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Cornelius Nuworsoo

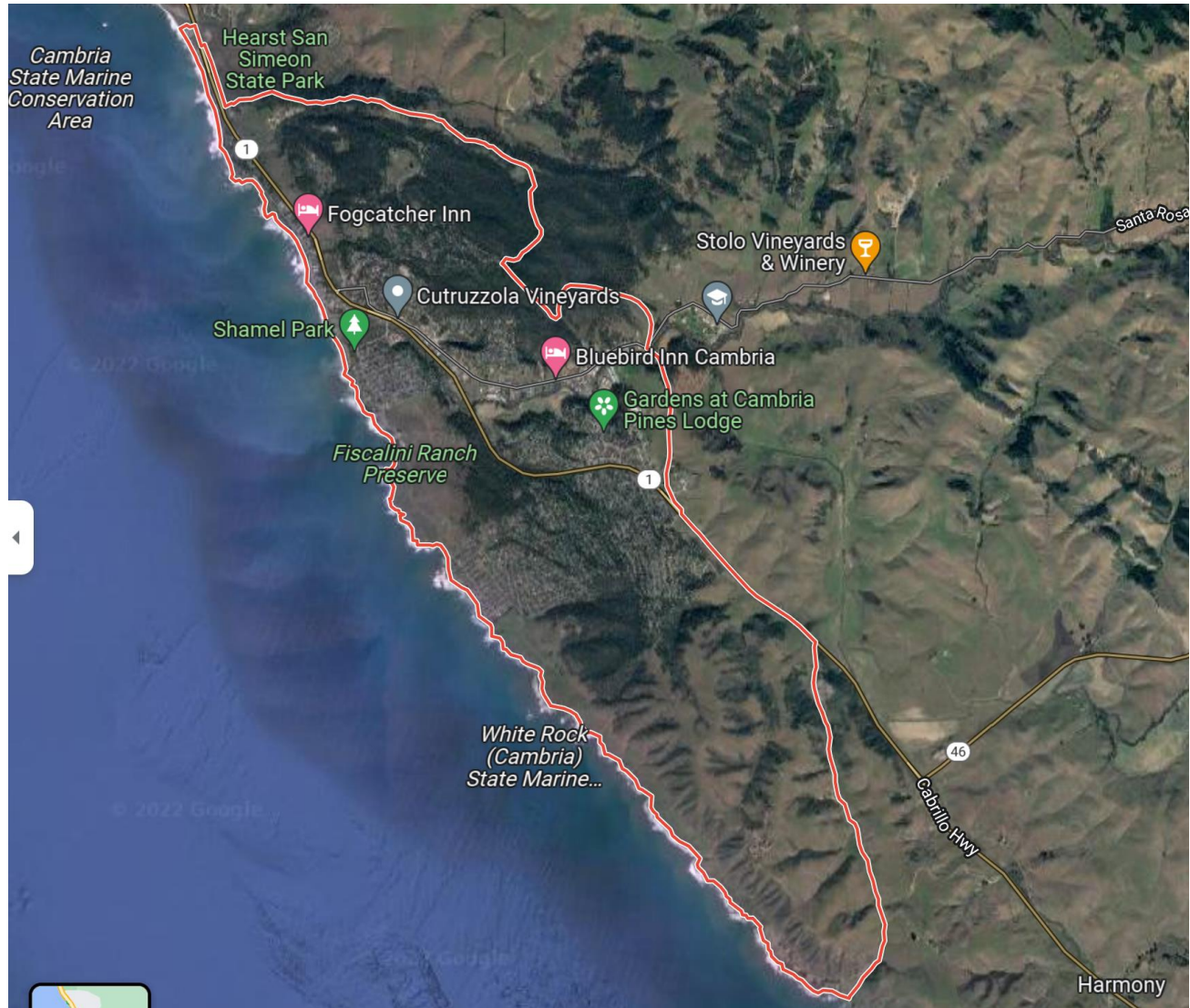
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Assessments for Cambria's Emergency Evacuation Planning



Sponsors:

California Department of Forestry and Fire Protection (CAL FIRE)
via
San Luis Obispo County Fire Safe Council, Inc.
for
Cambria Community Services District
and
Cambria Fire Safe Focus Group

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Executive Summary

This report covers the third study of fire evacuation in Cambria conducted by Dr. Cornelius Nuworsoo, professor of City and Regional Planning at Cal Poly San Luis Obispo. It is a follow-up to evacuation analyses conducted in 2019 for two parts of Cambria – areas south of Fiscalini Ranch and West of Highway 1, and areas east of Highway 1. With this study, Cambria now has analyses for all of Cambria under scenarios for different potential evacuation areas and alternate evacuation routes. Grant from CalFire funded the studies.

The new evacuation assessment, like the earlier ones, is designed to model the traffic movement that would occur during the rapid evacuation of large parts of Cambria during a major wildfire emergency. As with the other studies, it assumes that residential units and visitor lodgings are fully occupied, and that each household would evacuate with two vehicles, on average. All vehicle types in the traffic stream are converted to passenger car equivalents to account for buses, trailers, recreational vehicles, and commercial trucks in the traffic stream. Trucks count for three passenger cars and RVs for two.

It further assumes that through traffic on Highway 1 would be at normal levels before additional traffic is generated by evacuation from Cambria. This assumption adds the equivalent of 500 passenger cars on Highway 1 during the period of evacuation. Only southbound evacuation is modeled in all scenarios.

Note that this analysis, though assuming maximum *traffic*, is not able to predict the potential for other factors to impede evacuation, such as poor visibility due to smoke, nighttime conditions or fallen trees, stalled cars, and other potential obstructions.

In addition to scenarios based on using Highway 1 in its normal two-lane configuration (with one lane each southbound and northbound), this study also analyzes scenarios with alternate evacuation routes, as well as a second southbound lane added to Highway 1 from Ardath Drive to Highway 46.

One alternate route is the existing emergency access road across the Fiscalini Ranch Preserve from Seacrift Estates to Marine Terrace. The other is a possible emergency access route from Marine Terrace to Highway 1 south of Highway 46. Labeled the “Beach Road” in the study, this route would follow the existing four-wheel-drive track through the Norris Rancho Marino Preserve and other properties to an existing private road, Harmony Ranch Road, which serves several residences on the coast and joins Highway 1 south of the Highway 46 junction. It is important to note that, at this point, public agencies have not made arrangements with the property owners for use of the route, nor have they secured funding to improve it for passenger-car travel.

The study analyzes these five new scenarios:

1. Evacuate Park Hill and Moonstone Beach areas toward the south using *one* southbound lane on Highway 1.
2. Evacuate Cambria west of Highway 1 (Lodge Hill, Marine Terrace, Park Hill and Moonstone Beach) toward the south using *two* southbound lanes on Highway 1 from Ardath Drive to Highway 46.
3. Evacuate all neighborhoods toward the south using *two* southbound lanes on Highway 1 from Ardath Drive to Highway 46.
4. Evacuate Park Hill and Moonstone Beach toward the south across the existing emergency access route on the Fiscalini Ranch Preserve, continuing through Marine Terrace to the end of Ardath Drive, then on to Highway 1 via the Beach Road.
5. Evacuate both Lodge Hill and Marine Terrace toward the south using two routes: Highway 1 with *one* southbound lane, and the Beach Road to Highway 1 from the end of Ardath Drive in Marine Terrace.

In Scenario 5, the evacuation traffic would be divided along a line running northwest to southeast along Trenton Ave. and Norwich Ave. in lower Lodge Hill. Residents to west of that line would take the Beach Road route. Those to the east would evacuate via Highway 1.

In addition to these five scenarios, the study includes results (Scenarios 6 & 7) from the two previous studies, as well as modeling (Scenario 8) for all neighborhoods. Scenario 8 incorporates data from all three of the studies assuming the worst possible scenario of evacuating the entire Cambria community via a single southbound lane on Highway 1.

Among its key findings, the new study shows that an added southbound lane on Highway 1 from Ardath Drive to Highway 46 -- the “critical segment” on which all traffic would have to travel --would not have a significant impact on overall evacuation times.

For instance, the evacuation of all Cambria neighborhoods using two southbound lanes between Ardath and Highway 46 (Scenario 3) would take the same *total* time (6.8 hours) as full evacuation with one southbound lane only (Scenario 8). Travel time on that critical and final segment of Highway 1 would be half as long (albeit at nearly three times the hourly capacity of the highway in the southbound direction) in Scenario 3, but time spent reaching that final segment would negate the advantage of the two-lane option. Extending the two-lane option further north (see recommendations, below) would be at least a partial solution to this problem.

Also, using alternate routes – the Fiscalini Ranch emergency road and the proposed “Beach Road” from Marine Terrace to Highway 1 south of Highway 46 – would not offer a significant advantage over Highway 1 in evacuation of the Park Hill and Moonstone Beach neighborhoods. (See Scenarios 1 and 4 in Table 1).

On the other hand, the “Beach Road” option would substantially improve evacuation times from Marine Terrace and Lodge Hill (west of Highway 1) if traffic from that area were split between the Beach Road and Highway 1 (Scenario 5). Total evacuation time would be 1.8 hours, in contrast to over 4 hours as modeled in the 2019 analysis of this area.

The study’s results are summarized in Table 1 of the report, with additional information in Tables 2, 3 and 4.

In conclusion, the study recommends:

- Establishing the Beach Road as an additional exit route.
- Designating the Beach Road for use by those in the southwest area of Cambria (western Lodge Hill and Marine Terrace).
- Widening and strengthening shoulders on Highway 1 to enable an improvised second southbound exit lane during emergencies.
- Extending the improvised second southbound lane further north on Highway 1, ideally as far as the intersection with Cambria Pines Road.

