



## TECHNICAL MEMORANDUM 2B

DATE: May 19, 2021

TO: Don Morehouse | ODOT

FROM: John Bosket, PE and Kayla Fleskes, PE | DKS Associates

SUBJECT: US 97 Baker Road IAMP  
Existing Transportation System Inventory

Project #20020-006

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This memorandum describes the location and condition of existing transportation facilities surrounding the US 97/Baker Road interchange, primarily focused on the Area of Potential Impact (API). It is a companion document with Technical Memoranda 2A and 2C, that describe existing land uses, environmental resources, and protected populations that are historically underrepresented and underserved. Together, these memoranda will help provide a baseline understanding of the land uses, people, and transportation system within the API and any potential constraints to a future interchange solution. The subsequent Technical Memorandum 3 will use this information to describe how well the transportation system is functioning (e.g., congestion, safety, accessibility).

### EXISTING STREET NETWORK

Figure 1 shows the existing street network and study intersections in the API. There are six study intersections along Baker Road within one-quarter mile of the US 97/Baker Road interchange. The remaining four study intersections are included to help understand potential impacts of any future proposed frontage connections or access changes along the US 97 mainline. The interchange is currently outside of the existing City of Bend Urban Growth Boundary (UGB). However, as Bend continues to grow in the future, it is likely that the entire “thumb” area (between Knott Road, US 97 and China Hat Road) would be incorporated into the UGB.



**FIGURE 1. STUDY INTERSECTIONS**

Table 1 lists classifications and designations of significant roadways in the API. US 97 is classified as a Statewide Highway and is further designated as part of the National Highway System, an expressway, state freight route, reduction review route, high clearance route, and Seismic Tier 1 Route. Baker Road and Knott Road are classified as Rural Arterials by Deschutes County and Cinder Butte Road is classified as a Rural Collector<sup>1</sup>. Knott Road is also classified as a minor arterial by Bend within the UGB<sup>2</sup>. Knott Road (and SE 27<sup>th</sup> Street) are commonly used to bypass congestion on US 97 and US 20 to access eastern Bend. The US 97 northbound off-ramp at Knott Road is also signed as a direct route to the St. Charles Medical Center and Mountain View High School and will be a direct route to the new Caldera High School (opening Fall 2021).

**TABLE 1: STUDY AREA ROADWAY CLASSIFICATIONS AND DESIGNATIONS**

STREET	JURIS-DICTION	FUNCTIONAL CLASS	NUMBER OF LANES	POSTED SPEED (MPH)	AADT <sup>A</sup>
US 97	ODOT	Statewide Expressway	4	65	19,100 – 26,700
BAKER RD/ KNOTT RD	County/City	Rural Arterial	2	35 (50 mph east of Scale House Rd)	8,800 - 11,500
CINDER BUTTE RD	County	Rural Collector	2	35	4,500 <sup>B</sup>
BAKER CT	County	Local	2	25	NA
POCAHONTAS LN	County	Local	2	NP <sup>C</sup>	NA
APACHE RD	County	Local	2	35	NA

<sup>A</sup> Annual average daily traffic (vehicles per day) obtained from ODOT Transgis: <https://gis.odot.state.or.us/transgis/>

<sup>B</sup> Data provided by Deschutes County

<sup>C</sup> Speed limit not posted.

As shown in Figure 2, all of the study intersections are two-way stop-controlled intersections. Table 2 lists additional geometric characteristics of significant roadways in the API. The US 97 southbound and northbound off-ramps include striped right turn lanes (with approximately 350 feet and 175 feet of storage, respectively). There is no marked on-street parking within the API.

<sup>1</sup> Deschutes County Transportation System Plan

<sup>2</sup> The City of Bend Comprehensive Plan notes that facilities located outside the UGB may not be constructed to an urban standard until the area is brought into the UGB and that the City must seek approval from the County to improve facilities to urban standards that are located in the Urban Reserve Areas (City of Bend Comprehensive Plan Policy 7-15 and 7-16)

