



# Technical Memorandum #5: Alternatives

U.S. 20 Bend Facility Plan  
*Bend, Oregon*

July 28, 2023





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## Acronyms and Abbreviations

ADA	Americans with Disabilities Act
ATC	Automatic Traffic Control
BUD	Blueprint for Urban Design
City	City of Bend
LPIs	Leading Pedestrian Intervals
MAC	Mobility Advisory Committee
MUT	Median U-Turns
ODOT	Oregon Department of Transportation
Plan	U.S. 20 Bend Facility Plan
RCUT	Restricted Crossing U-Turns
ROW	Right-of-Way
STIP	Statewide Transportation Improvement Program
TSP	Transportation System Plan

# 1 Introduction

U.S. 20 is located in central Oregon and serves the residents of Bend, freight traffic and other travelers. As the region has grown, so have congestion and safety concerns. The U.S. 20 Bend Facility Plan (Plan) will identify strategies to improve safety for all users, with an emphasis on improvements for people who walk, bike and use public transit. The study area begins at the intersection of U.S. 20 (NE Greenwood Avenue) and NE 3rd Street, and ends at the intersection of U.S. 20 and Powell Butte Highway.

This memorandum introduces intersection and corridor improvement concepts to address capacity, comfort, and safety for all transportation modes along the U.S. 20 corridor. While U.S. 20 is an Oregon Department of Transportation (ODOT) facility, the majority of side street approaches that intersect the highway are City of Bend (City) facilities.

# 2 Pedestrian, Bicycle and Transit Improvement Concepts

This section identifies locations and briefly describes concepts that would improve the U.S. 20 corridor for people walking, biking or riding transit. Concepts include improvements along and across U.S. 20, on parallel routes, and on key lateral connections between them. The improvement concepts were informed by the following documents and sources:

- Background plans (e.g., Bend Transportation System Plan (TSP), Bend Park and Recreation Plan, Bend Safety Implementation Plan, Key Walking/Bicycling Routes, Low-Stress Network).
- Input received at Technical Advisory Committee and stakeholder meetings.
- Information from ODOT, City and partner agencies outside of project meetings.

Because U.S. 20 is an ODOT facility, ODOT's Highway Design Manual/Blueprint for Urban Design (BUD) plays a prominent role in prioritizing modes and informing the corridor's broader planning and design features, which are also largely informed by the land use contexts through which the corridor passes. As described in the Existing Conditions Memo, the BUD's land use contexts for the study area corridor include Urban Mix, Commercial, Residential Corridor and Rural Community. Upon defining a corridor's land use context, the BUD's subsequent sections present guidance for the location and design of typical roadway features such as motor vehicle travel lanes, turn lanes, center medians, bicycle facilities, sidewalks and formalized pedestrian crossings. While typology and design guidance for most roadway features are similar for most land use contexts, the BUD guidance for pedestrian crossing spacing varies, as shown in Table 1.



**Table 1. BUD Land Use Contexts and Pedestrian Crossing Spacing Guidance for U.S. 20**

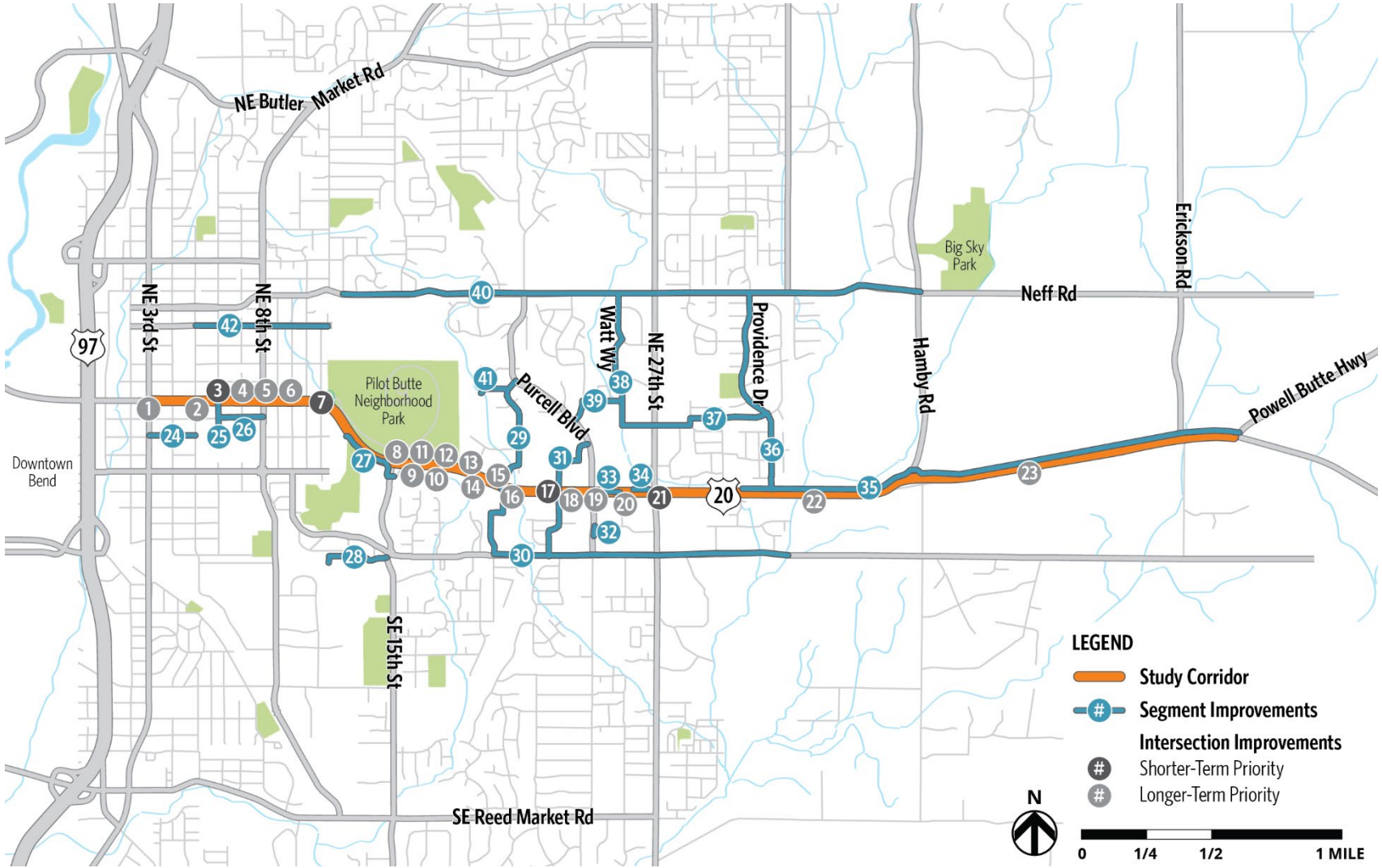
Land Use Context	Section	Target Pedestrian Crossing Spacing (feet)
Urban Mix	NE 3rd Street to NE 12th Street	250-550
Commercial Corridor	NE 12th Street to NE Benson Way	500-1,000
Residential Corridor	NE Benson Way to NE Providence Drive	500-1,000
Rural Community	NE Providence Drive to Powell Butte Highway	250-750

Figure 1 presents an overview of the study area and identifies potential pedestrian, bicycle and transit improvement concepts. Table 2 summarizes the concepts by location. Most concepts located along U.S. 20 focus on reducing the corridor’s barrier effect with improved multimodal crossings, including new crossings and enhancements to existing crossings. As a result, most corridor segments would fall within the BUD’s target pedestrian crossing spacing parameters. It should be noted that, given the multitude of new or improved crossings, Figure 1 identifies priority locations for which ODOT and its partners may elect to focus nearer-term investments.