Culled from the report of the Cambria Community Services District (CCSD) Board Ad Hoc Committee on Wildfire Evacuation

Karen Dean and Tom Gray

1.0 Background

Cambria Community Services District

Cambria is a historic town of approximately 6,000 residents (US Census, 2017) within a forest area of Monterey pines along California's Central Coast. The community is highly susceptible to wildfire hazard in addition to such other hazards as periodic flooding and the potential of a tsunami. In recognition of such hazards, state and local government agencies, including CAL FIRE, San Luis Obispo County, the Cambria Community Services District (CCSD), and the Cambria Community Healthcare District have cooperated in coordinating a plan for emergency evacuation of residents and visitors from the community and its nine identifiable neighborhoods. The community telephone directory shows such key elements of the plan as designated safe refuge areas and primary exit points out of town. However, there was no opportunity to evaluate the plan to answer the question that is potentially critical to its success – how long would it take to evacuate the community or individual neighborhoods of residents and visitors under specified emergency scenarios?

Study Purpose

This study is to evaluate multiple evacuation scenarios to support emergency evacuation planning for Cambria. In concept, the evacuation tests are to assess the potential performance of exit routes by estimating the minimum times needed to evacuate sets of neighborhoods that constitute varying emergency scenarios. This is to help the CCSD in confirming or modifying key evacuation routes, and in determining potential impacts if wildfire cuts off certain key routes. The evacuation analysis focused on routes usable for effective **departures** while allowing access for first responders. This report presents the composite of results from three of such analyses.

Task Order 3 Analyses

This task order is for new rounds of testing on potential evacuation scenarios, which assume the following:

- a. Evacuation of the rest of the neighborhoods north of those already covered under tasks 1 and 2 on areas along both sides of Highway 1 in Cambria. The additional neighborhoods for new testing include Park Hill and Moonstone Beach areas.
- b. An assortment of scenarios which includes combinations of scenarios under task orders 1 and 2.
- c. One-directional evacuation – all to the south via Highway 1 southbound with or without use of an auxiliary emergency-only route along the coast.
- d. Fire approaches from east or north of the community.

Evacuation Scenarios

This task order analyzed five new evacuation scenarios as follows:

1. Evacuate Park Hill and Moonstone Beach areas – all toward the south using *1 southbound lane* on Highway 1 (Hwy 1)
2. Evacuate Cambria west of Highway 1 (Lodge Hill, Marine Terrace, Park Hill and Moonstone Beach) toward the south using *2 southbound lanes on Highway 1 from Ardath Drive to Highway 46*
3. Evacuate all neighborhoods toward the south using *2 southbound lanes* on Hwy 1 Ardath Drive to Highway 46
4. Evacuate Park Hill and Moonstone Beach toward the south across the *existing emergency access route on the Fiscalini Ranch Preserve, continuing through Marine Terrace to the end of Ardath Drive, then on to Highway 1 via the Beach Road.*
5. Evacuate both Lodge Hill and Marine Terrace toward the south using two routes: *Highway 1 with one southbound lane, and a potential "Beach Road" to Highway 1 from the end of Ardath Drive in Marine Terrace.*

Approach

Evaluation of Cambria’s Evacuation scenarios involved compilation of relevant data, application of an evacuation modeling tool, and mapping of results. The analytical approach calculated the evacuation travel time across each roadway segment in the study network.

San Luis Obispo County provided the necessary geospatial datasets or layers online. The data include roadway network, building footprints, and addresses (with only images of assessor’s parcel information) that Geographic Information Systems (GIS) consolidated into data files for analysis. The roadway network data include the street identification number, street name, roadway segment length, the design speed, and the number of lanes on each roadway segment.

US Census data aided the determination of the average number of vehicles per dwelling unit, which produced the assumption that each household would evacuate with an average of two automobiles. Estimates of the number of vehicles from counts of parked vehicles during field observations or aerial images from Google Earth helped determine the potential number of vehicles to evacuate from commercial, industrial, public facilities, and other non-residential sites. Similarly, online information on the number of rooms in hotels helped in determining the potential number of hotel guests to evacuate.

Study Area Network & Evacuation Envelope

Figure 1 shows the division of the study area into three primary evacuation zones. Figure 2 is a map of the entire Cambria Census Designated Place (CDP) and immediate surroundings. This represents the overall evacuation envelope within which analyses of various scenarios took place. The bold lines depict primary evacuation routes.

Note that the map includes two roadways other than designated public streets or highways. One is an existing emergency access road across the Fiscalini Ranch Preserve from Park Hill Seaclift Estates to Marine Terrace. Another is a possible emergency access route (the “Beach Road”) from Marine Terrace along the coastline, joining Hwy 1 south of Hwy 46. Figure 3 presents a close-up of the built-up area of Cambria.

Figure 1: Cambria Evacuation Zones



Figure 2: Cambria Evacuation Envelope

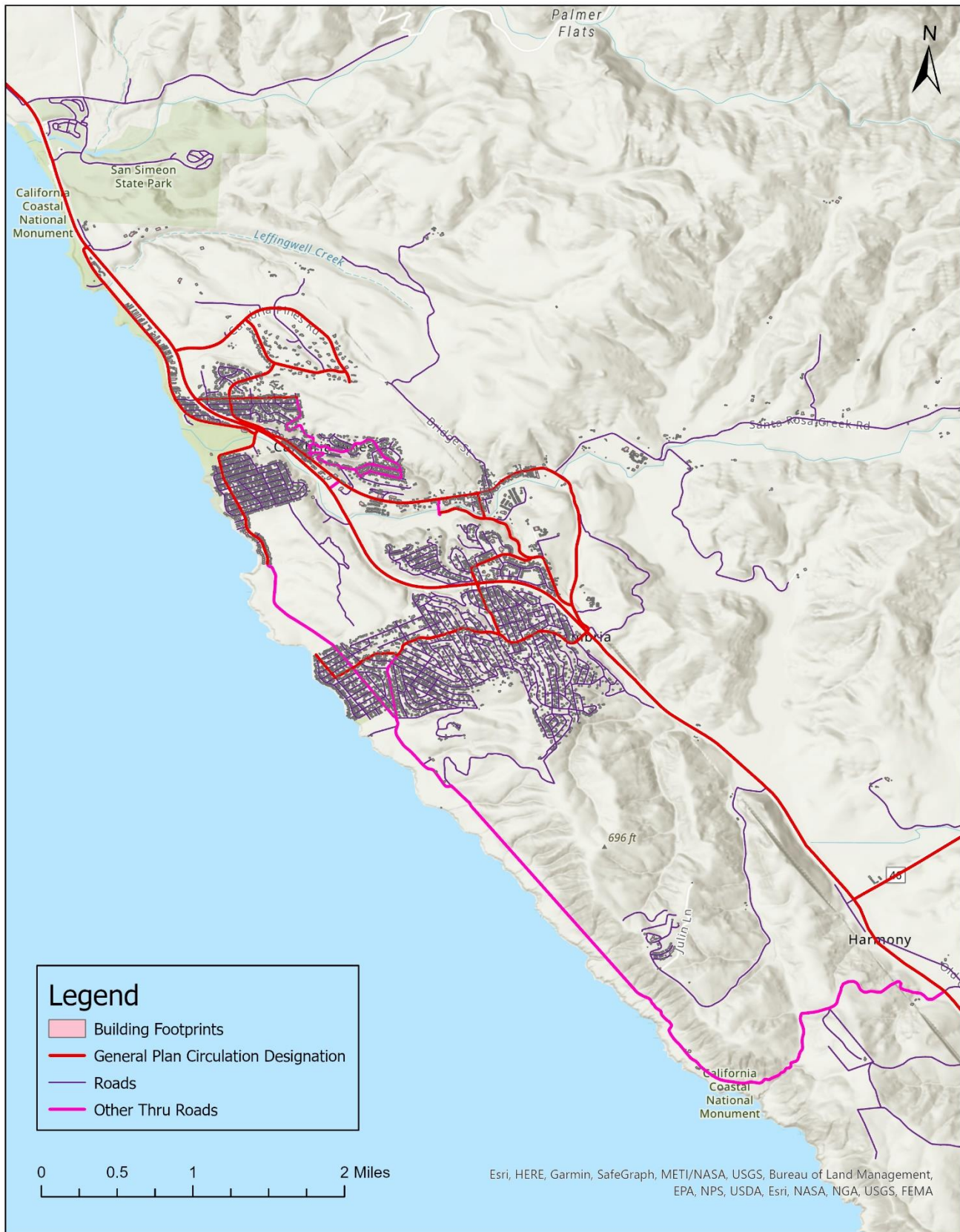
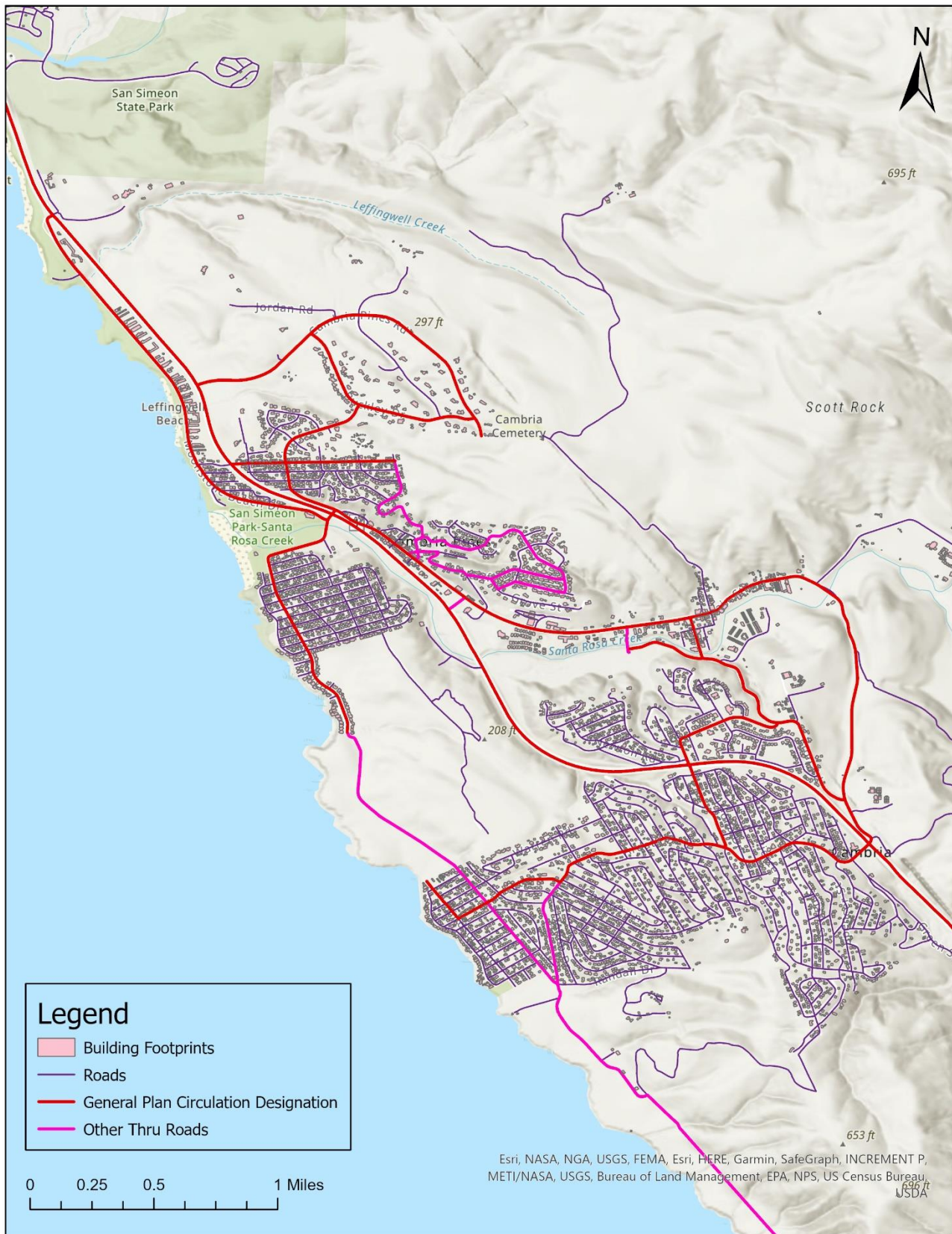