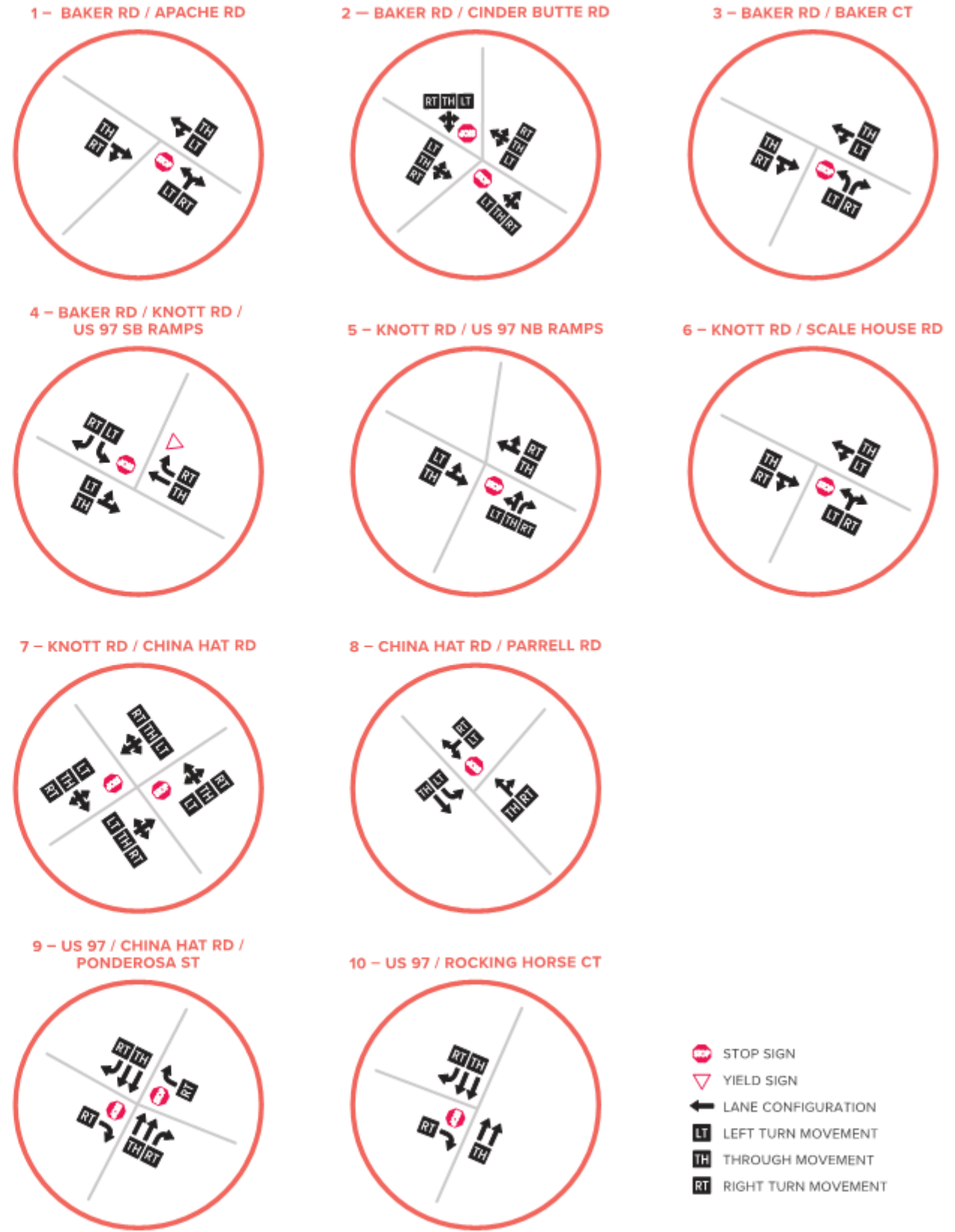


FIGURE 2: STUDY INTERSECTION LANE CONFIGURATIONS

**TABLE 2: ROADWAY GEOMETRY**

STREET	PAVEMENT TYPE/ CONDITION	PAVEMENT WIDTH (FT)	SHOULDER TYPE; WIDTH	LANE WIDTH (FT)	MEDIAN TYPE/ WIDTH	APPROX. RIGHT-OF-WAY WIDTH <sup>A</sup>
<b>US 97 MAINLINE</b>	Asphalt Concrete; Good	36	Paved; Left=8 ft, Right=4 ft	12	Barrier; 8 ft	min. 142 ft
<b>US 97 NB OFF-RAMP</b>	NA	26	Paved; Left=4 ft, Right=6 ft	16	NA	NA
<b>US 97 NB ON-RAMP</b>	NA	26	Paved; Left=4 ft, Right=6 ft	16	NA	NA
<b>US 97 SB OFF-RAMP</b>	NA	26	Paved; Left=4 ft, Right=6 ft	16	Painted; 12 ft	NA
<b>US 97 SB ON-RAMP</b>	NA	26	Paved; Left=6 ft, Right=8 ft	12	Painted; 12 ft	NA
<b>BAKER RD/ KNOTT RD</b>	Asphalt Concrete; Good	34 - 44	Paved/Gravel; Right=3-4 ft	11 - 12	NA	60-72 ft
<b>CINDER BUTTE RD</b>	Asphalt Concrete; Good	24	Gravel; Varies	12	NA	60-66 ft

<sup>A</sup> Measured from taxlot maps: <https://ormap.net/gis/index.html>  
 Source: Aerial imagery and ODOT Transgis: <https://gis.odot.state.or.us/transgis/>

**ACCESS SPACING STANDARDS**

ODOT has adopted interchange and access management spacing standards in the Oregon High Plan (OHP)<sup>3</sup> that specify the minimum separation required between interchange crossroads, adjacent interchange ramp tapers and access points along crossroads. There are different standards for urban areas (assumed 45 mph speed of mainline) and rural areas (55 mph). While the US 97/ Baker Road interchange is currently outside of the existing UGB, it is likely that in the future the UGB will be expanded to be immediately adjacent to the interchange.