While this Plan generally identifies opportunities for enhanced crossings, the following should be considered as projects advance toward implementation:

- Further engineering analysis will be necessary to determine particular crossing enhancements and design elements at most locations; this subsequent analysis should consider criteria set forth in ODOT’s Traffic Manual, Traffic Line Manual, Signal Policy, Sign Policy and ODOT overall engineering judgement.
- Depending on circumstances, Region or State Traffic/Roadway Engineer approval will be necessary for most concept elements presented in Table 2.
- As U.S. 20 is a Statewide Freight Route and a Reduction Review Route, engagement with ODOT’s Mobility Advisory Committee (MAC) may be necessary.

Figure 1. Pedestrian, Bicycle and Transit Improvement Concepts Location Overview





**Table 2. Pedestrian, Bicycle and Transit Improvement Concepts**

Map #	Reference/Location	Description
1	U.S. 20 at NE 3rd Street	<p>Pedestrian treatments:</p> <ul style="list-style-type: none"> <li>• Leading Pedestrian Intervals (LPIs) on all legs (subject to analysis relative to ODOT Signal Policy).</li> <li>• Warning signage on all approaches (Turning Vehicles Yield to Bikes/Peds) (per Bend Safety Implementation Plan).</li> <li>• Right-turn-on-red prohibition (per 2012 Multimodal Traffic Safety Assessment).</li> </ul> <p>Transit treatments:</p> <ul style="list-style-type: none"> <li>• Transit signal priority implemented with Automatic Traffic Control (ATC) upgrade.</li> </ul>
2	U.S. 20 at NE 5th Street	New enhanced crossing at (or in vicinity of) intersection.
3	U.S. 20 at NE 6th Street	<p>Per Bend Safety Implementation Plan:</p> <ul style="list-style-type: none"> <li>• Modified median refuge to include bicycle cut-through(s).</li> <li>• Rectangular Rapid Flashing Beacon.</li> </ul>
4	U.S. 20 at NE 7th Street	New enhanced crossing at (or in vicinity of) intersection.
5	U.S. 20 at NE 8th Street	<p>Pedestrian treatments:</p> <ul style="list-style-type: none"> <li>• LPIs on all legs (subject to analysis relative to ODOT Signal Policy).</li> <li>• Warning signage on all approaches (Turning Vehicles Yield to Bikes/Peds).</li> </ul> <p>Bicycle treatments:</p> <ul style="list-style-type: none"> <li>• NB and SB approaches: green bike lanes (solid fill) immediately upstream from intersection.</li> <li>• All approaches: green bike lane conflict markings traversing the first lane of cross-street traffic (subject to ODOT approval).</li> </ul> <p>Transit treatments:</p> <ul style="list-style-type: none"> <li>• Transit signal priority (to be implemented upon completion of ATC upgrade).</li> </ul> <p>Note: TSP Project #C-30 (details not specified).</p>
6	U.S. 20 at NE 10th Street	New enhanced crossing at (or in vicinity of) intersection.
7	U.S. 20 at NE 12th Street	Modified median refuge to include bicycle cut-through(s).
8	U.S. 20 at NE 15th Street	<p>Pedestrian treatments:</p> <ul style="list-style-type: none"> <li>• LPIs on all legs (subject to analysis relative to ODOT Signal Policy).</li> <li>• Warning signage on EB and NB approaches (Turning Vehicles Yield to Bikes/Peds)</li> </ul> <p>Bicycle treatments:</p> <ul style="list-style-type: none"> <li>• EB approach: green bike lane conflict markings immediately upstream from EB right turn lane (subject to ODOT approval).</li> <li>• NB approach: shared lane marking in NB left turn lane.</li> </ul> <p>Transit treatments:</p> <ul style="list-style-type: none"> <li>• Transit signal priority (to be implemented upon completion of ATC upgrade).</li> </ul>
9	Larkspur Trail Stairway Connection	Consider adding stairway along existing demand path to streamline pedestrian connections between U.S. 20 and the Larkspur Trail (note: may require supplemental Americans with Disabilities Act (ADA) accessible ramp connection).
10	Larkspur Trail Bicycle Connection	Add ramp to facilitate direct linkage between Larkspur Trail south of US 20 and the U.S. 20 EB bike lane.
11	EB Transit Stop Consolidation	Consider removal of existing EB transit stop, and consolidate with existing EB transit stops at NE 15th Street and/or NE Azure Drive.
12	Larkspur Trail Bicycle	Add ramp to facilitate direct linkage between Larkspur Trail north of US



Map #	Reference/Location	Description
	Connection	20 and the U.S. 20 WB bike lane.
13	WB Transit Stop Consolidation	Consider removal of existing WB transit stop, and consolidate with existing WB transit stops at NE Azure Drive and/or NE 15th Street.
14	U.S. 20 at NE Arnett Way	New enhanced crossing at (or in vicinity of) intersection; potential to leverage existing pedestrian cut-through on west leg.
15	WB Transit Stop Enhancement	Lengthen existing concrete pad to serve rear-door passenger alighting.
16	U.S. 20 at NE Azure Drive	New enhanced crossing at (or in vicinity of) intersection.
17	U.S. 20 at Dean Swift Road	New enhanced crossing at (or in vicinity of) intersection.
18	EB Transit Stop Consolidation	Consider removal of existing EB transit stop, and consolidate with existing EB transit stops at NE Azure Drive and/or NE Purcell Boulevard
19	U.S. 20 at NE Purcell Boulevard	<p>Pedestrian treatments:</p> <ul style="list-style-type: none"> <li>• LPIs on all legs (subject to analysis relative to ODOT Signal Policy).</li> <li>• Dual curb ramps on NW corner.</li> <li>• Warning signage on all approaches (Turning Vehicles Yield to Bikes/Peds).</li> </ul> <p>Bicycle treatments:</p> <ul style="list-style-type: none"> <li>• SB approach: green bike lane conflict markings immediately upstream from SB right turn lane (pending required approvals).</li> <li>• EB and WB approaches: green bike lanes (solid fill) immediately upstream from intersection, and green bike lane conflict markings traversing the first lane of cross-street traffic (subject to ODOT approval.)</li> </ul> <p>Transit treatments:</p> <ul style="list-style-type: none"> <li>• Upgrades to existing SB transit stop (upstream from intersection) (per Cascades East Transit).</li> <li>• Transit signal priority (to be implemented upon completion of ATC upgrade).</li> </ul>
20	U.S. 20 at NE Windy Knolls Drive	New enhanced crossing at (or in vicinity of) intersection.
21	U.S. 20 at NE 27th Street	<p>Pedestrian treatments:</p> <ul style="list-style-type: none"> <li>• LPIs on east, north and south legs (subject to analysis relative to ODOT Signal Policy).</li> <li>• Audible pedestrian signals.</li> <li>• Dual curb ramps on NE and SE corners.</li> <li>• Warning signage on EB, NB, WB approaches (Turning Vehicles Yield to Bikes/Peds).</li> </ul> <p>Bicycle treatments:</p> <ul style="list-style-type: none"> <li>• SB approach: green bike lane conflict markings on SB slip lane.</li> <li>• EB, NB, WB approaches: green bike lanes (solid fill) immediately upstream from intersection, and green bike lane conflict markings traversing the first lane of cross-street traffic (subject to ODOT approval).</li> </ul> <p>Transit treatments</p> <ul style="list-style-type: none"> <li>• Transit signal priority (to be implemented upon completion of ATC upgrade).</li> <li>• New EB transit stop immediately east of intersection.</li> </ul> <p>Note: Specific design elements to be coordinated with the City's pending project to develop a shared use path on NE 27<sup>th</sup> Street between U.S. 20 and Bear Creek Road.</p>
22	U.S. 20 at Future "Hanson to Big Sky Trail" Crossing	Future trail undercrossing (to be confirmed upon finalizing trail alignment) (per Bend Park and Recreation District Comprehensive Plan).