Figure 3: Close-up of Cambria Built-up Area



2.0 Evaluation Results

Table 1 combines results of evacuation analyses across all new and previous scenarios at a glance. Subsequent tables break down the results into small comparisons.

Table 1: Overall Analyses Results

	Evacuation Scenario	Evacuation Via Highway 1			Passenger Car Equivalent Volume	Evacuation Via Proposed Beach Road		
		Critical Roadway Segment-1 (CritSeg1)	Hours to clear CritSeg1 only	Hours to clear CritSeg1 including travel delay		Critical Roadway Segment-2 (CritSeg2)	Hours to clear CritSeg2 only	Hours to clear CritSeg2 including travel delay
1	Evacuate Park Hill and Moonstone Beach areas toward the south using 1 southbound lane on Highway 1.	Hwy 1 south of Ardath Dr	1.5	1.9	2490			
2	Evacuate Cambria west of Highway 1 (Lodge Hill, Marine Terrace, Park Hill and Moonstone Beach) toward the south using 2 southbound lanes on Highway 1 from Ardath Drive to Highway 46	Hwy 1 south of Ardath Dr	4.4	4.8	7445			
3	Evacuate all neighborhoods toward the south using 2 southbound lanes on Highway 1 from Ardath Drive to Highway 46.	Hwy 1 south of Ardath Dr	2.8	6.8	9660			
4	Evacuate Park Hill and Moonstone Beach toward the south across the emergency access route on Fiscalini Ranch Preserve , through Marine Terrace to the end of Ardath Drive , then to Highway 1 via the Beach Road .				1975	Beach Rd	1.2	1.9
5	Evacuate Lodge Hill and Marine Terrace toward the south using two routes: Highway 1 with one southbound lane, and the Beach Road to Highway 1 from the end of Ardath Drive in Marine Terrace.	Hwy 1 south of Ardath Dr	1.7	1.8	2825 Hwy 1 / 2330 Beach Rd	Beach Rd	1.4	1.8
6	Lodge Hill & Marine Terrace via Hwy 1 with 1 SB lane .	Hwy 1 south of Ardath Dr	2.9	4.7	4910			
7	East Cambria via Hwy 1 using 1 SB lane .	Hwy 1 south of Ardath Dr	1.8	2.8	3735			
8	All CDP (#3) using 1 SB lane on Hwy 1.	Hwy 1 south of Ardath Dr	5.7	6.8	9660			

Passenger Car Equivalent (PCE) Estimates

Table 2 illustrates how straight forward combination of individual results of scenarios could include duplications of estimated through volumes on Hwy 1. This is to caution readers. Under the newest 2019 to 2022 conditions, the total estimate of passenger car equivalent volumes across the entire Cambria Census Designated Place (CDP) is approximately 9660 vehicles. This estimate includes the following assumptions:

- All housing units are occupied at the time of evacuation and are evacuating with the average number of vehicles per household
- All hotels and schools are occupied at the time of evacuation and are evacuating with an average number of vehicles per room or number of buses for the size of the school.
- Adjustments for estimates of household vehicles, trailers, buses, recreation vehicles, and trucks into passenger car equivalent volumes.
- A through volume of 500 passenger car equivalent vehicles on Hwy 1 over the duration of the evacuation under the scenarios involving evacuation via Hwy 1. This is an estimate from the peak hourly volume of motorists passing through Cambria who would otherwise be “trapped” to continue travel on Highway 1 before word gets around to inform travelers to switch to alternate routes or the highway is closed in the north if necessary.

Table 2: Comparative Summary

Evacuation Scenario	Evacuation Via Highway 1			Passenger Car Equivalent Volume	Evacuation Via Proposed Beach Road		
	Critical Roadway Segment-1 (CritSeg1)	Hours to clear CritSeg1 only	Hours to clear CritSeg1 including travel delay		Critical Roadway Segment-2 (CritSeg2)	Hours to clear CritSeg2 only	Hours to clear CritSeg2 including travel delay
Sum of individual zones (with duplicate thru volume on 1-lane Hwy 1)	Hwy 1 south of Ardath Dr	6.1	9.4	11135			
Sum of individual zones (without duplicate thru volume on 1-lane Hwy 1)	Hwy 1 south of Ardath Dr	5.7	6.8	9660			
Sum of individual zones (without duplicate thru volume on 2-lane Hwy 1)	Hwy 1 south of Ardath Dr	2.8	6.8	9660			

Comparison of Individual Evacuation Zones

The Cambria evacuation envelope includes three primary evacuation zones as follows:

- Zone 1 – **Cambria South** includes Lodge Hill and Marine Terrace
- Zone 2 – **Cambria East** includes Leimert, Happy Hill, and Pine Knolls
- Zone 3 – **Cambria Northwest** includes Park Hill and Moonstone Beach

For the purposes of analysis, Zone 1 is divided into two zones under certain scenarios as follows:

- Zone 4 – **Cambria Southeast** includes eastern parts of Lodge Hill to evacuate toward Hwy 1 under a split-zone scenario
- Zone 5 – **Cambria Southwest** includes Marine Terrace and western parts of Lodge Hill to evacuate toward proposed Beach Road under a split-zone scenario

Table 3 shows that larger evacuation zones with expectedly larger passenger car equivalent volumes would require incrementally higher evacuation times. Most interestingly, delay along the routes to the critical roadway segment would increase proportionately more over the time it would take to traverse the critical roadway segment.

Table 3: Comparison of Individual Evacuation Zones

<i>Individual Evacuation Zones via Hwy 1 with 1 SB Lane</i>		Evacuation Via Highway 1			
Scenario Number	Evacuation Scenario	Critical Roadway Segment-1 (CritSeg1)	Hours to clear CritSeg1 only	Hours to clear CritSeg1 including travel delay	Passenger Car Equivalent Volume
1	Zone 3. Evacuate Park Hill and Moonstone Beach areas – all toward the south using 1 southbound lane on Hwy 1	Hwy 1 south of Ardath Dr	1.5	1.9	2490
7	Zone 2. East Cambria via Hwy 1 using 1 SB lane	Hwy 1 south of Ardath Dr	1.8	2.8	3735
6	Zone 1. Lodge Hill and Marine Terrace via Hwy 1 using 1 SB lane	Hwy 1 south of Ardath Dr	2.9	4.7	4910

Comparison of Modified Network Scenarios

Table 4 compares results of modified network scenarios. Note that scenario 8 is the absolute worst-case and no-change scenario, under which all zones would evacuate via the single southbound lane on Hwy 1. The scenario provides a baseline against which to compare the modified network scenarios. The table reveals the following:

- Use of the proposed Beach Rd (scenarios 4 and 5) shows promise in alleviating evacuation times, but these scenarios are only for partial segments of the Cambria CDP.
- Combining zones (scenarios 2, 3, and 8) would expectedly worsen evacuation conditions and times irrespective of network modifications.
- Improvising an additional southbound lane on Hwy 1 south of Ardath Drive can reduce the time to traverse the critical roadway segment (scenario 3) but does not significantly reduce overall delay in getting to the critical segment (scenarios 2 and 3).