ODOT’s interchange spacing standards require a minimum of 1.9 miles between interchange crossroads in urban areas and 3 miles in rural areas. The Murphy Road interchange is the nearest interchange to the north at 1.88 miles away, effectively meeting the urban spacing standard. There are no interchanges within 3 miles to the south.

<sup>3</sup> 1999 Oregon Highway Plan, as amended May 2015, Oregon Department of Transportation, Appendix C.

Furthermore, ODOT’s spacing standards for the distance between adjacent ramp tapers on a freeway (US 97 is not technically a freeway, but functions similarly to one) requires 1 mile in an urban area and 2 miles in a rural area.<sup>4</sup> Between the existing US 97/Baker Road and Murphy Road interchanges, there is approximately 1.2 miles between tapers northbound and 1.1 miles between tapers southbound, which would meet the standard for urban areas but not for rural areas.

Table 3 lists the urban and rural spacing standards for access points near an interchange along an expressway. To the north, the intersections with Rocking Horse Court and China Hat Road/ Ponderosa Street are located approximately 0.65 miles and 0.82 miles from the US 97/ Baker Road ramp tapers, respectively. While these are much closer than the spacing standard requires, these at-grade access points are planned to be closed in the future as noted in the City of Bend Transportation System Plan and the US 97 Parkway Plan. After those are closed, there would not be any at-grade access points between the US 97/Baker Road and US 97/Murphy Road interchanges.

To the south, the nearest at-grade access point is 1.35 miles away at the High Desert Museum, which is closer than the 2-mile spacing standard for rural areas. While not listed in Table 3, there is also a gated emergency vehicle access to the Deschutes River Woods neighborhood located approximately 1.15 miles south of the interchange.

**TABLE 3: US 97 ACCESS SPACING BETWEEN THE US 97/BAKER RD INTERCHANGE AND ADJACENT ACCESS POINTS**

SEGMENT	DIRECTION	NEAREST INTERSECTION	APPROX. SPACING (MI)	OHP SPACING STANDARD (RURAL/URBAN) (MI) <sup>A</sup>
<b>NORTHBOUND US 97</b>	North of Baker Rd Interchange	China Hat Road	0.82	2 / 1
	South of Baker Rd Interchange	High Desert Museum Access	1.35	2 / 1
<b>SOUTHBOUND US 97</b>	North of Baker Rd Interchange	Rocking Horse Court	0.65	2 / 1
	South of Baker Rd Interchange	High Desert Museum Access	1.35	2 / 1

<sup>A</sup> 1999 Oregon Highway Plan, as amended May 2015, Oregon Department of Transportation, Appendix C, Table 19.

<sup>4</sup> 1999 Oregon Highway Plan, as amended May 2015, Oregon Department of Transportation, Appendix C, Tables 17 and 18.

OHP standards also indicate that a minimum of 1,320 feet (0.25 mi) be provided between the ramp terminals and the first intersection on the crossroad (note that County cooperation would be needed to apply these standards as Baker Road and Knott Road are not under state jurisdiction).<sup>5</sup> This standard is not met under existing conditions.

On the west side of the interchange, the Baker Court intersection which serves as access to the Riverwoods Country Store and the Morning Star Christian School is only 110 feet from the southbound ramp terminal. Further to the west, public street access is provided at Cinder Butte Road/Pocahontas Lane (425 feet away) and Apache Road (1,335 feet away). In addition, there are 14 driveways to single-family homes between Cinder Butte Road/Pocahontas Lane and Apache Road. On the east side of the interchange there are two access points within 1,320 feet of the northbound ramp terminal: one at Scale House Road (525 feet away) and a gated driveway farther to the east (970 feet away).

### RAMP ACCELERATION/DECELERATION LANE STANDARDS

ODOT’s Highway Design Manual (HDM) provides a standard length for acceleration and deceleration lanes at interchange ramps<sup>6</sup>. Table 4 lists the length of acceleration and deceleration lanes at the interchange and the applicable standard. As shown, the southbound off-ramp and northbound on-ramp deceleration and acceleration lane lengths are longer than the minimum lengths required. However, the northbound off-ramp deceleration lane length is just 30 feet shy of meeting the minimum standard length and the southbound on-ramp, which is a loop ramp with a much lower ramp speed than the northbound on-ramp, has an acceleration lane that is 400 feet shorter than the minimum length.