Map #	Reference/Location	Description
23	U.S. 20 at Future Trans-Canada Trail Crossing-	Future trail crossing (specific crossing type to be confirmed upon finalizing trail alignment) (per Bend Park and Recreation District Comprehensive Plan).
24	Hawthorne Neighborhood Greenway	Hawthorne Neighborhood Greenway (portion of TSP Project #R6-A).
25	NE 6th Street Neighborhood Greenway Extension	Extend Neighborhood Greenway south to Juniper Swim and Fitness Center.
26	NE Irving Avenue	Neighborhood Greenway.
27	Larkspur Trail/Hawthorne Neighborhood Linkage	Shared use path linking the Larkspur Trail and Hawthorne Neighborhood Greenway (project includes new crosswalk at NE 15th Street).
28	Bear Creek Safe Routes to Schools	Larkspur Trail/Coyner Trail Connection (TSP Project #R2-D).
29	NE Cessna Drive/ NE Azure Drive/ NE Savannah Drive	Enhanced bikeway.
30	NE Bear Creek Road	Shared use path adjacent to roadway; sidewalk infill (TSP Project #R2-E).
31	Dean Swift Road	Enhanced bikeway.
32	NE Purcell Boulevard	Sidewalk infill.
33	Ped Crossing Enhancement	Remove EB deceleration lane, tighten EB turn radius (pending engineering study).
34	Bike Lane Gap Closure	Remove WB deceleration lane, tighten WB turn radius, add WB bike lane (pending engineering study).
35	U.S. 20 Shared Use Path	Shared use path (north or south side of U.S. 20) between Bend city limits vicinity and Powell Butte Highway.
36	NE Providence Drive	Enhanced bikeway.
37	NE Forum Drive/ NE Locksley Drive	Enhanced bikeway.
38	NE Forum Drive/ NE Watt Way/ Medical Center	Enhanced bikeway (corridor identified as Key Walking/Bicycling Route in Bend TSP).
39	NE Paula Drive/ NE Donegon Road	Enhanced bikeway.
40	NE Neff Road	Shared use path adjacent to roadway; sidewalk infill (TSP Project # R3-C).
41	NE Parkview Court	Shared use path connection to Larkspur Trail; enhanced bikeway on NE Parkview Court.
42	NE Norton Avenue Neighborhood Greenway	Neighborhood Greenway (TSP Project #R-3A).

## 2.1 U.S. 20 Cross-Section Improvements

Supplementing the multimodal improvements described above, the Project Team developed cross-section concepts for the entirety of U.S. 20 within the study area. Illustrated in Figure 2 through Figure 16, the concepts are organized by roadway segment, beginning at the study area's west end. In developing the concepts, the Project Team considered the following primary factors:

- The Project's principal vision of improving conditions for vulnerable roadway users, notably people walking, bicycling and accessing transit along and across U.S. 20.
- Maintaining a relatively consistent concept design theme while responding to local conditions where necessary.
- Balancing aspirations with cost as well as other practical considerations and Facility design guidance established in the BUD, tied to the land use contexts established to the U.S. 20 corridor.

For each corridor segment, the figures below display three cross-section concepts:

- The **existing cross-section** (with approximate measurements).
- **Shorter-term enhancements.**
  - To minimize costs, these enhancements would maintain the outside curb lines while remaining within the existing right-of-way (ROW). Improvements would primarily consist of striping modifications to widen the existing bike lanes or add delineated buffers. In the rural segment of U.S. 20 (east of NE Providence Drive) a shared use path on one side would serve foot and bicycle traffic. These shorter-term enhancements would be compatible with the crossing upgrades described earlier in this memo.
  - The following should be noted when considering these concepts:
    - In order to retain the existing curb lines and avoid ROW acquisition needs, this concept omits the BUD's recommended Sidewalk Frontage Zone.
    - While the corridor's motor vehicle volumes and speeds exceed ODOT's thresholds for separated bike lanes, the provision of conventional and buffered bike lanes may derive limited level-of-comfort benefits for interested-but-concerned riders.
    - As U.S. 20 is a designated Statewide Freight Route and Reduction Review Route, further feasibility analysis and MAC engagement may be necessary.
- **Longer-term/aspirational enhancements.**
  - While remaining within the existing ROW, these enhancements would involve more substantial cross-section adjustments to improve vulnerable roadway user comfort and safety, notably the creation of physically-separated shared use paths.

- The following should be noted when considering these concepts:
  - As with the shorter-term enhancements, most corridor segments in this concept omit the BUD's recommended Sidewalk Frontage Zone (in order to remain within the existing ROW). If ROW acquisition is feasible, this feature should be added on both sides of the corridor.
    - If additional ROW acquisition is feasible, an additional Buffer Zone between the shared use path and the curb is recommended in order to provide more lateral separation between motorized and non-motorized users while providing a zone for the placement of signs, fire hydrants and luminaires. Depending on location, this space could also accommodate driveway aprons, thereby enabling the shared use path to remain at sidewalk level.
  - Access management, particularly on U.S. 20 between NE 3<sup>rd</sup> Street and NE 12<sup>th</sup> Street, will be critical for minimizing conflicts between path users and motor vehicles entering and exiting driveways.

