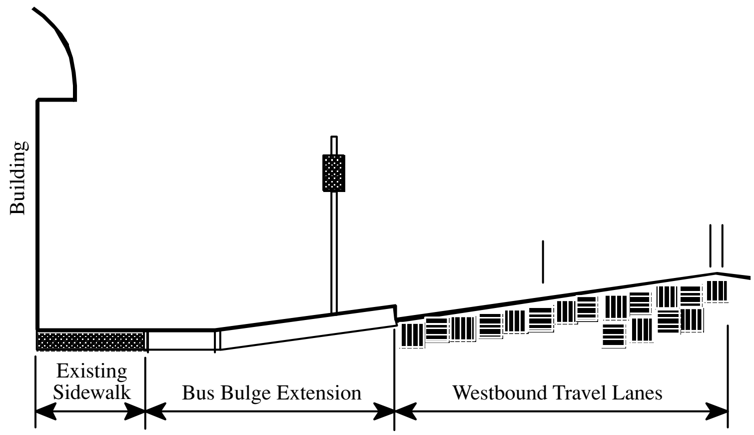


Figure A-34. Cross section of westbound bus bulge (10th Avenue at Sasamat Street).

PORTLAND, OREGON

The city of Portland has several existing and pending bus bulb locations. Unlike other cities' reasons for needing bus bulbs, a majority of the bulbs in Portland are needed for reasons other than transit. The pedestrian and bicycle program in Portland is strong and influential. Consequently, a majority of the bulbs are being installed as part of traffic-calming measures or to reduce pedestrian crossing times at intersections. The one exception is the Sandy Boulevard bus bulbs between 66th and 79th Streets where the goal is to improve transit ridership.

The Sandy Boulevard and Broadway Street sites are the newest bus bulbs in the region. The oldest examples of bus bulbs in Portland are located on northwest 23rd Avenue. The bulbs are approximately 10 years old. Similar to other bulb projects in Portland, the northwest 23rd Avenue sites were initiated as part of a pedestrian improvement and traffic-calming program in the corridor. Figure A-37 shows the approximate location of the bus bulbs in the Portland region.

Overview of Practices and Experiences

Width and Length of Bulbs

Currently, the standard width of all bulbs in Portland is 6 ft (1.8 m), which provides a 2-ft (0.6-m) "shy" zone between the bulb and traffic on a 36-ft (11-m) wide cross section. However, drivers would prefer that this zone not exist, and Portland is now considering a 7-ft (2.1-m) wide bulb to accommodate this desire. The length of the bulbs is highly variable throughout the city and appears to be dependent on the width of the street, the amount of existing parking, and the policy regarding how many doors are used for boarding and alighting the transit vehicle. Tri-County Metropolitan Transportation District of Oregon (Tri-Met) is phasing out articulated buses; however, the buses currently are being used in the Sandy Boulevard corridor. Tri-Met will convert its fleet to low-floor, 40-ft (12.2-m) long buses. The length of the bulbs along Sandy Boulevard is approximately 30 ft

Figure A-35. Traffic queue at bus bulge.

Figure A-36. Placement of vending machines on bus bulge.

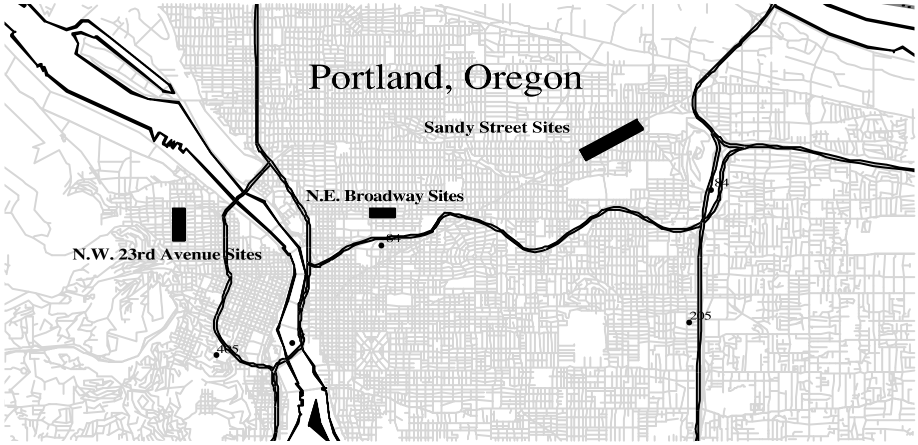


Figure A-37. Location of existing bus bulbs in Portland, Oregon.