**TABLE 4: US 97/BAKER RD INTERCHANGE RAMP ACCELERATION AND DECELERATION LENGTHS**

RAMP	TYPE	POSTED MAINLINE SPEED (MPH)	POSTED RAMP SPEED (MPH)	HDM MINIMUM ACCEL./ DECEL. LANE LENGTH (FT)	EXISTING ACCEL./ DECEL. LANE LENGTH (FT)
US 97 SB TO BAKER ROAD	Off-Ramp	65	45	340'	420'
BAKER ROAD TO US 97 SB	On-Ramp	65	25	1350'	950'
US 97 NB TO KNOTT ROAD	Off-Ramp	65	45	340'	310'
KNOTT ROAD TO US 97 NB	On-Ramp	65	55	580'	735'

<sup>5</sup> 1999 Oregon Highway Plan, as amended May 2015, Oregon Department of Transportation, Appendix C, Table 19.

<sup>6</sup> Highway Design Manual, Oregon Department of Transportation, Chapter 9, 2012.

## BAKER ROAD RAILROAD CROSSING

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A Burlington Northern Santa Fe (BNSF) railroad line parallels US 97 to the west before crossing above US 97 south of Rocking Horse Court. There is an at-grade railroad crossing on Baker Road located within 225 feet of the US 97 southbound ramps, with gate arms for train crossings. The railroad line typically sees freight trains but no passenger trains. Train speeds are less than 50 mph at the crossing. There have been no incidents reported at the railroad crossing in nearly four decades<sup>7</sup>.

## BRIDGES AND CULVERTS

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Currently, there are seven bridges documented in the National Bridge Inventory located within the API. Five are located on US 97 and two along China Hat Road and Baker Road. A bridge sufficiency rating is a system defined and mandated by the Federal Highway Administration used to determine whether a bridge is structurally deficient or functionally obsolete and, therefore, needs to be replaced. The rating takes into account a number of factors including the structural health of individual components, (condition of decking, footings, appearance of rust or cracks in structural components) and functionality (is the bridge at capacity for existing vehicle volumes, is the channel under the bridge adequate for flooding events, etc.). As listed in Table 5, all seven of the bridges in the API are in good condition with sufficiency ratings greater than 93 (out of 100) where ratings are provided. Figure 3 shows both bridges in the API and culverts located on US 97 within the API.

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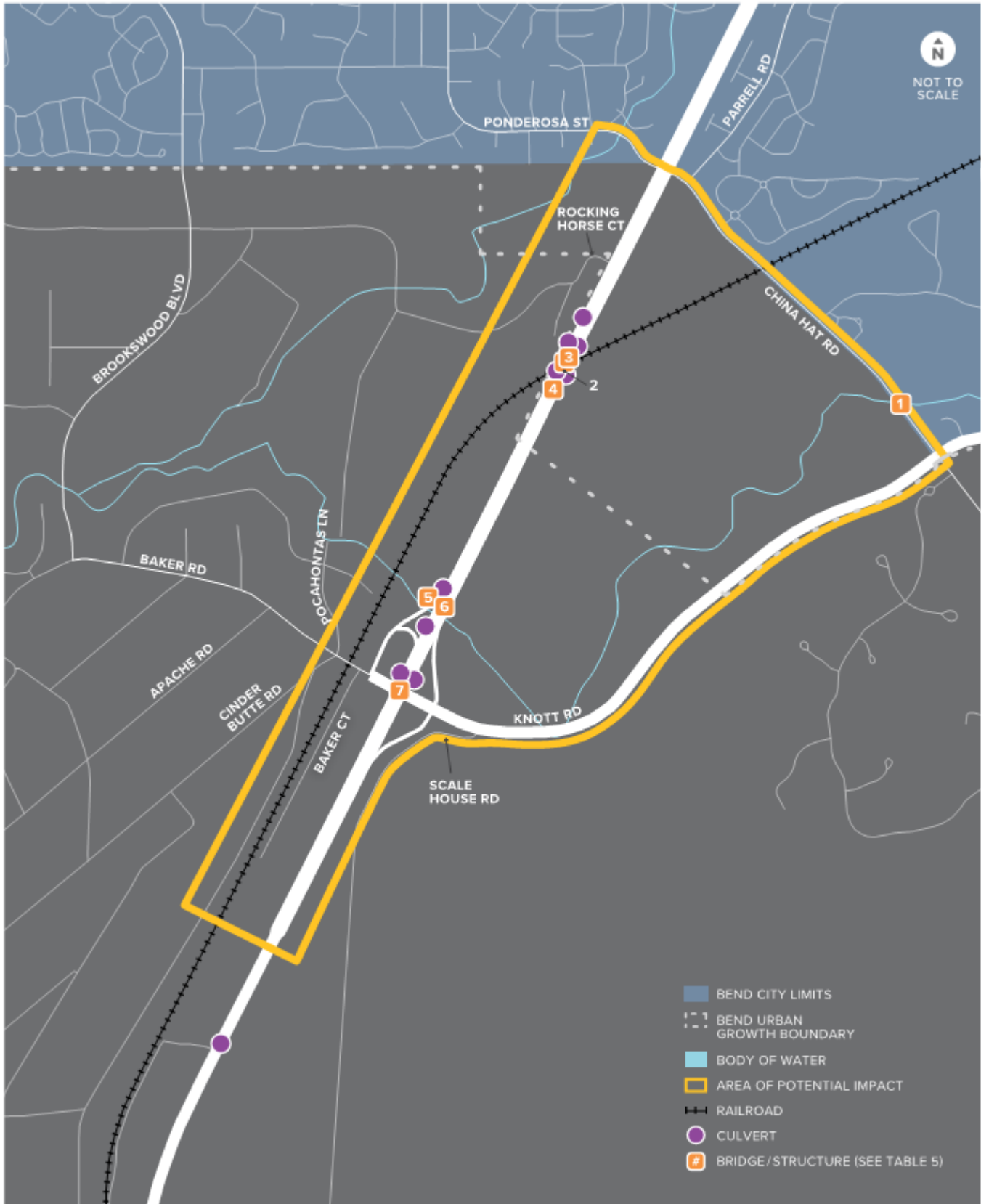
<sup>7</sup> Highway-Rail Grade Crossing Accident/Incident Report, Federal Railroad Administration, October 2020, Accessed January 2021