Figure 2. NE 3rd to NE 12th – Existing Cross Section

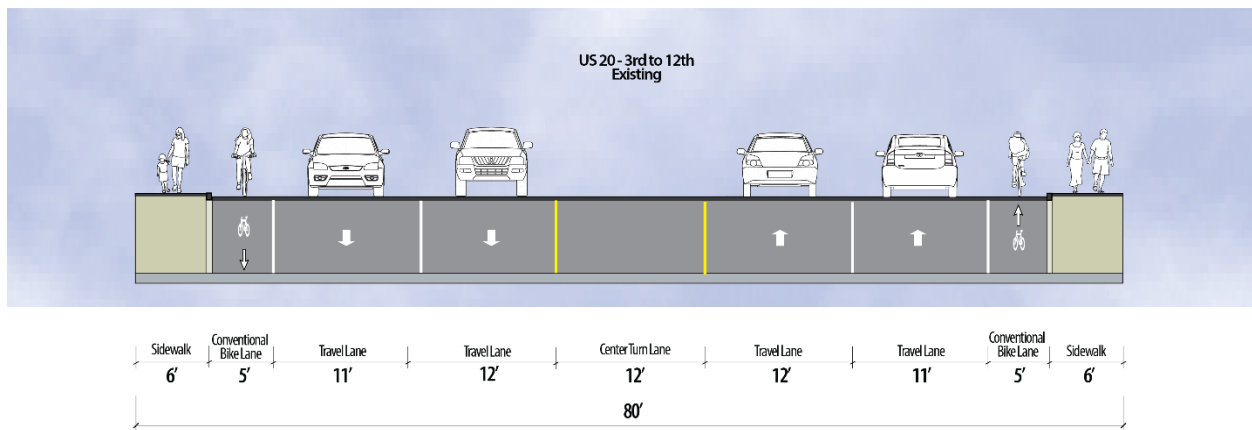


Figure 3. NE 3rd to NE 12th – Shorter-Term Cross Section

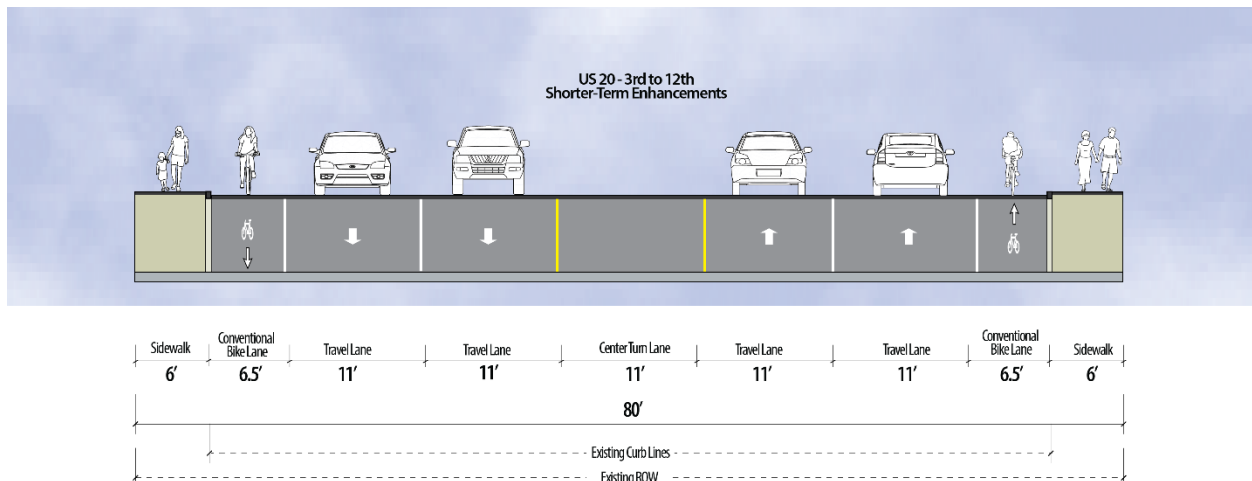


Figure 4. NE 3rd to NE 12th – Longer-Term Cross Section

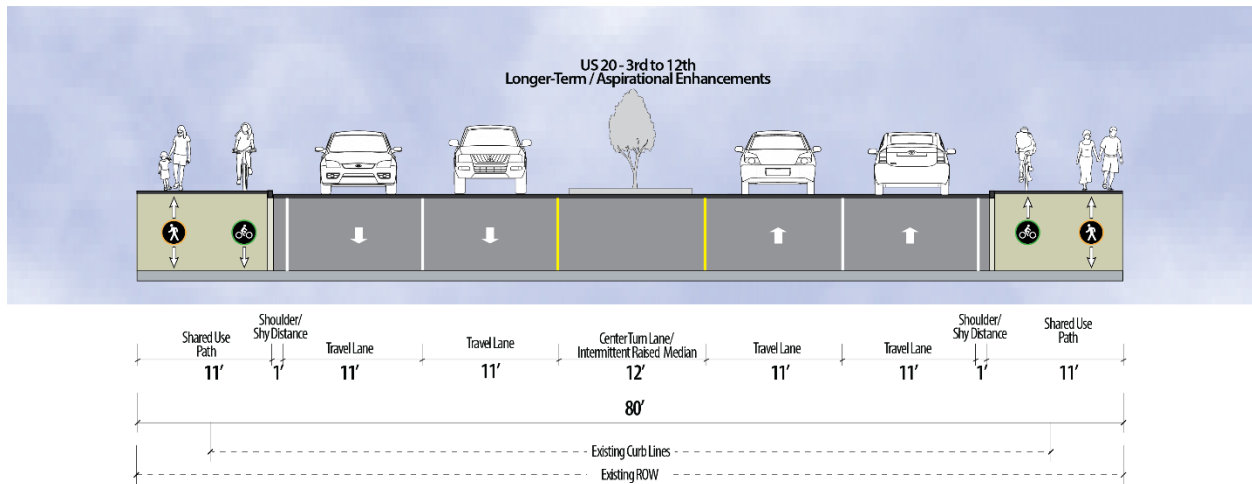


Figure 5. NE 12th to NE 15th – Existing Cross Section

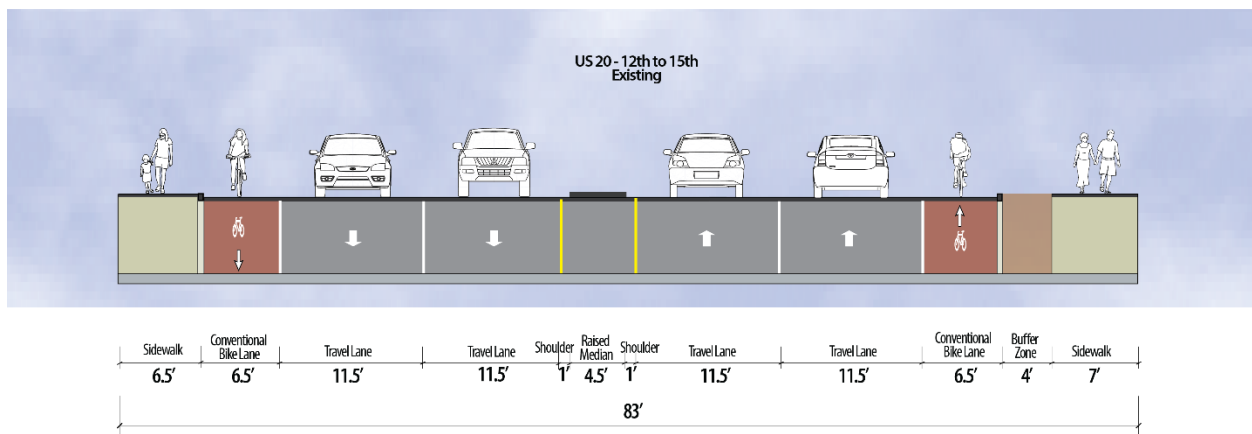