(9.2 m). Tri-Met is debating whether to install 20-ft (6.1-m) bulbs in the downtown area where boarding and alighting would occur in the front of the bus only. Bulbs will be installed to service a downtown streetcar system. Although the streetcars will be low-floor vehicles, the platform will still have to be 10 in. high for boarding and alighting purposes.

Parking

All of the bulbs observed in Portland are installed on streets that have curbside parking lanes. The parking lanes are delineated with several parking signs. All bus bulbs have No Parking signs to discourage illegal parking along the curb by general-purpose vehicles. In most instances, the No Parking sign is on the same pole as the Bus Stop sign (Figure A-38). An additional No Parking sign was installed at bus bulb locations where there were pedestrian curb extensions at the intersection. The curb facing of some bulb locations is marked with yellow tape to help further delineate the no-parking area. The city is now considering painting the entire curb face at all bulb locations rather than using tape.

ADA Wheelchair Lift Deployment

Retrofitting or rebuilding the street to install a bulb has raised some issues associated with ADA wheelchair lift deployment—primarily, the issue of maintaining the appropriate slope at the bus stop. However, other comments were also made concerning lift deployment. At sites where bulbs are short in length, it is difficult to accommodate the lift. Transit vehicle operators have noted patrons experiencing difficulty navigating in and around Bus Stop and No Parking signs and vending machines. Vending machines especially were noted as a problem. The city is considering taping or painting pathways at the stops to illustrate where vending machines *cannot* be placed.

Drainage

Drainage is a major issue with both rebuilt and retrofitted designs. A major percentage of the overall cost of installing a bulb is associated with drainage. The bulbs dramatically affect how water drains into the gutter. Drains were installed in the parking lane just prior to the bulb and on the pedestrian curb extension on most of the Sandy Boulevard sites (Figure A-39). The city has also tried different drain types to reduce the amount of maintenance associated with the drains. Strip drains were a maintenance problem at some sites.

Bus Stop Location

The preferred location of bus stops in the Portland region is the near side of intersections. Because of the front-end boarding-and-alighting policy and the retirement of articulated buses, Portland Tri-Met can consider shorter bulbs than can other areas of the country. Tri-Met is concerned with trapping vehicles in the intersection when bus bulbs are located at the far side of the intersection. The city will consider extending the all-red phase if requested to do so; however, no extensions have been requested as of July 1998.

Pedestrians

As mentioned previously, strong attention is paid to pedestrian and bicycle concerns in Portland. A majority of the bulbs are installed to reduce pedestrian crossing times at intersections, thereby reducing pedestrian exposure while in the crosswalk. Several of the bus bulbs observed in Portland had pedestrian curb extensions at opposing intersections to further reduce pedestrian crossing times. A major goal of the bus bulbs that were installed on northwest 23rd Avenue was

Figure A-38. No Parking/Bus Stop sign.

Figure A-39. Typical upstream drainage.

to reduce any type of disruptions caused by the bus activities to passing pedestrians and to nearby businesses. The Sandy Boulevard sites are a part of a larger pedestrian-to-transit strategy. The bulbs are meant to improve pedestrian accessibility to transit in the corridor.

Bicycles

The interaction of bicycle lanes with bus bulbs is an issue in Portland. The issue is especially acute when bicyclists are using an underutilized parking area for travel, and they encounter a bulb. The bus bulb moves the bicyclist to the general-purpose lanes. The current 6-ft (1.8-m) width at the Sandy Boulevard sites provides a 2-ft (0.6-m) shy zone from the edge of the travel lane to the curb for bicyclists when the bicyclists encounter a bulb (Figure A-40). The city will not stripe a bike lane on a lane that is less than or equal to 14 ft (4.3 m). Portland will consider striping a bike lane when the lane width is 15 ft (4.6 m) or more.