**TABLE 5: BRIDGES AND STRUCTURES IN THE API**

NO	BRIDGE ID	ROADWAY	MILE-POST	STRUCTURE NAME	OWNER	SUFFICIENCY RATING	CONDITION
1	17C52	China Hat Rd	0.6	Arnold Canal, China Hat Rd	City	95	Good
2	17280	US 97	142.7	BNSF over Hwy 4	BNSF	-	Good
3	23259	US 97	142.67	Sign Structure	ODOT	-	Good
4	20560	US 97	142.76	Sign Structure	ODOT	-	Good
5	17437	US 97	143.27	Arnold Ditch, Hwy 4 Conn	ODOT	96	Good
6	01135A	US 97	143.27	Arnold Ditch, Hwy 4	ODOT	97	Good
7	17281	US 97	143.45	Baker Road over Hwy 4	ODOT	94	Good

Source: ODOT Transgis: <https://gis.odot.state.or.us/transgis/>



**FIGURE 3: CULVERTS AND BRIDGES**

## EXISTING BICYCLE/PEDESTRIAN NETWORK

While common for rural areas, there are currently no sidewalks or bike lanes on any of the roads near the interchange and many of the shoulders are narrow and/or unpaved. There are no marked crosswalks or ADA accessible facilities near the interchange. The interchange area does not meet current ODOT *Blueprint for Urban Design* (BUD) design criteria for bicycle or pedestrian facilities. While the BUD criteria vary based on six urban contexts, including “rural community” and “suburban fringe” contexts, the criteria for bicycle facilities for most contexts is at least a buffered bicycle lane and curbed sidewalk.

Within the rest of the API, there are limited sidewalks and bike lanes along China Hat Road, but no other pedestrian or bicycle facilities. For roadways that are uncurbed with vehicle speeds greater than 25 miles per hour, Deschutes County standards<sup>8</sup> indicate a shoulder bikeway should be at least four feet in width. Deschutes County does not require sidewalks outside of the unincorporated communities of Terrebonne and Tumalo<sup>9</sup>.

Since much of the API is sparsely developed today, trip origins and destinations are far apart, making walking and biking trips less feasible. In addition, US 97 and the railroad act as barriers to east-west travel for people walking and biking. However, the Baker Road interchange provides one of the few grade-separated crossings of US 97 for people walking and biking and is identified as a County Bikeway by the Deschutes County TSP. Furthermore, a cursory review of Strava heatmaps<sup>10</sup> shows that the Baker Road/Knott Road interchange overcrossing is part of a popular recreational bicycling route. When development of the “thumb” area occurs, use of Baker Road as a grade-separated crossing of US 97 will continue to increase for people walking and biking. In particular, Riverwoods Country Store is a likely trip generator in the API, as well as a transit stop at River Woods Baptist Church on Cinder Butte Road, approximately 0.15 miles south of Baker Road.