Figure 6. NE 12th to NE 15th – Shorter-Term Cross Section

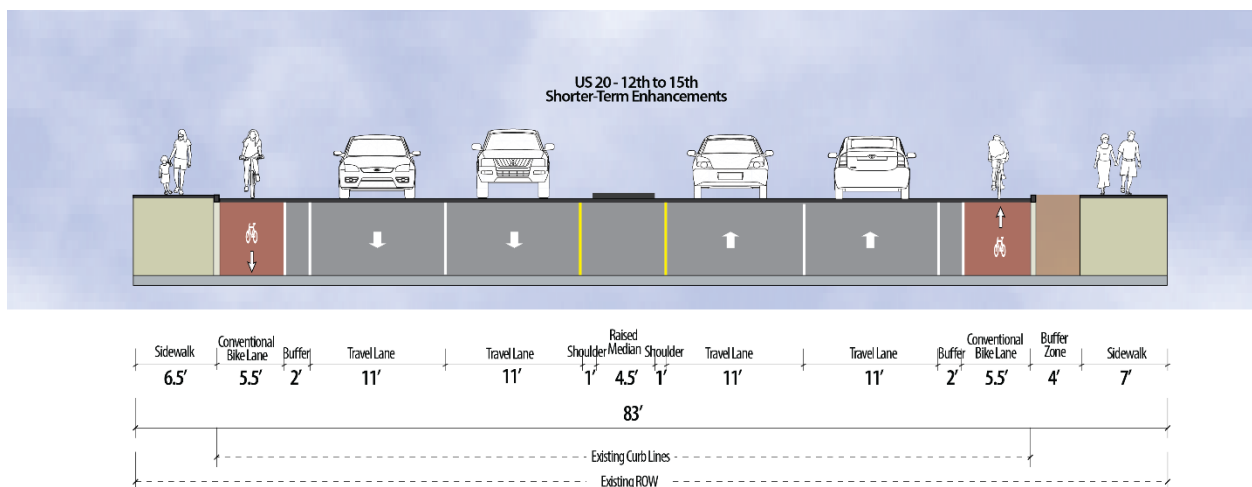


Figure 7. NE 12th to NE 15th – Longer-Term Cross Section

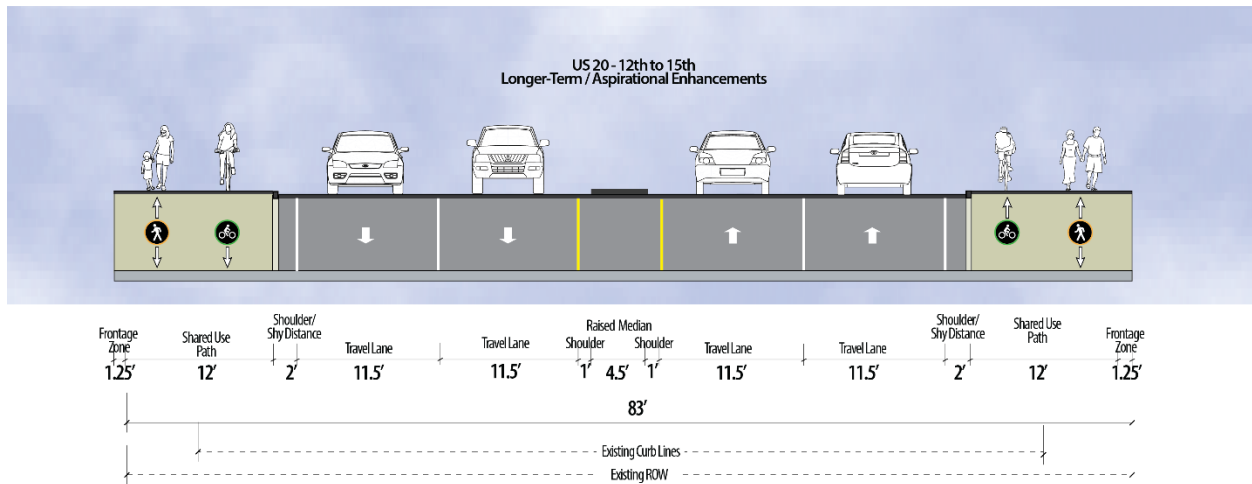


Figure 8. NE 15th to NE Bellevue/NE Benson – Existing Cross Section

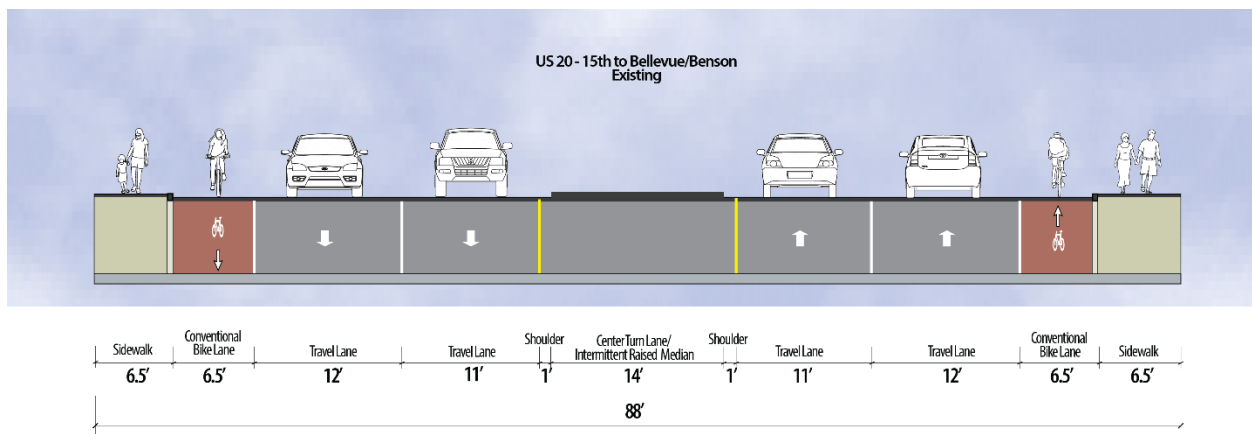


Figure 9. NE 15th to NE Bellevue/NE Benson – Shorter-Term Cross Section