Table 4: Comparison of Modified Network Scenarios

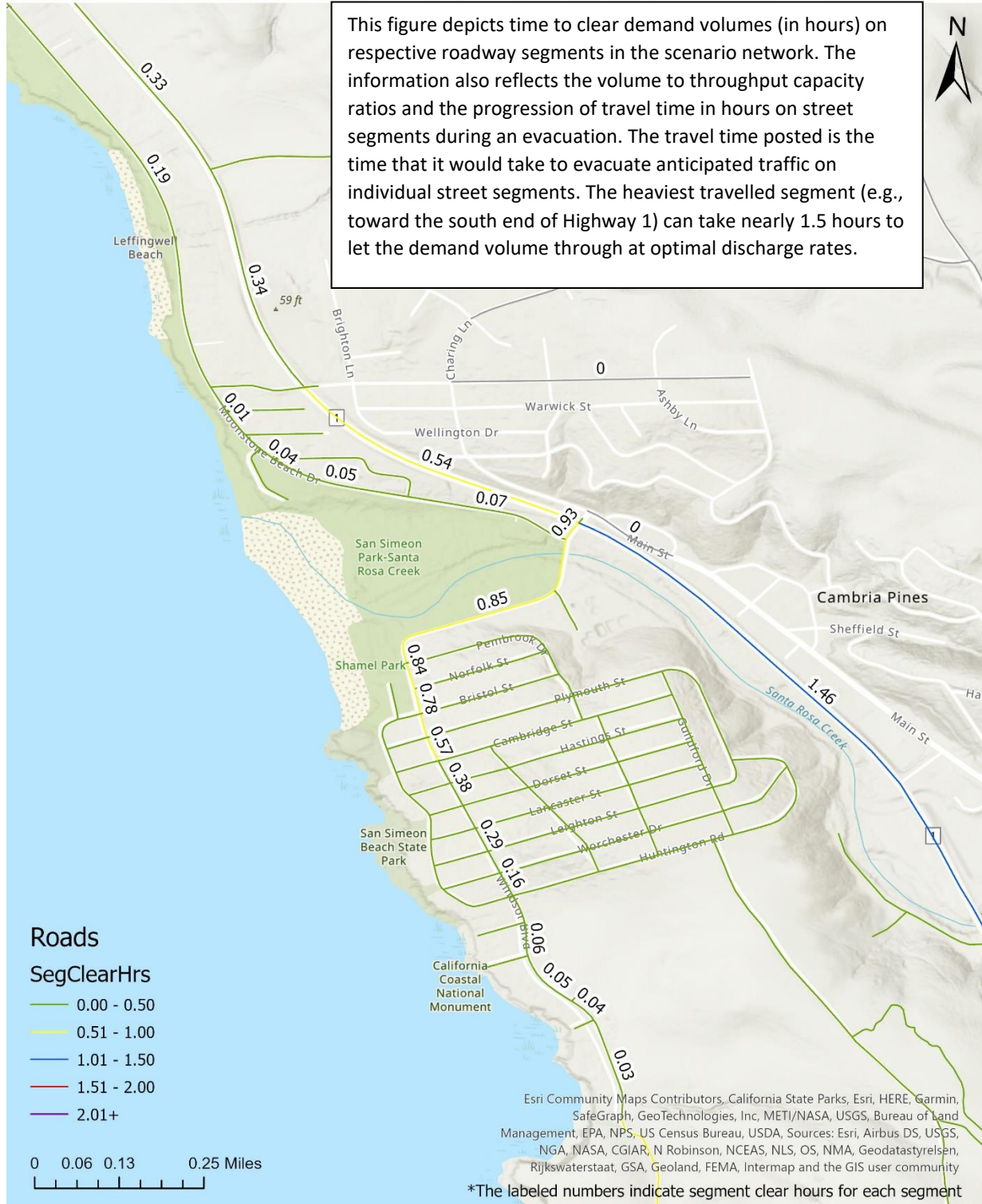
Scenario Number	Evacuation Scenario	Critical Roadway Segment-1 (CritSeg1)	Hours to clear CritSeg1 only	Hours to clear CritSeg1 including travel delay	Passenger Car Equivalent Volume
4	Evacuate Park Hill and Moonstone Beach toward the south across emergency access route on Fiscallini Ranch Preserve , through Marine Terrace to the end of Ardath Drive , then to Highway 1 via the Beach Road .	Beach Rd	1.2	1.9	1975
5.1	Evacuate Lodge Hill (including Marine Terrace) SPLIT toward the south using Highway 1 with 1 southbound lane	Hwy 1 south of Ardath Dr	1.7	1.8	2825
5.2	Evacuate Lodge Hill (including Marine Terrace) SPLIT toward the south from the end of Ardath Drive in Marine Terrace using 1 southbound lane on the Beach Road to Highway 1.	Beach Rd	1.4	1.8	2330
2	Evacuate Cambria west only toward the south with 2 southbound lanes on Hwy 1 from Ardath Drive to Highway 46 (includes Lodge Hill, Moonstone, Park Hill).	Hwy 1 south of Ardath Dr	4.4	4.8	7445
3	Evacuate all neighborhoods toward the south combined with 2 southbound lanes on Hwy 1 Ardath Drive to Highway 46.	Hwy 1 south of Ardath Dr	2.8	6.8	9660
8	All CDP (#3) using 1 SB lane on Hwy 1.	Hwy 1 south of Ardath Dr	5.7	6.8	9660

3.0 Evaluation Results by Scenario

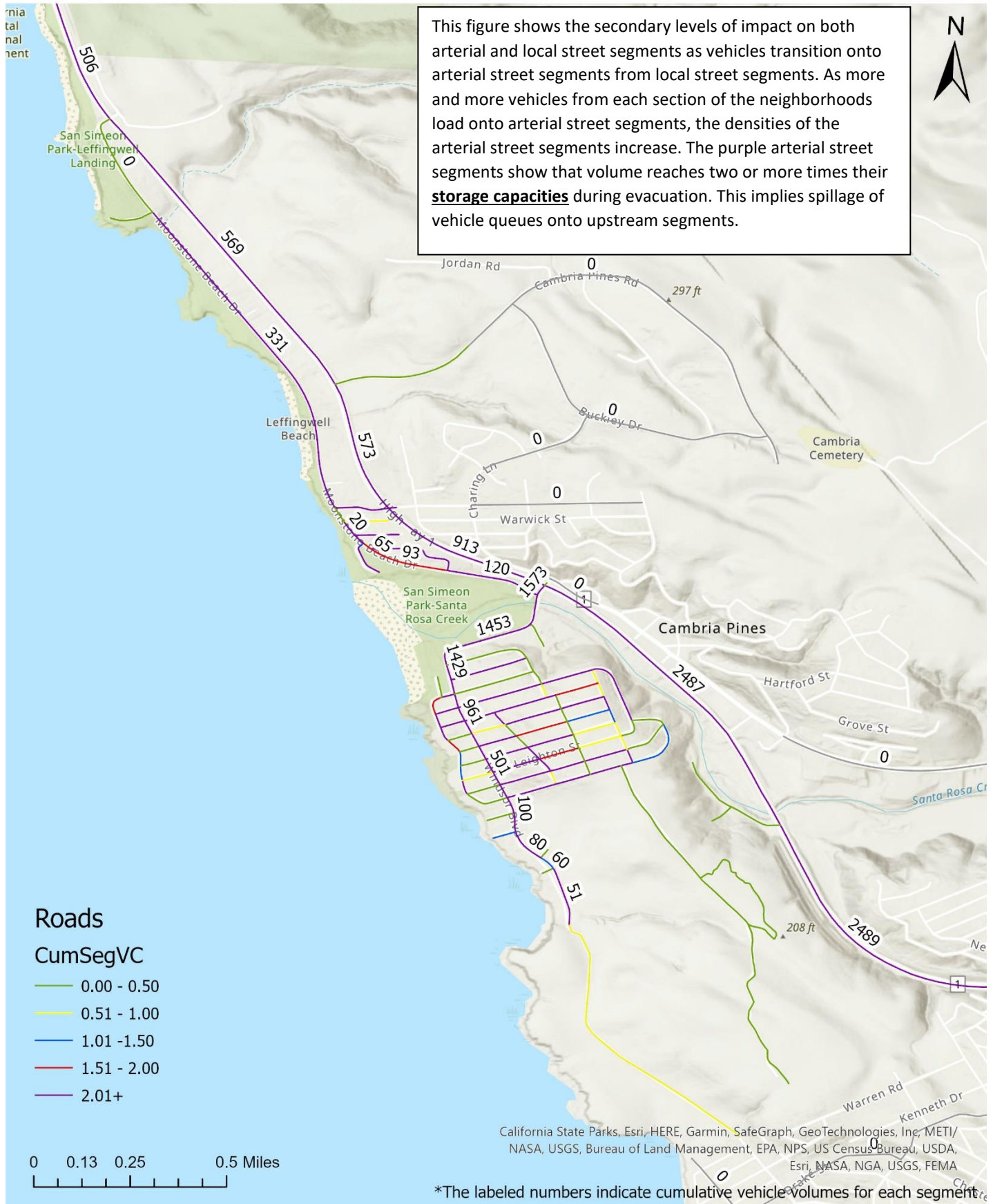
Scenario 1:

Evacuate Park Hill and Moonstone Beach areas – all toward the south using 1 southbound lane on Hwy 1