## LEVEL OF TRAFFIC STRESS ANALYSIS

The Level of Traffic Stress (LTS) was analyzed for pedestrian and bicycle facilities in the API using the methodology from the ODOT *Analysis and Procedures Manual*. This methodology breaks road segments into four classifications to qualitatively rate the effects of traffic-based stress on people walking and biking. The measure of traffic stress quantifies the perceived safety issue of being in close proximity to vehicles, primarily considering the physical distance to traffic and the speed of traffic. The four levels of stress are described below:

- **LTS 1 (lowest):** Represents little traffic stress and requires less attention, so is suitable for bicycling for all ages and abilities. This includes children that are trained to safely cross intersections alone and supervising riding parents of younger children. Generally, the age of 10 is assumed to be the earliest age that children can adequately understand traffic and make safe

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<sup>8</sup> Deschutes County Code 17.48.140

<sup>9</sup> Deschutes County Transportation System Plan

<sup>10</sup> <https://www.strava.com/heatmap>

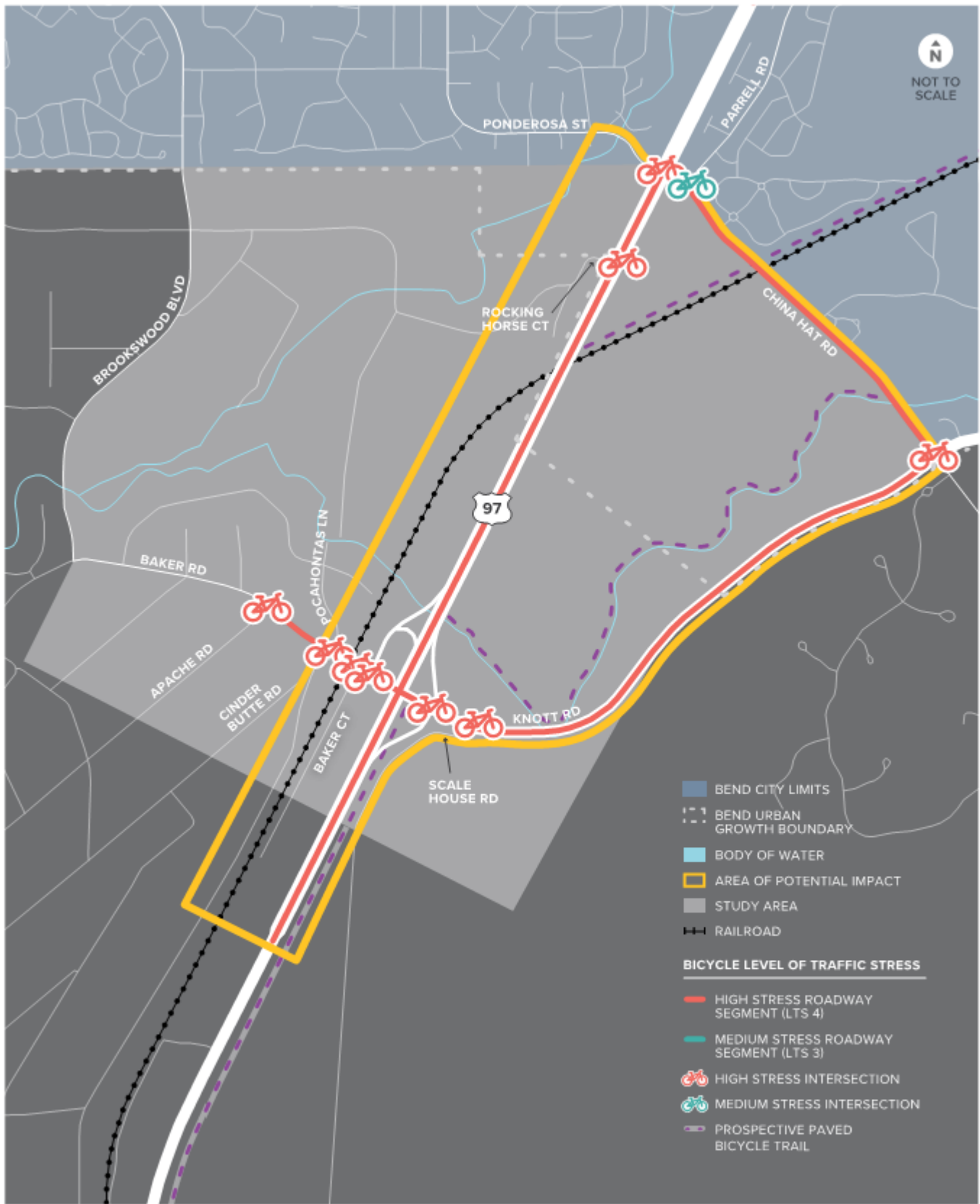
decisions, which is also the reason that many youth bike safety programs target this age level. Traffic speeds are low and there is no more than one lane in each direction. Intersections are easy to cross by children and adults. Typical locations include residential local streets and separated bike paths/cycle tracks.