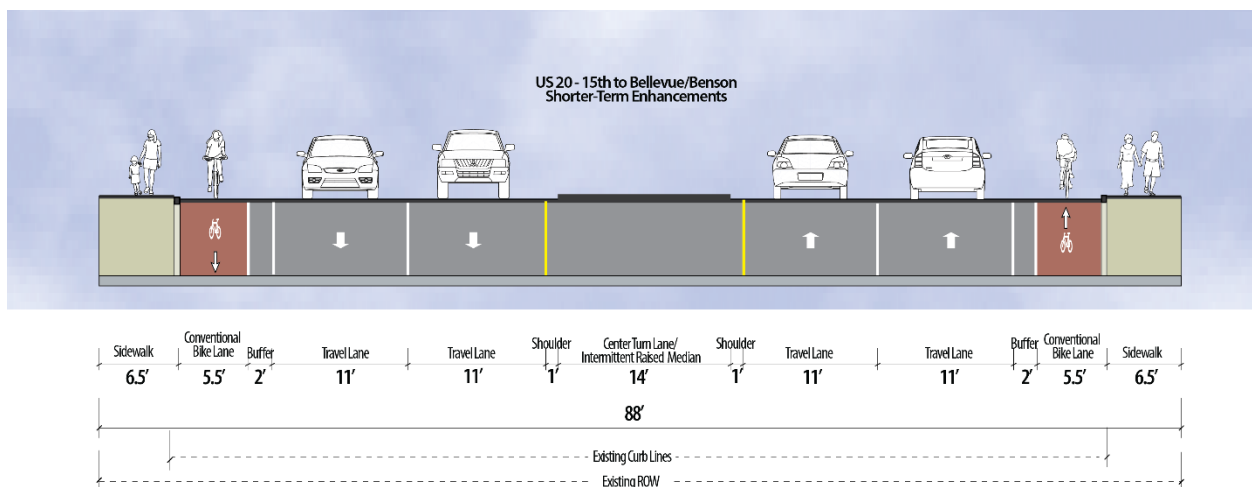


Figure 10. NE 15th to NE Bellevue/NE Benson – Longer-Term Cross Section

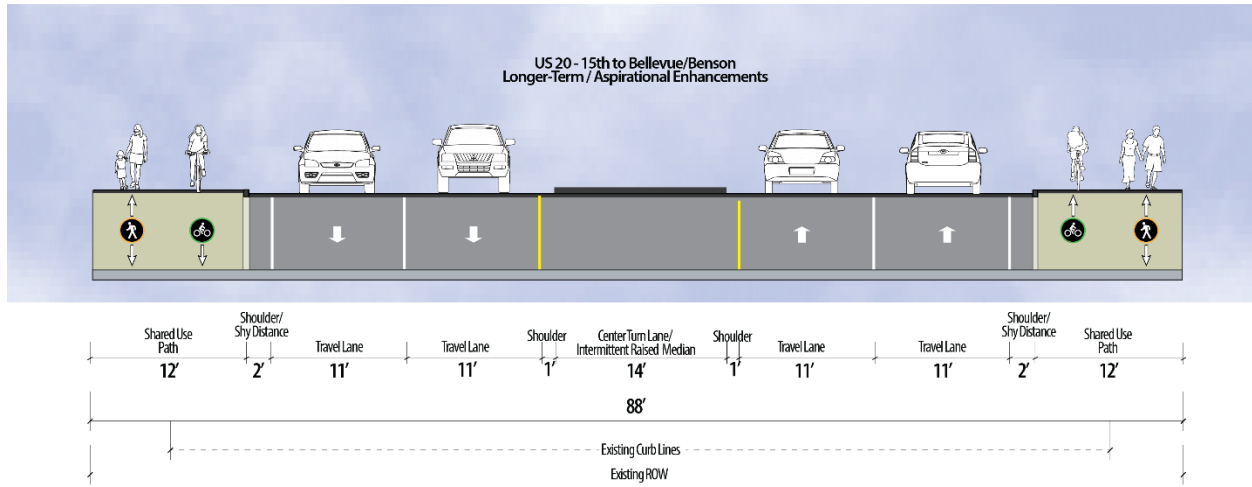


Figure 11. NE Bellevue/NE Benson to NE Providence – Existing Cross Section

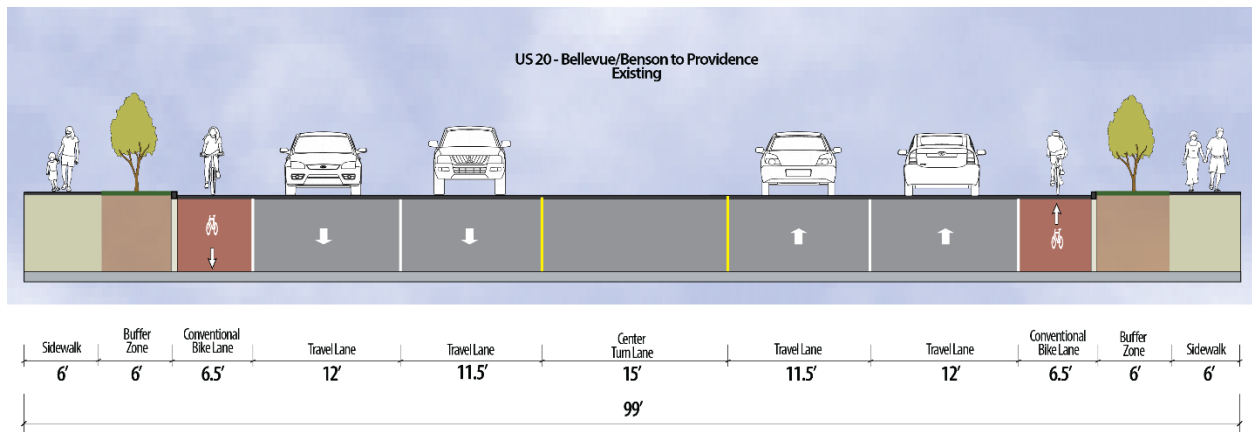


Figure 12. NE Bellevue/NE Benson to NE Providence – Shorter-Term Cross Section

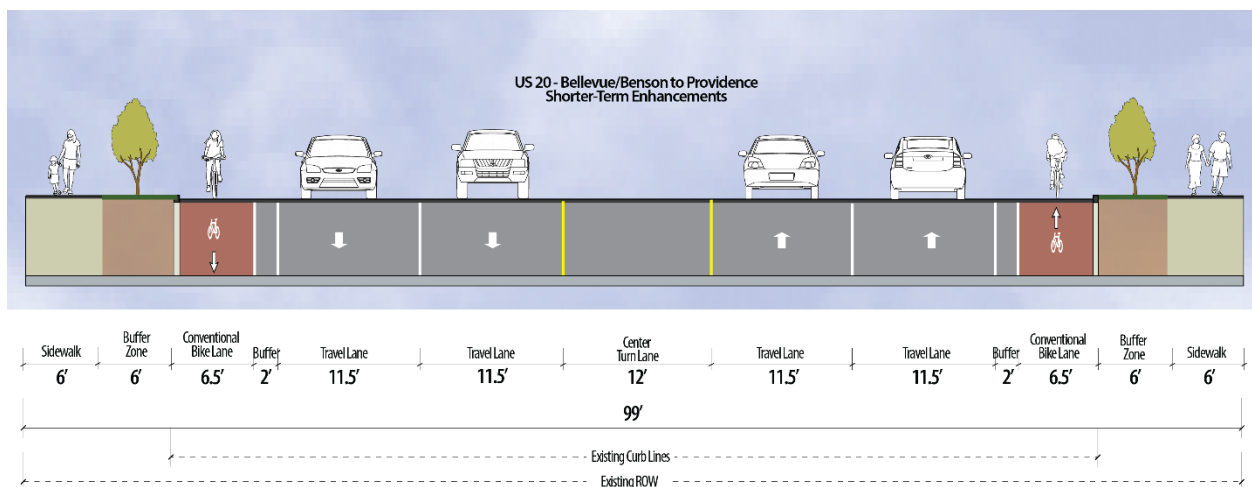