Cost

The approximate cost is $15,000 to $30,000 per bulb pair. The cost is dependent on whether the site is retrofitted to a bulb or is rebuilt entirely. Another major cost factor is drainage. Drainage is a problem with both rebuilt and retrofit designs. The total preliminary engineering cost estimate for the five bulbs on Division Street is approximately $17,000 per bulb.

Sandy Boulevard Sites

Several bus bulbs were recently installed between 66th and 79th Streets on Sandy Boulevard. The Sandy Boulevard bus bulbs were installed to encourage greater transit ridership in the corridor, which is the goal of the “Pedestrian to Transit” demonstration project. The bulbs are meant to improve the attractiveness of the corridor by improving pedestrian access. Currently, the corridor has lower-than-expected ridership levels based on the area’s demographics. Portland Tri-Met would like to increase the number of choice riders (i.e., individuals

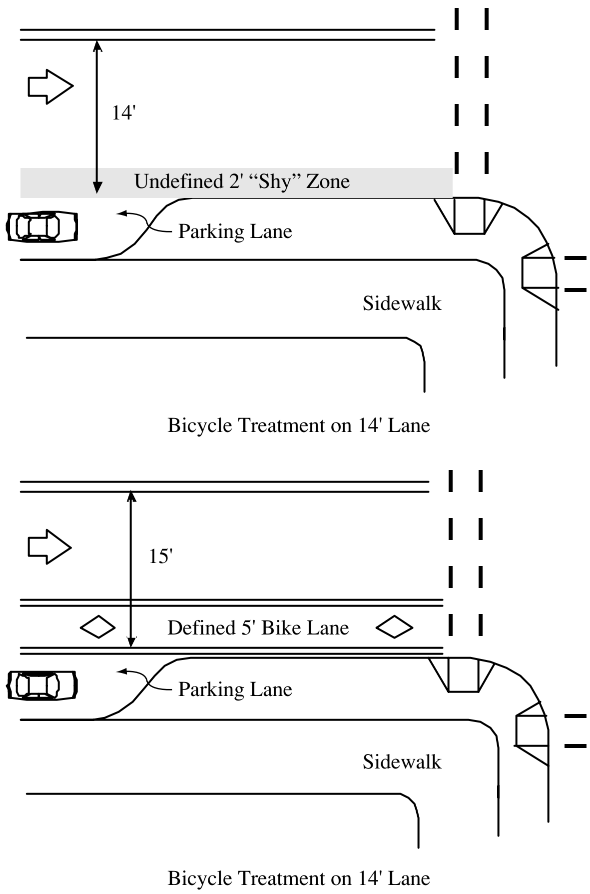


Figure A-40. Bike lane treatments with bus bulbs.

who have a choice between driving or using transit) in the corridor based on these demographics. The question was how to get people from the surrounding areas to use transit. Several pedestrian treatments, such as well-defined crosswalks, overhead flashing crosswalk signals, pedestrian refuge islands, increased landscaping, and pedestrian curb extensions, were added to the corridor. Additional lighting and transit amenities were also added. The presence of bus bulbs also allows more amenities at each stop. Although sidewalk congestion is not an issue along Sandy Boulevard, the existing sidewalk widths were not conducive for transit amenities such as shelters, bike racks, and benches. The bulbs would provide the necessary space for these types of amenities.

The widths of the bulbs are 6 ft (1.8 m) along Sandy Boulevard (Figure A-41). This width allows the 2-ft (0.61 m) shy zone around the bulbs for bicycle riders who use the parking lane to travel. The bulbs are located at the nearside of the intersection. Most bulb examples are coordinated with pedestrian curb extensions to further reduce pedestrian crosswalk exposure (Figures A-42 and A-43). The Sandy Boulevard at 67th Avenue site is an example of combined bus bulbs and pedestrian curb extensions.

The one negative note thus far with the Sandy Boulevard sites is that motorists and bus operators accidentally hit or run over the bulb/curb extensions. Turning vehicles occasionally have trouble negotiating the turning radius at the bus bulb sites (Figures A-44 and A-45). The issue was discussed in the meeting with city and transit agency representatives. The posted speed limit along the Sandy Boulevard corridor is 35 mph (56.4 km/h).