1_3.2 Hours For Segment to Clear - Cambria, CA



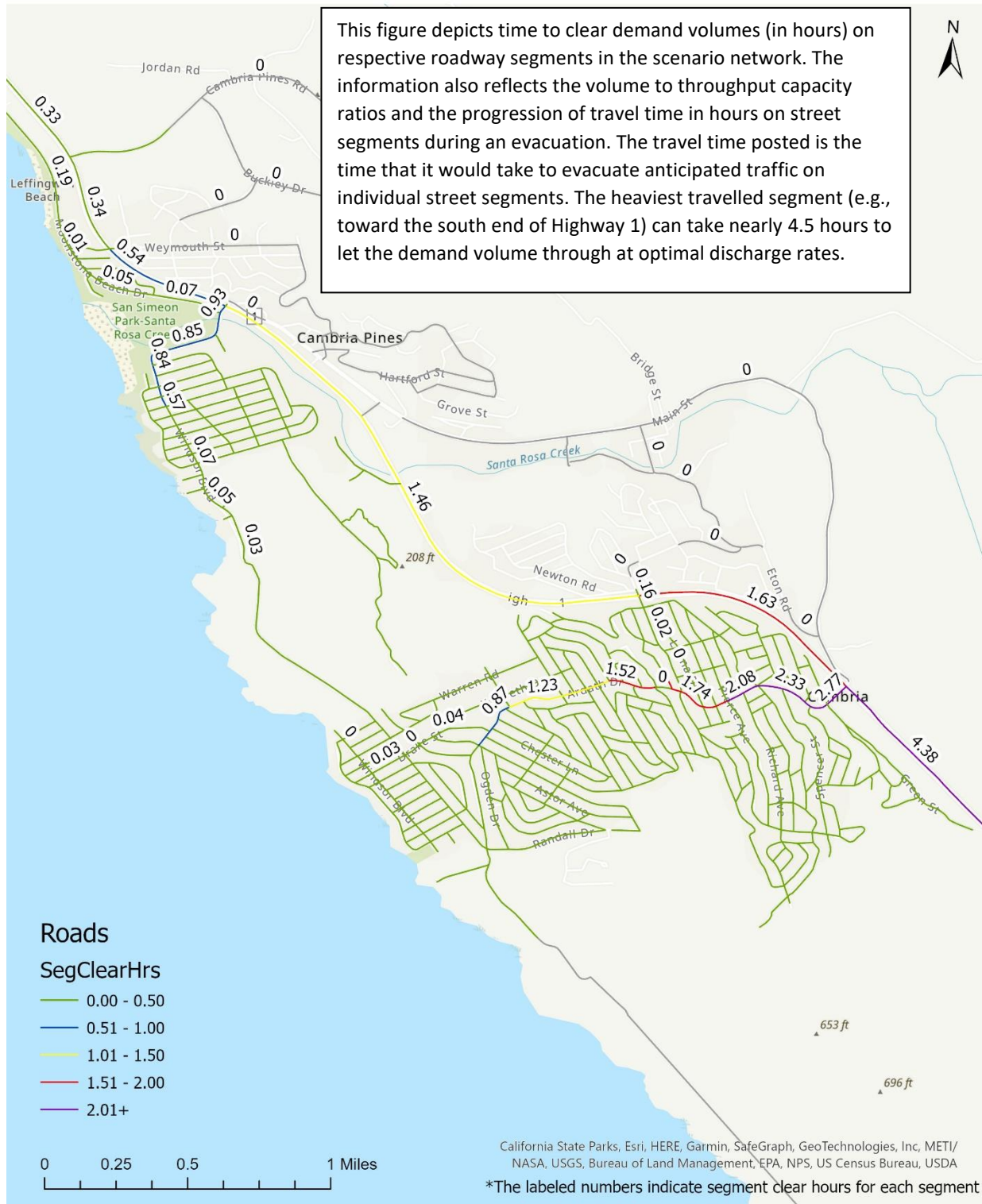
1_2.2 Cumulative Segment VC & Volumes - Cambria, CA



Scenario 2:

Evacuate Cambria west of Highway 1 (Lodge Hill, Marine Terrace, Park Hill and Moonstone Beach) toward the south using two southbound lanes on Highway 1 from Ardath Drive to Highway 46

2_3.2 Hours for Segment to Clear - Cambria, CA



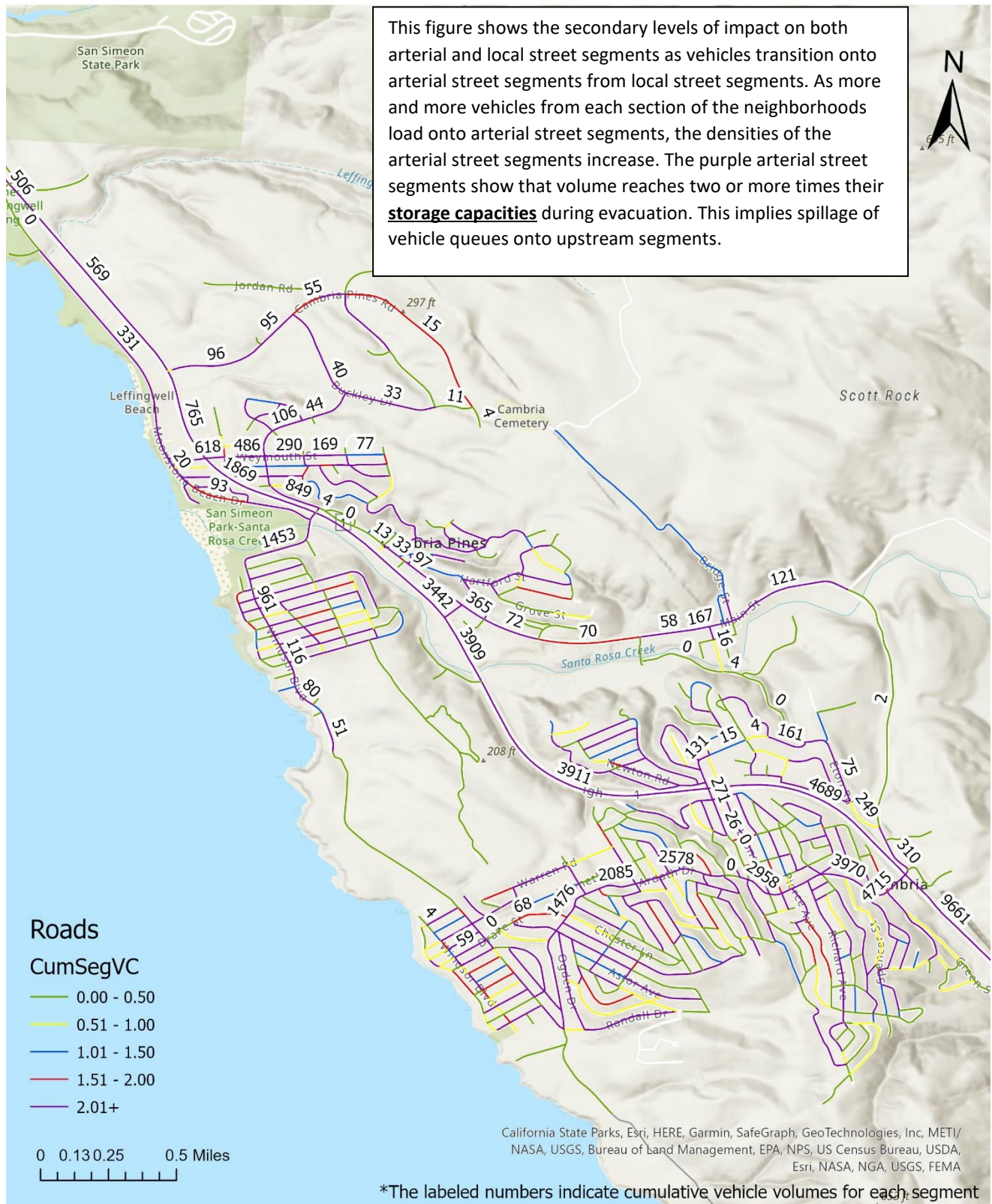
2_2.2 Cumulative Segment VC & Volumes - Cambria, CA



Scenario 3:

Evacuate all neighborhoods toward the south using 2 southbound lanes on Highway 1 from Ardath Drive to Highway 46

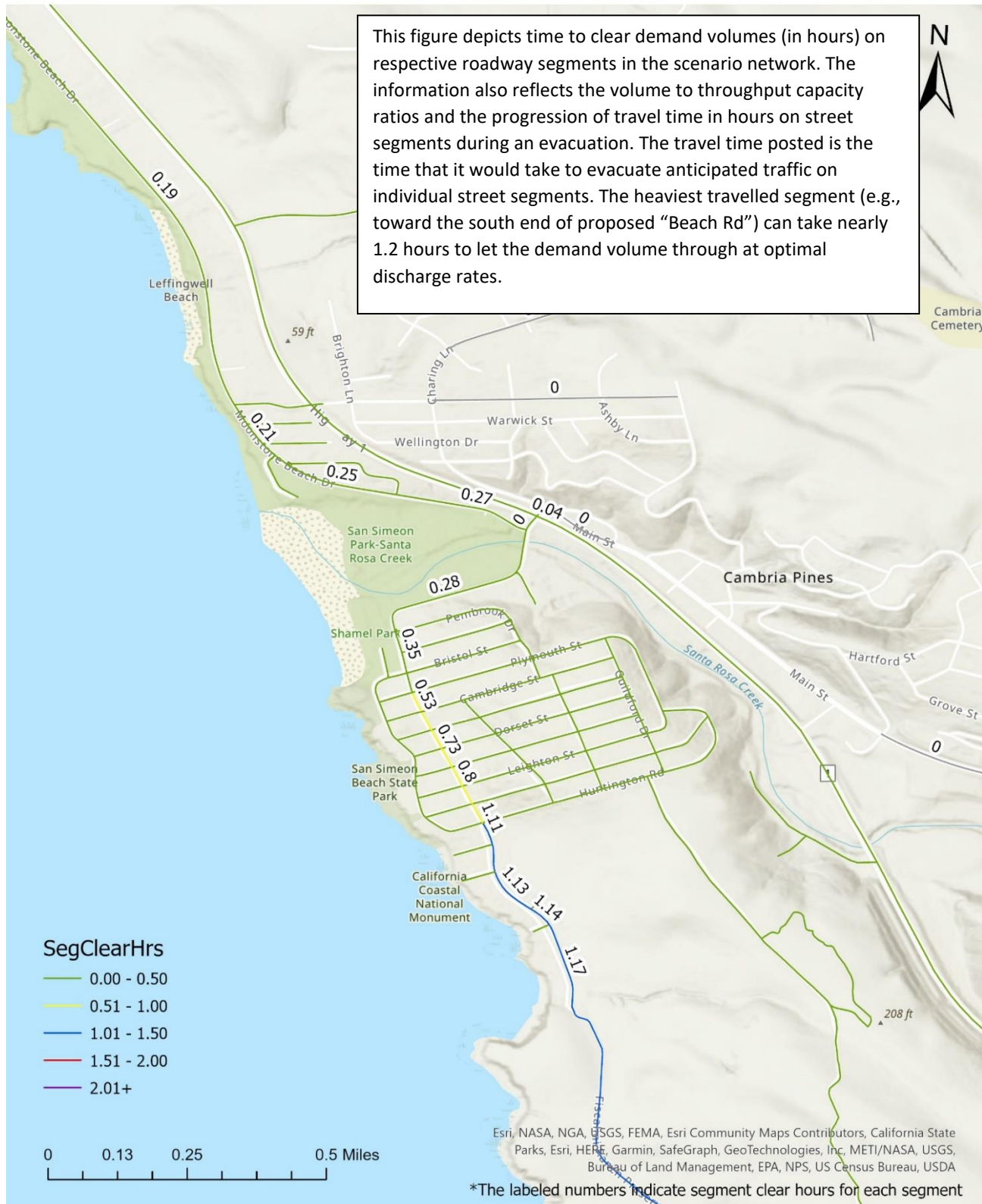
3_2.2 Cumulative Segment VC & Volumes - Cambria, CA