Figure 13. NE Bellevue/NE Benson to NE Providence – Longer-Term Cross Section

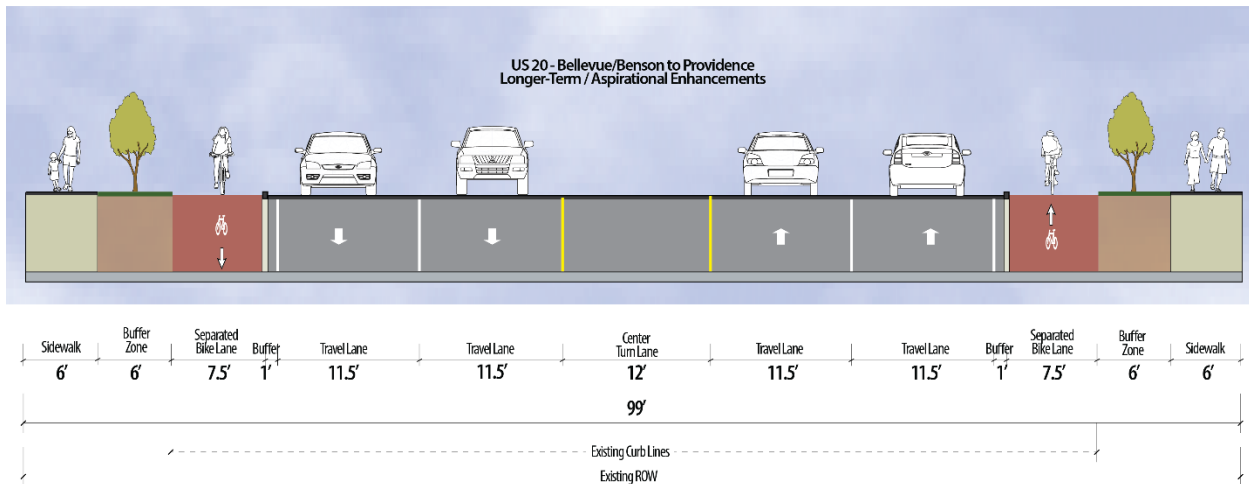


Figure 14. NE Providence to Powell Butte – Existing Cross Section

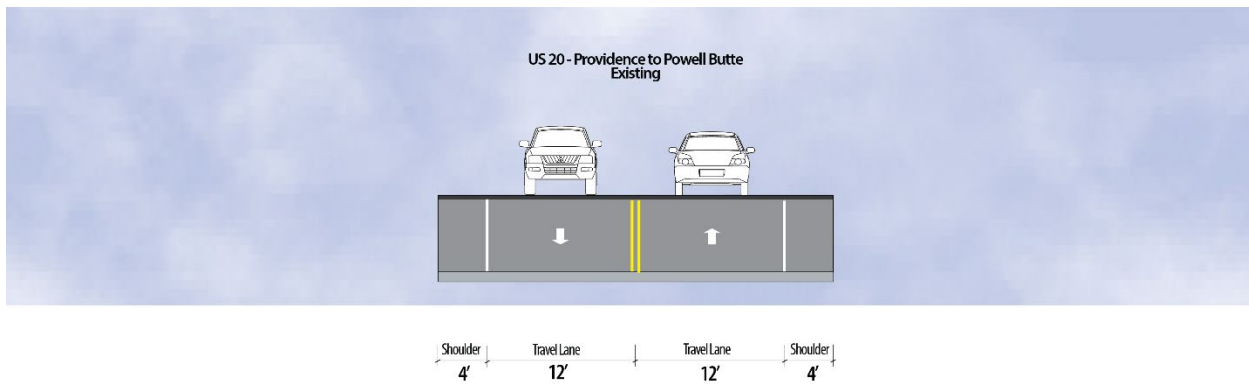


Figure 15. NE Providence to Powell Butte – Shorter-Term Cross Section

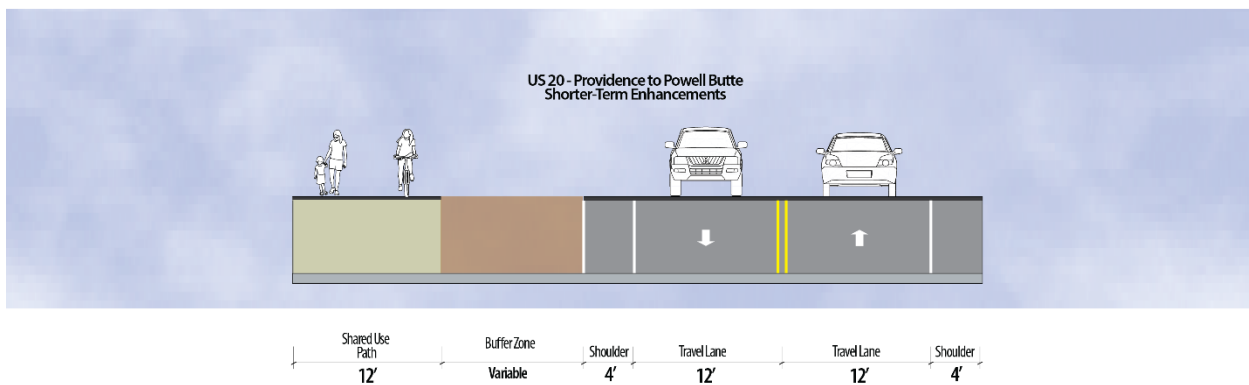
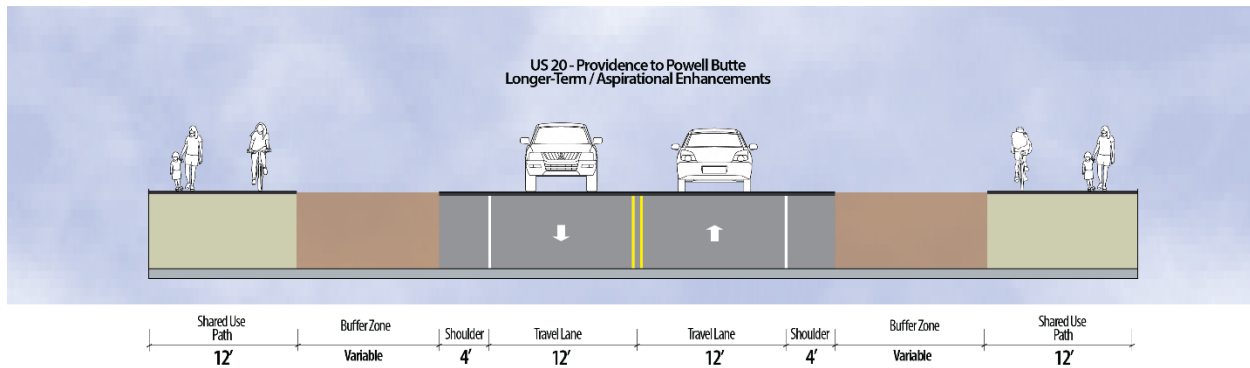