Northwest 23rd Avenue Sites

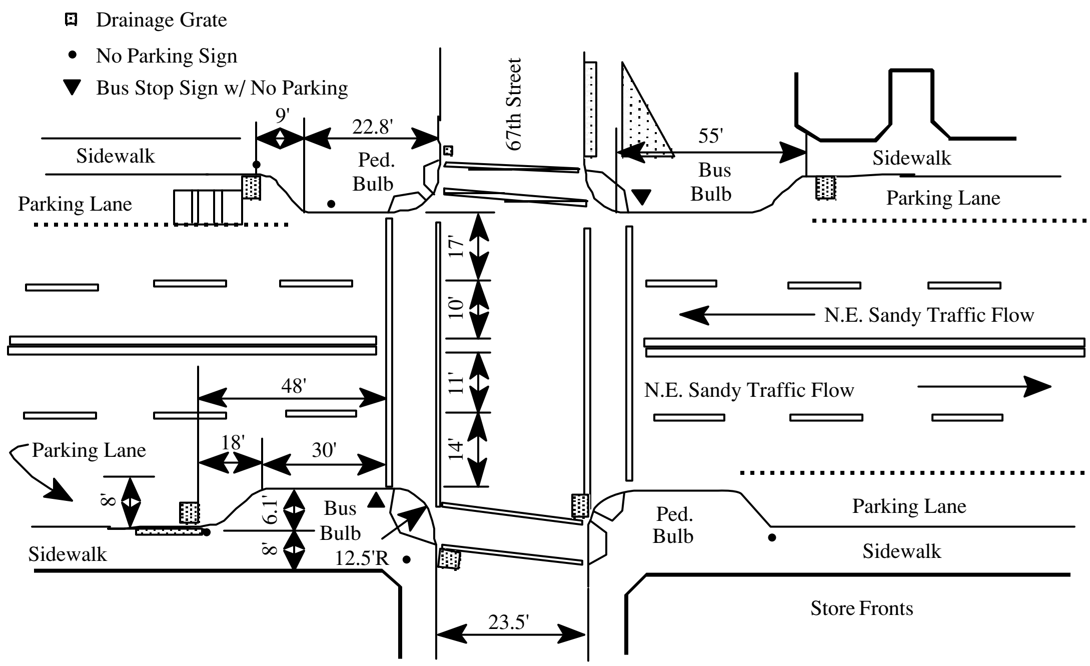
The northwest 23rd Avenue sites are the oldest examples of bus bulbs in Portland. The bulbs were installed between 1990 and 1991 and were initially conceived of as pedestrian and traffic-calming improvements. Transit was an afterthought in the project. To avoid the re-entry problem after boarding and alighting, buses were operating as if bulbs were already present at the bus stops. However, having a bus stop in the roadway was a major issue of the project.

The northwest 23rd Avenue area of Portland can be characterized as a fairly upscale neighborhood shopping and residential area. The area seems to be well established, and the neighborhood has a traditional feel with walk-in shops and well-kept housing just behind the shops. The goal of the project was to provide additional room along the sidewalks to segregate pedestrian and business activities from transit activities. Figures A-46 and A-47 are examples of how the bulb has provided separation of pedestrian and bus boarding and alighting activities and has provided additional sidewalk space for pedestrians and business activities.

Each of the bus bulbs on northwest 23rd Avenue was also extended as a pedestrian bulb on the cross street. Figure A-48 shows the pedestrian bulb at one of the bus bulbs along northwest 23rd Avenue. The presence of pedestrian bulbs places further emphasis on pedestrian movement in the corridor. The combination of bus bulbs and pedestrian bulbs noticeably slowed traffic along northwest 23rd Avenue and turning vehicles along intersecting streets. The city did not change the signal timing with the installation of the curb extensions. In the opinion of Tri-Met, the bulbs have accomplished their intended goal, but the impact of the bulbs on transit operations is negligible.