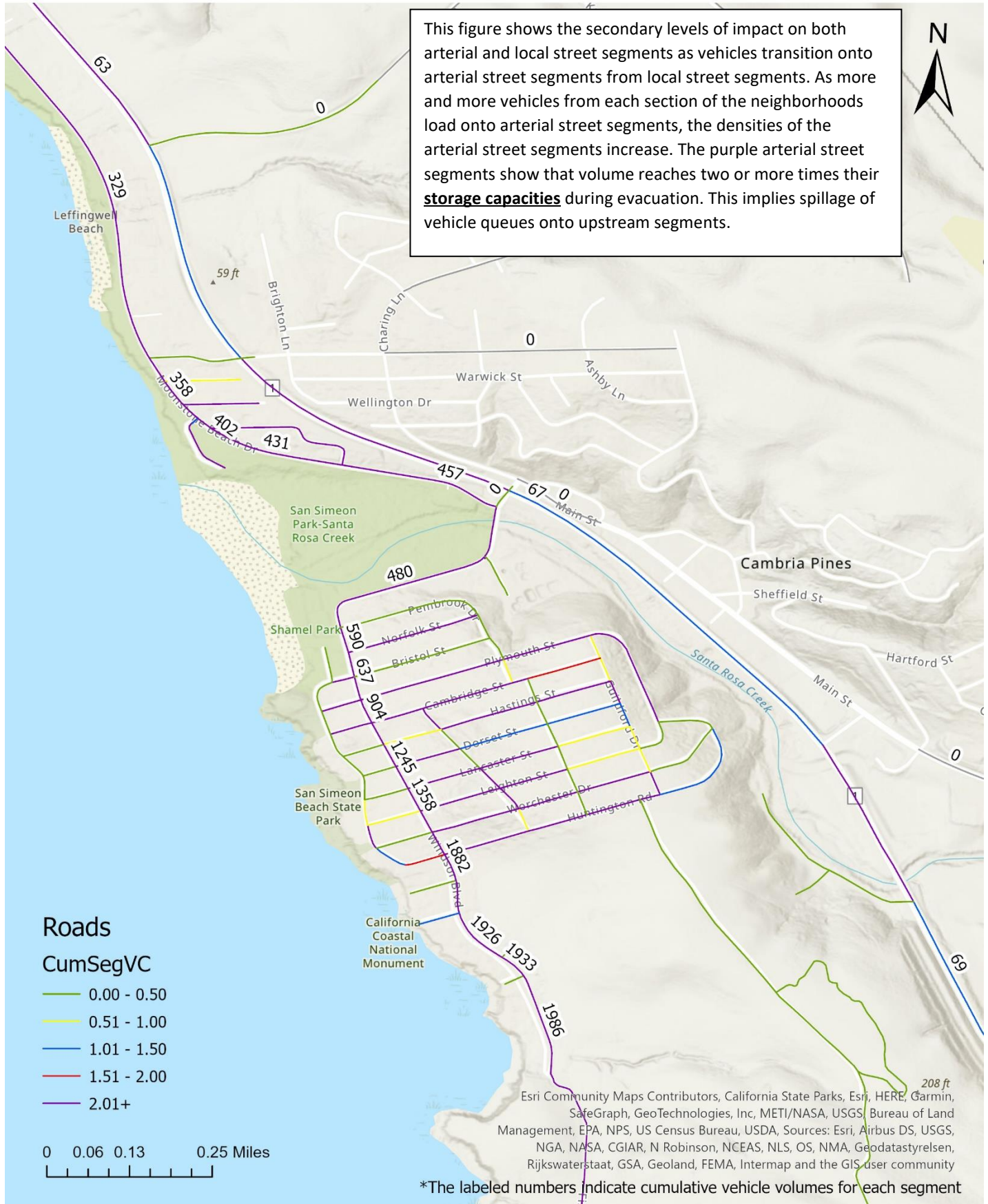
Scenario 4:

Evacuate Park Hill and Moonstone Beach toward the south across existing emergency access route on the Fiscalini Ranch Preserve, continuing through Marine Terrace to the end of Ardath Drive, then to Highway 1 via the Beach Road.

4_3.2 Hours for Segment to Clear - Cambria, CA



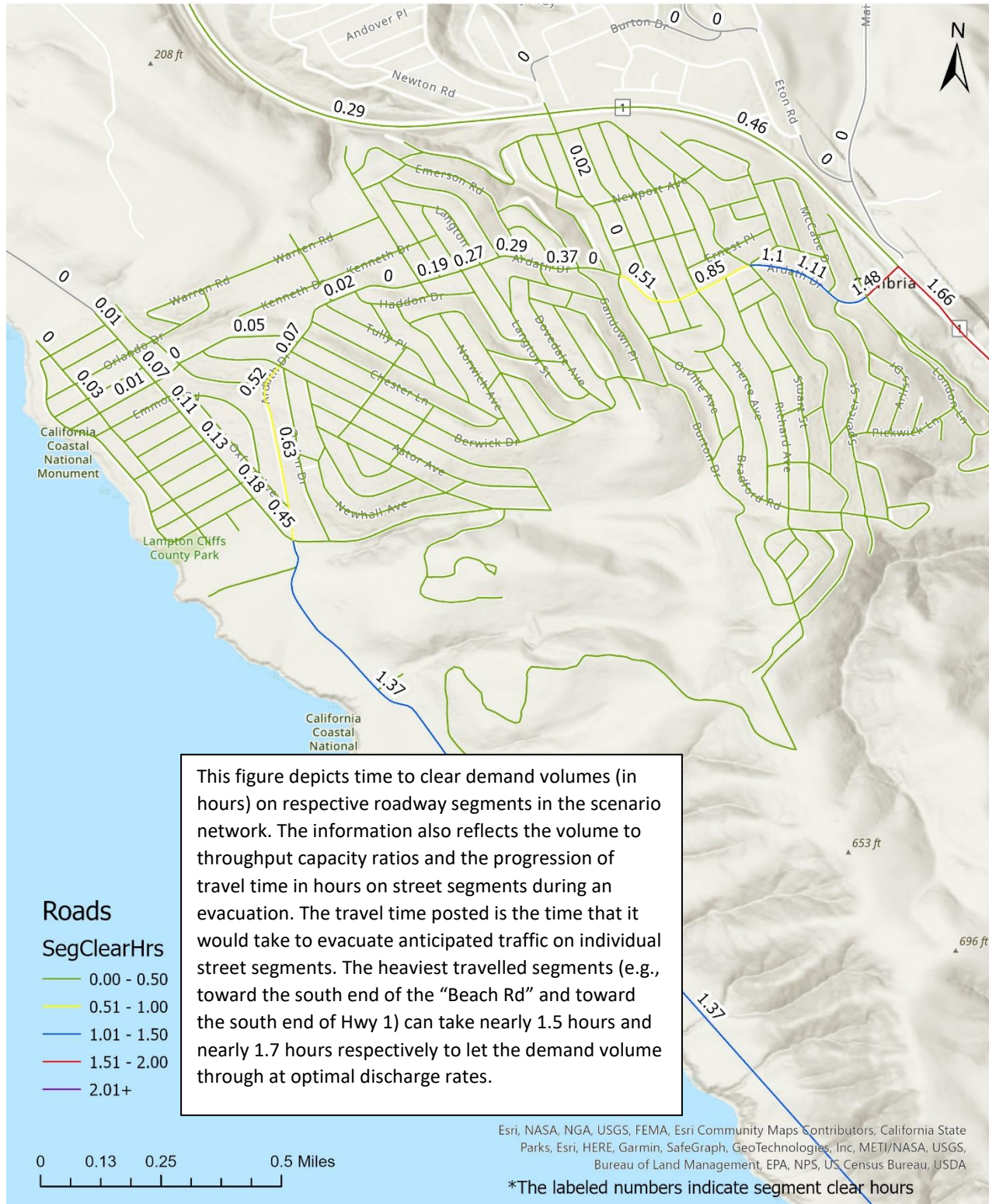
4_2.2 Cumulative Segment VC & Volume - Cambria, CA