Figure 16. NE Providence to Powell Butte - Longer-Term Cross Section



## 2.2 Other Pedestrian, Bicycle and Transit Improvements

In addition to the cross-section concepts and other location-specific improvements described above, the following pedestrian, bicycle, and transit enhancements would apply to larger corridor segments or corridor-wide:

- Access management/driveway consolidation (to be partially addressed in ODOT's upcoming Statewide Transportation Improvement Program (STIP) project on U.S. 20 between NE 3rd Street and NE 15th Street).
- Sidewalk surface improvements.
- Removal or relocation of sidewalk obstructions (e.g., light poles and signs).
- Curb ramp upgrades at locations where existing ramps are not ADA accessible and not covered in upcoming STIP projects.
- Consideration of colored bike lanes throughout the corridor's entirety to increase their visibility while providing design continuity.
- Protected intersection treatments (pending further analysis and MAC engagement), particularly as adjacent properties redevelop thereby providing opportunities for strategic ROW acquisition.
- Transit stop infrastructure improvements (e.g., shelters, lighting, passenger information and enhanced crosswalks).

## 3 Intersection Improvements

In addition to bicycle and pedestrian improvements, operational improvements were also evaluated at major intersections and crossings along the corridor. These were evaluated to work in harmony with the proposed bicycle and pedestrian improvements and were intended to improve vehicular operations as well as safety and connectivity. Select intersection treatments were analyzed at each location and are discussed in sections 3.1 to 3.4.



The following intersections were evaluated:

- U.S. 20 at 3rd Street – signalized
- U.S. 20 at 8th Street – signalized
- U.S. 20 at Purcell Boulevard – signalized
- U.S. 20 at Dean Swift Road – unsignalized, minor approach stop-controlled
- U.S. 20 at 27th Street – signalized
- U.S. 20 at Benson Way – signalized
- U.S. 20 at Hamby Road – roundabout

### 3.1 Roundabout

Roundabouts were considered at each intersection as they can benefit safety, capacity and traffic flow. In accordance with the TSP, roundabouts are the City's preferred intersection treatment. However, many intersections along this corridor are constrained by the existing ROW and built environment, making roundabouts less feasible. The demand volume at several intersections may also make roundabouts infeasible. Additionally, U.S. 20 is a National Highway System Freight Route and will require coordination with the ODOT MAC. Garnering MAC support of roundabouts is feasible as long as the roundabouts are designed to accommodate the appropriate design vehicles.

### 3.2 Traditional Widening at Intersections

Traditional widening includes both major widening and minor widening. Major widening necessitates widening to accommodate multiple additional turn lanes to the intersection, significantly impacting adjacent ROW. Minor widening includes widening the intersection to provide a single additional turn lane and pedestrian and bicyclist improvements.

### 3.3 Median U-Turn/Restricted Crossing U-Turn

Median U-turns (MUT) and restricted crossing U-turns (RCUT) improve safety and increase capacity at signalized and unsignalized intersections. A MUT diverts the left turns from either the major, minor, or both approaches at the main intersection. The left turns are then diverted downstream to a location where the U-turn is accommodated. At locations with a narrow median ranging from 16 to 30 feet, a loon or bulb-out is required to accommodate the U-turn for the design vehicle. Cyclists make the left turn at the main intersection using a two-stage crossing and bike boxes. Pedestrians cross the main intersection using the typical crosswalks.

RCUTs divert both the left turn and through movements from the minor approach, forcing all vehicles from the minor approach to turn right. The left turns and through movements are then diverted downstream to a location where the U-turn is accommodated. A median island is constructed within the center of the main intersection, channelizing the major approach left turning vehicles and the minor approach movements. Similar to the MUT, a loon or bulb-out is often required to accommodate the design vehicle. When signalized, the signal operation only requires two phases, improving vehicular capacity.

People on bikes turning left to or from the minor approach and travelling through on the minor approach are to dismount the bicycle and utilize the multiple stage Z-crossing as a pedestrian.

RCUTs and MUTs improve safety by reducing the number of conflict points at the intersection and increases vehicular capacity by reducing signal phasing and lose time. Although RCUTs do increase the pedestrian delay, the pedestrian exposure to vehicles is often reduced compared to traditional intersection widening to increase capacity. Signalized MUTs and RCUTs can also provide an additional protected pedestrian crossing along the corridor at the dedication U-turn intersections.

Along U.S. 20, RCUTs and MUTs might be difficult to accommodate without impacts to ROW and adjacent buildings due to the highly urban nature of a portion of the corridor, and the need to provide adequate turning space for larger vehicles.

### 3.4 Remove Lefts

This Plan considered removing lefts at intersections while leaving the through movements. The option to remove lefts at intersections would benefit intersection operations but would force left turning vehicles to find an alternate route. Unlike RCUTs or MUTs, this option would not provide a signal protected or designated U-turn location along U.S. 20 that would replace the left turn at the intersection. This would require less ROW and be less impactful than RCUTs or MUTs since no U-turn widening would be needed but might add additional traffic to residential or side streets.

## 4 Evaluation Metrics

The intersection treatments will be evaluated based on the following criteria. Each treatment will be given a score from -2 to 2, indicating whether the treatment achieves the desired metric. The treatments will be evaluated independently of the intersections at first, in order to quickly determine if they meet the overall goals of the project.

- Increase system functionality.
  - Provide for efficient travel for traffic utilizing U.S. 20.
  - Reduce U.S. 20's barrier effect by enhancing walking and bicycling accessibility along and across the corridor.
  - Enhance transit mobility and accessibility.
- Improve safety for vulnerable users.
  - Reduce serious injuries and fatalities.
  - Maximize safety and comfort for vulnerable roadway users.
  - Move in the direction of meeting ODOT's adopted access spacing standards along U.S. 20 or meet the standards where feasible.
- Support economic development.



- Maintain effective access to properties along U.S. 20 in a manner that supports the economic development objectives of existing and future businesses.
- Provide for efficient freight movement throughout the corridor.
- Protect livability and ensure equity and access.
  - Incorporate a complete streets and complete network approach on U.S. 20 and other study area corridors.
  - Reduce the burden of regional motor vehicle traffic on adjacent residential neighborhoods.
  - Strive for people of all income levels and abilities to have access to the transportation options that best meet their daily needs.
- Steward the environment.
  - Reduce vehicle emissions through reduction of vehicular delay, improved connections in the local system, and the use of alternative travel modes.
  - Prioritize solutions that avoid or minimize adverse environmental impacts.
- Develop solutions that are cost-effective and implementable.
  - Prioritize lower-cost, high-benefit solutions.
  - Prioritize solutions that leverage partnerships, existing planned projects and programs.
  - Develop solutions that are constructable in phases and can be reasonably maintained.