The curb-to-curb width of northwest 23rd Avenue is only 36 ft (11 m). This width means that there is an 18-ft (5.5-m) shared parking and travel lane. The street is lined with older trees, which gives the corridor an impression of increased narrowness. The bulbs vary in width from being as wide as a parking lane to half as wide as a parking lane, depending on the narrowness of the cross section of the street (Figure A-49). Since the bulbs have been installed, there have been some sideswipe accidents between buses and cars. The bulbs must also be signed so that automobile drivers cannot illegally park in the bus stop zone, which was mentioned as an occasional problem (Figure A-50).

As part of the project, Tri-Met consolidated stops to a three-block spacing. Prior to this consolidation, the spacing



1 ft = 0.305 m

Figure A-41. Bus and pedestrian bulbs on northeast Sandy Boulevard at 67th Avenue.

between stops was two blocks. This strategy increased the amount of parking on northwest 23rd Avenue and improved the speeds of transit vehicles. Although the transit vehicle speed between stops increased, the travel time in the corridor has remained the same because of the increased dwell times at the bus stops caused by more people boarding at fewer stops. The posted speed along northwest 23rd Avenue is 25 mph (40.3 km/h). A study has not been conducted to determine the effects of the bulbs on general vehicular speeds or volumes.

The length of the bulbs on northwest 23rd Avenue is rather short. Boarding and alighting activities occur at the front door. Shelters have also been installed at some of the sites as a patron amenity. The shelters are located toward the upstream end of the bulbs. Therefore, boarding and alighting activities, as well as the ADA wheelchair landing pad activities, occur at

Figure A-42. Nearside bus bulb on north Sandy Boulevard at northeast 67th Avenue (looking downstream).

Figure A-43. Nearside bus bulb at north Sandy Boulevard at northeast 67th Avenue (looking upstream).

Figure A-44. Tire marks over curb on bulb.

Figure A-45. Evidence of automobiles hitting curb on bulb.

Figure A-46. Separation of pedestrian and bus activities (northwest 23rd Avenue and Flanders Street).

Figure A-47. Increased sidewalk space (northwest 23rd Avenue at Irving Street).

Figure A-48. Pedestrian bulb used with bus bulb.

Figure A-49. Example of a narrow bulb (northwest 23rd Avenue and Burnside Street).

Figure A-50. Traffic control signs at bulb.

the downstream end of the bus bulbs. Transit vehicle operators have noted difficulties for patrons navigating wheelchairs around the Bus Stop and No Parking signs and vending machines.

Aggressive placement of vending machines on the bulbs is another concern with wheelchair lift operations on bulbs that are already constrained by shelters and signage (Figure A-51). Tri-Met is considering the placement of a painted or taped "pathway" to illustrate where vending machines cannot be placed.

Northeast Broadway Street Sites

Several new bus bulbs were installed on northeast Broadway Street between 10th and 16th Streets. Northeast Broadway Street is a three-lane, one-way facility that eventually moves through downtown Portland. The bulbs are installed across the Willamette River near a newer suburban retail development. There is an older residential development north

Figure A-51. "Crowding" at bulb for lift deployment.

of Broadway Street. Strip retail development, mixed with apartment complexes, characterizes the corridor near the bulbs. Figure A-52 shows the cross section of northeast Broadway Street near the bus bulb at the intersection of 12th Street.

Parking is available on either side of the street. Tri-Met uses a combination of No Parking signs and yellow tape masked to the top of the curb to help define the bus stop zone (Figures A-53 and A-54). There were two No Parking signs on the bulbs—one at the beginning of the bulb and another on the pedestrian curb extension at the intersecting street.

Similar to other bus bulbs in the Portland region, the northeast Broadway Street sites were also constructed with pedestrian curb extensions (Figure A-55). The opposing curb was also extended to reduce pedestrian exposure in the intersection. Both sides of 12th Street have well-defined pedestrian crossings across northeast Broadway Street.

A defined bike lane runs along the outside lane. When a bus is stopped at the bulb, it is stopped directly on the bike lane (Figure A-56). It was not known whether bicyclists wait

Figure A-52. Cross section of northeast Broadway Street near bus bulb.