- **LTS 2 (low):** Represents little traffic stress but requires more attention than young children can handle, so is suitable for teens and adults bicycling with adequate bike handling skills. Traffic speeds are slightly higher but speed differentials are still low and roadways can be up to three lanes wide in total for both directions. Intersections are not difficult to cross for most teenagers and adults. Typical locations include collector-level streets with bike lanes or a central business district.
- **LTS 3 (medium):** Represents moderate stress and is suitable for most observant adult bicycling. Traffic speeds are moderate but can be on roadways up to five lanes wide. Intersections are still perceived to be safe by most adults. Typical locations include low-speed arterials with bike lanes or moderate speed non-multilane roadways.
- **LTS 4 (high):** Represents high stress and is suitable only for experienced and skilled people on bicycles. Traffic speeds are moderate to high and can be on roadways from two to over five lanes wide. Intersections can be complex, wide, and or high volume/speed that can be perceived as unsafe by adults and are difficult to cross. Typical locations include high-speed or multilane roadways with narrow or no bike lanes.

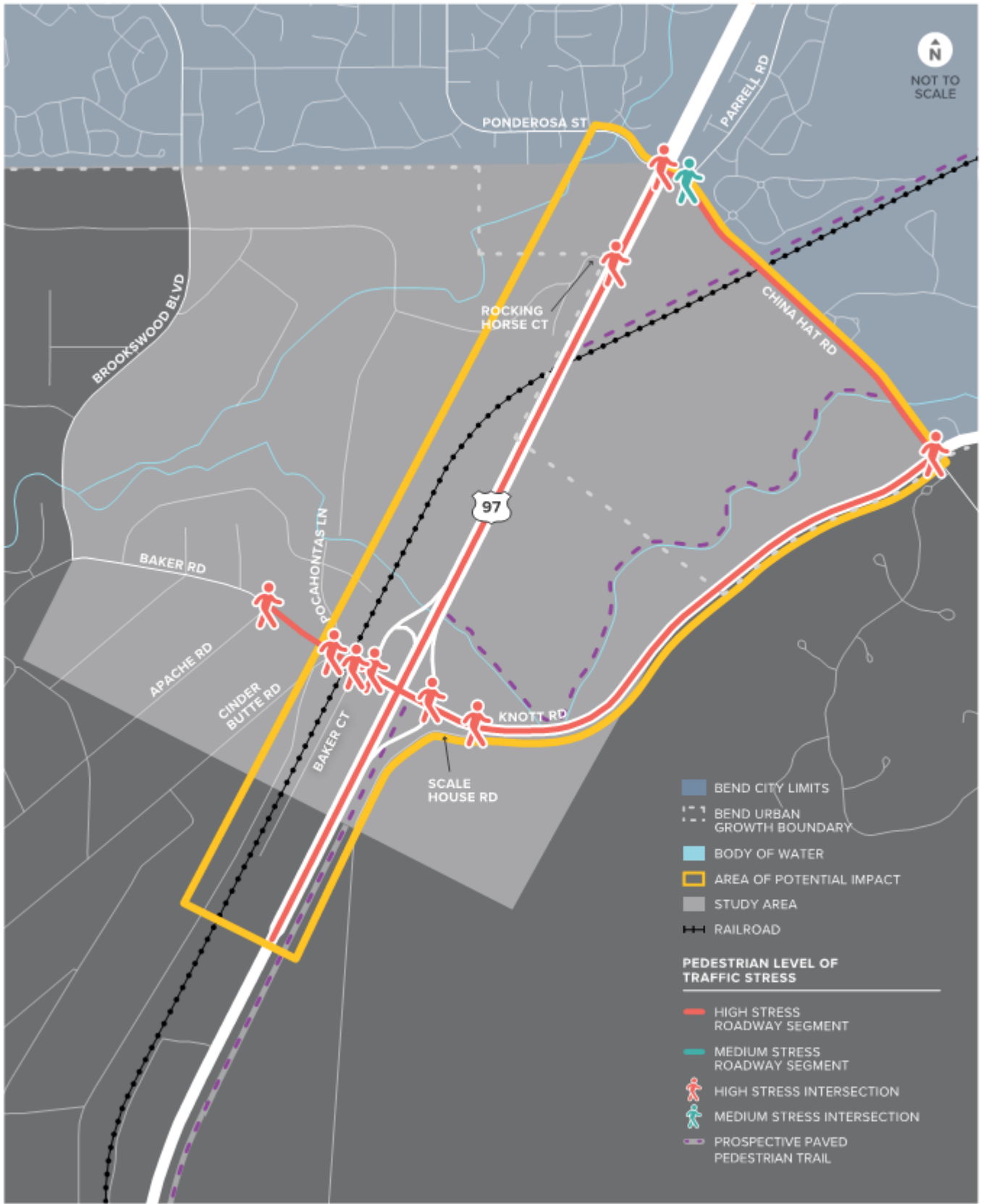
For this analysis, the mainline of the US 97 corridor, Baker Road, Knott Road, and China Hat Road within the study area were analyzed, as well as key crossing locations. The results of the LTS analysis for people walking and biking are illustrated in Figures 4 and 5. The speed of the adjacent traffic is a major factor in this analysis, therefore, corridors with lower posted speeds tend to have more favorable ratings, while corridors with higher posted speeds (over 35 mph) tend to have less favorable ratings. Along US 97 and Baker Road, the LTS experienced is high due to the lack of sidewalks and bicycle lanes.