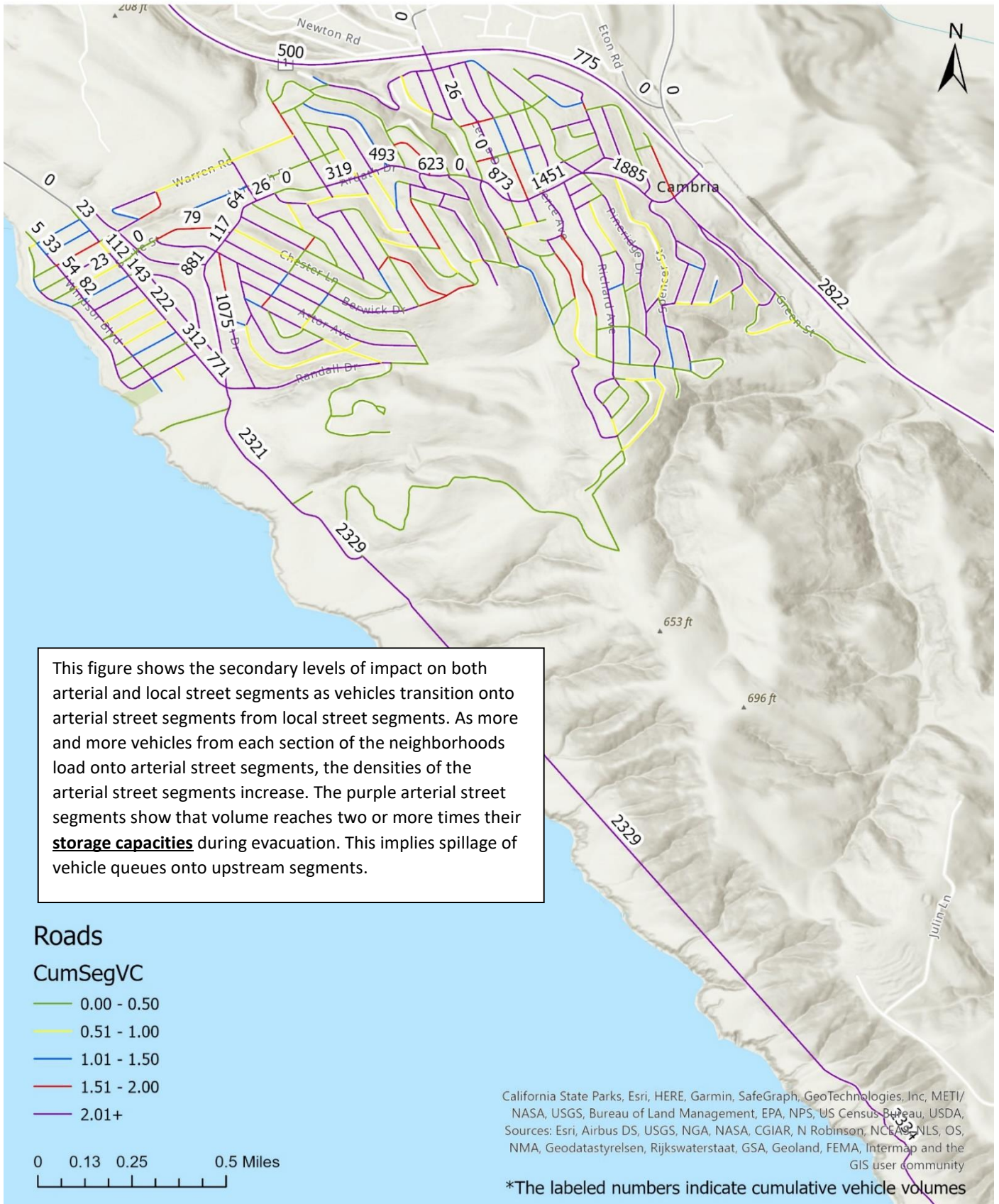
Scenario 5:

Evacuate both Lodge Hill and Marine Terrace toward the south using two routes: Highway 1 with one southbound lane; and the Beach Road from the end of Ardath Drive in Marine Terrace with one southbound lane to Highway 1

5_3.2 Hours for Segments to Clear - Cambria, CA



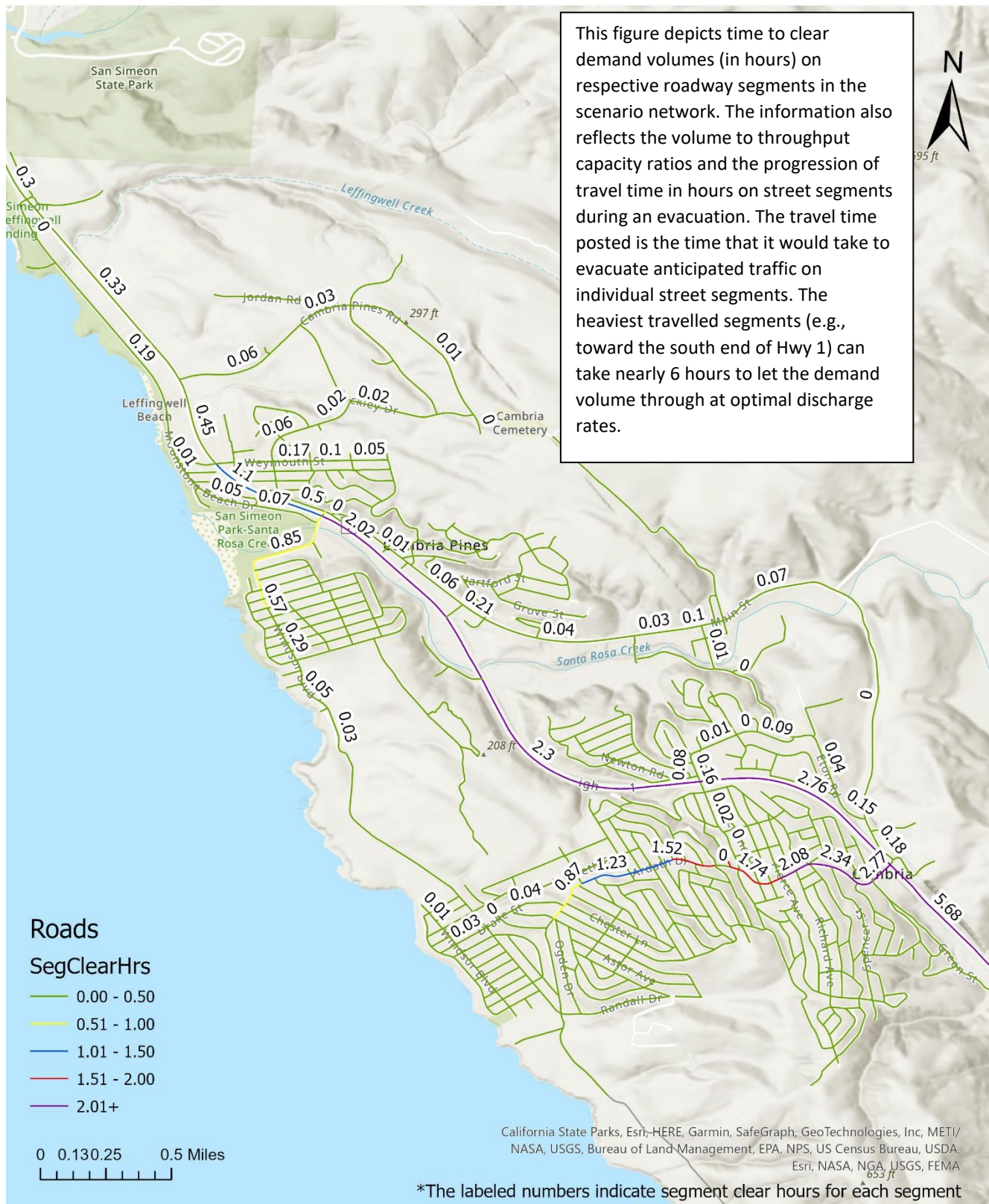
5_2.2 Cumulative Segment VC & Volumes - Cambria, CA



Scenario 8:

Evacuate entire Cambria CDP (scenario #3) using 1 southbound lane on Hwy 1

3_3.2 Hours for Segments to Clear - Cambria, CA



4.0 Concluding Observations

The following general observations provide key considerations to help in crafting Cambria's Emergency Evacuation Plan:

- The manageable evacuation scenarios are those likely to involve small zones or parts of evacuation zones. However, these types of evacuation scenarios are the least plausible given location, pattern of development, and vegetation in the study area.
- Evacuations of large zones or combinations of neighborhoods can create tenuous conditions which would pose danger to lives. While these are the more plausible scenarios under today's climate and related fire hazard conditions, Cambria has one evacuation route with one directional exit lane on Hwy 1 under baseline scenarios. This calls attention to an urgent need for more than one evacuation route and more than one lane for exit.
- Testing of improvised two lanes for exit on Hwy 1 or the addition of a secondary beach side road hold promise but again for small zones or parts of evacuation zones. Using two southbound lanes from south of Ardath Dr has the limitation of not ameliorating potential delay in the road network leading to the point of enabling the two lanes on Hwy 1, which happens to be the end of the route to safety as it were.
- The ideal evacuation condition should consider the following:
 - Completing a secondary exit route, for instance via the potential Beach Road
 - Designating the Beach Road for use by those in the southwest area of Cambria (including western Lodge Hill and Marine Terrace as they are in the closest proximity to that emergency access facility
 - Widening and strengthening shoulders on Hwy 1 to enable an improvised second southbound exit lane during emergencies.
 - Extending the improvised second southbound lane further north on Hwy 1 from its intersection with Cambria Pines Road to a point below the intersection of Hwy 1 and Hwy 46. Various scenarios indicate capacity troubles on Hwy 1 as far north as the segment south of its intersection with Cambria Pines Road.

Appendices

Questions and Answers on Volume 3: Draft Report (of 3-24-2022) on Summary of Analyses Results

Q1 – Hwy 1 vs Beach Road Travel Times

One of the people who read the report was skeptical of the time you determined for clearing of the Beach road “critical roadway segment” in the scenario (#5 on Table 1, and #s 5.1 and 5.2 on Table 4), where Lodge Hill and Marine Terrace evacuees are split between Highway 1 and the Beach road. He questioned how the clearance time for the Beach road could be about equal to that of Highway 1; he thought it would have to be much longer, given the limited capacity of the Beach road.

First, if on an ordinary day a motorist travels by Hwy 1 and another by Beach Road, yes, it is true that the motorist traveling via the Beach Road would take longer to get to the same destination as the first motorist. But **an evacuation event is not an ordinary event.**

Second, one-lane directional roads have similar capacities measured as ***maximum sustained throughput per unit of time***. A one-lane road with a faster design speed than another with a slower design speed would enable motorist A travel a given distance more quickly on the faster road than motorist B when both motorists are uninhibited by others along their respective routes. By the time you get to maximum throughput, the speed differential is small. And under **breakdown** (commonly termed **congested**) conditions, speed differential is out the window and the time to physical pass through takes over. That is why certain freeway segments (designed for 70 mph) can move more slowly under congested conditions than parallel surface streets, which have much lower design speeds of say 30 mph.