While there are currently bike lanes and sidewalks along most of China Hat Road from US 97 to Knott Road, key gaps remain. Even where there are continuous sidewalk and bike lanes, the LTS experienced is still high because people walking and biking are adjacent to high-speed traffic (40 mph). Physical separation between people biking and motorized traffic would be required to make the corridor a more comfortable place to ride a bike while a buffered sidewalk (e.g., using a landscaped or solid surface buffer) would be required to make the corridor a more comfortable place for people to walk.

The LTS analyses also consider the difficulty of crossing streets (at intersections between collectors and arterials only). This considers the number of motor vehicle travel lanes, the speed of motorized traffic, and the average daily traffic volumes. As shown in Figures 4 and 5, all intersections have high levels of stress for people walking and biking with the exception of the intersection of China Hat Road and Parrell Road, which was found to have medium traffic stress due to the lower level of motor vehicle traffic volume entering the intersection.



**FIGURE 4: BICYCLE LEVEL OF TRAFFIC STRESS**



**FIGURE 5: PEDESTRIAN LEVEL OF TRAFFIC STRESS**

## PLANNED PEDESTRIAN AND BICYCLE FACILITIES

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There are future planned pedestrian and bicycle facilities in the API, as shown in the figures above. The Bend TSP identifies urban upgrades on Parrell Road, Knott Road and China Hat Road within the city limits to add sidewalks and bicycle lanes. The Arnold Irrigation Canal Trail is identified as a high-priority project in the Bend Parks and Recreation District (BPRD) Comprehensive Plan. The trail is planned to parallel the Arnold Canal starting on the east side of US 97, cutting through the “thumb” area and connecting to 15<sup>th</sup> Street. This trail would also tie into the City of Bend’s low-stress bicycle network. A rail with trail corridor is also identified in the BPRD Comprehensive Plan which parallels the railroad east of US 97 and continuing north of China Hat Road through Bend. In addition, ODOT and Deschutes National Forest Service are currently planning a paved multiuse path paralleling US 97 that connects the US 97/Baker Road interchange to Lava Lands Visitor Center. The exact alignment of the multiuse path is still to be determined.

## EXISTING TRANSIT SERVICES

Cascades East Transit (CET) is the primary transit provider in the region. Within the API, CET provides fixed route service between Bend and La Pine on Route 30 and operates Dial-A-Ride paratransit services for disabled, low-income and senior riders. Route 30 connects La Pine and southern Bend to the Hawthorne Transit Station in downtown Bend, with a transit stop located at River Woods Baptist Church on Cinder Butte Road, approximately 0.15 miles south of Baker Road. Annual ridership on Route 30 is 7,331 rides, which equates to a productivity of approximately 4.2 rides per hour<sup>11</sup>. Route 30 buses stop at the transit stop within the API three times during the weekday. However, up to eight stops per day could be accommodated if delays associated with commuter traffic could be reduced to help maintain the route schedule.

CET’s 2040 Transit Master Plan identifies possible long-term and short-term modifications to Route 30. Planned modifications include:

- Improved/more efficient stop for Deschutes River Woods (e.g., Riverwoods Country Store and/or near the future trailhead for the multiuse path to Lava Lands Visitor Center) or an alternative way to serve Deschutes River Woods
- Increasing frequency of weekday trips and providing mid-day and weekend service
- Re-routing through downtown Bend and to serve Sunriver, High Desert Museum and Lava Lands Visitor Center

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<sup>11</sup> Based on 2017 ridership data from the Cascade East Transit 2040 Transit Master Plan, September 2020.