Q2 – Similarity in Clearance Times

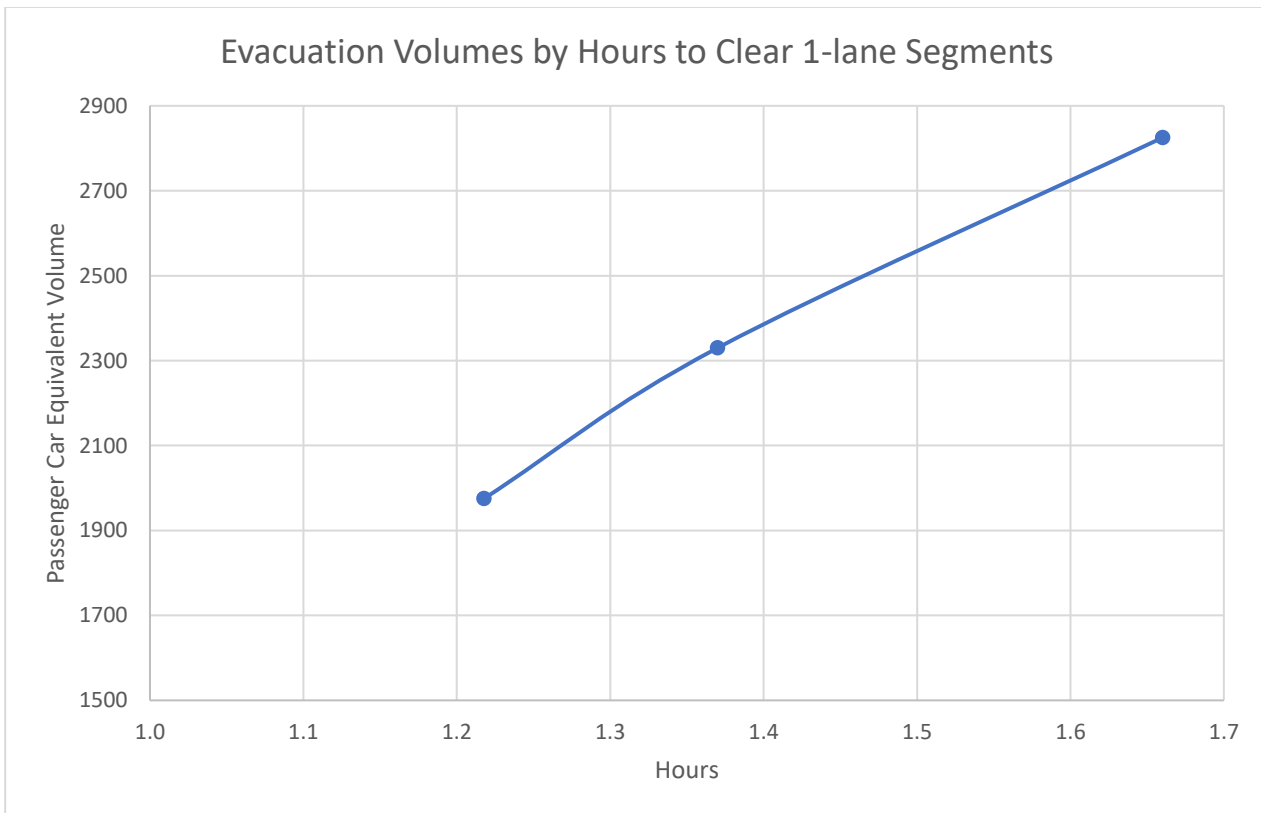
Is there a good way to explain why that clearance times come out roughly the same? I’ve assumed that the southbound traffic already on Highway 1, from north of Cambria) might have something to do with this. Is that correct?

The time to clear a segment is a function of the physical capacity for the geometric configuration of the roadway (1 lane, 2 lanes, etc.) and the volume passing through. On Hwy 1 therefore, the through volume only explains the slight increase in the clearance time compared to the Beach Road.

In splitting the traffic volumes between Hwy 1 and the Beach Road, the analysis considered the shortest travel time via the two route alternatives. Speed reduces as volumes increase until both routes get to capacity. At that point, the time to physically pass through the bottleneck takes over. Look at the comparison between Scenarios #5, which splits motorists from Lodge Hill/Marine Terrace among Hwy 1 and the Beach Road and Scenario #4, which carries motorists from Park Hill/Moonstone via the Beach Road. The following are notable from the comparison Table and chart:

- As volume goes up, time to clear a single-lane section goes up; [refer to first and second yellow columns and the chart].
- Including delay, time to clear a segment is similar indicating balancing of flows among the alternative routes; [refer to the blue column].
- The further the motorists travel to get to the critical segment, the higher the delay component; [look at the differences between the first yellow and the blue columns].

Scenario Number	Evacuation Scenario	Critical Roadway Segment-1 (CritSeg1)	Hours to clear CritSeg1 only	Hours to clear CritSeg1 including travel delay	Passenger Cars
4	Evacuate Park Hill and Moonstone Beach toward the south across the existing emergency access route on the Fiscalini Ranch Preserve, continuing through Marine Terrace to the end of Ardath Drive, then on to Highway 1 via the Beach Road.	Beach Rd	1.2	1.9	1975
5.2	Evacuate both Lodge Hill and Marine Terrace toward the south using two routes: The Beach Road to Highway 1 from the end of Ardath Drive in Marine Terrace.	Beach Rd	1.4	1.8	2330
5.1	Evacuate both Lodge Hill and Marine Terrace toward the south using two routes: Highway 1 with one southbound lane	Hwy 1 south of Ardath Dr	1.7	1.8	2825



Q3 – Effects of Max Speeds

A related question is how the maximum speeds assumed in the study affect the results. For instance, if the maximum on the Beach road were cut from 20 mph to 15 mph or even 10 mph, how much would that affect the evacuation time by that route? I'm assuming that this road and of course Highway 1 will be so packed that the cars will not move at anything like the maximum speed, but maybe I'm off base here.

You are right. In all the scenarios, the critical segments typically operate below 5 mph and sometimes get as low as 1.5 mph. So, the conditions under which evacuation is taking place, for all intents and purposes, remove the effects of the maximum design speeds.

Q4 – Definition of Scenario 4

Finally, in Scenario #4 on Table 4, is it correct to assume that the evacuation time for Park Hill across the Fiscalini Ranch and then to the Beach road assumes that Lodge Hill and Marine Terrace are not being evacuated at the same time?

As I understand it, Scenario #4 (Park Hill/Moonstone via Beach Road) is simply to enable a direct comparison with Scenario #1 (Park Hill/Moonstone via Hwy 1). When I compare both runs, the “total systemwide delay” is more than two times for motorists under Scenario #4 (14.2 hours) as under Scenario #1 (4.9 hours). That convinced me to conclude that it is better to assign those closest to the Beach Road (i.e., those in Lodge Hill/Marine Terrace) to use that option so as to reduce delay getting to the critical segment from far away neighborhoods. So, Scenario #4 as crafted is not necessarily because of an assumption but rather to shed light on the analyses.

Note that Scenario #2 combines motorists from Park Hill/Moonstone with those in Lodge Hill/Marine Terrace. Also note the following:

- *Scenario #4 shows poor results when evacuating Park Hill/Moonstone via the Beach Road;*
- *Whereas Scenario #2 shows much poorer results when we combined Park Hill/Moonstone with Lodge Hill/Marine Terrace via 2 southbound lanes on Hwy.*
- *Another scenario is to run Scenario #2 but split the volumes among the Beach Road and Hwy 1 as in Scenario #5. Results are likely to be worse than those from Scenario #5 because of the higher volumes.*

Anecdote: Wildfire in Butte County, California

2018 Camp Fire in Paradise

The 2018 Camp Fire in Paradise, California is known as the deadliest and most destructive wildfire in California (Baldassari, 2018). Much of the loss was due to issues with the evacuation routes. The emergency alerts system also had key issues, as emergency officers and city officials did not notify four areas that were at risk and residents did not have enough time to evacuate. The evacuation routes were extremely congested and led to cars being abandoned as people evacuated on foot. Some people were trapped inside their vehicles, which caused at least four deaths (CBS SF, 2018) while some walkers could not travel fast enough out of harm's way. The Camp Fire led to a total loss of 84 lives and many injuries (Lewin, 2019).

A decade earlier, a Butte County Grand Jury report on fires that occurred in 2008, stated that the majority of the roads in Paradise had serious capacity limitations, and there were no ideal evacuation routes due to lack of compliance with fire regulations and significant constraints due to road conditions and structure. It took **three hours to travel eleven miles** from Paradise to Highway 70 (Butte County, 2009). The appendix includes additional excerpts from the Grand Jury report. The following assessment is particularly notable from that report:

There are four available southbound evacuation routes from Paradise: Skyway, Neal, Clark, and Pentz Roads. There are no adequate northbound evacuation routes. During the Humboldt Fire Incident, Skyway, Neal, and Clark Roads were closed to all civilian traffic. This left only Pentz Road available for evacuation, with only one southbound lane being used. It took three hours to travel eleven miles from Paradise to Highway 70. Pentz Road has limited emergency pull off areas for temporarily parking disabled vehicles.

Summary from 2009 Butte County Grand Jury Report

SUMMARY

The wildfires in the foothills of Butte County during the summer of 2008 were the most severe in recent history. Some of the grim statistics were:

- 60,000 acres burned
- 200 homes lost or heavily damaged
- One fire related death reported
- Injuries to fire personnel

By some miracle, the Humboldt Fire Incident did not cross the West Branch of the Feather River. Had this occurred, property damage could have been huge and thousands of lives could have been threatened in Paradise and the Upper Ridge.

Three of four major evacuation routes south from Paradise, Skyway, Neal and Clark Roads, were closed due to heavy smoke and fire. The fourth evacuation route, Pentz Road, was jammed with single-lane traffic, making the trip from Paradise to Highway 70 nearly three hours long.

Forest Route 171 north of Magalia, currently does not qualify as a viable evacuation route. This route includes ten miles of dirt road between Inskip and Butte Meadows. Even if upgraded as planned, this route will not be classified as an evacuation route. Additional evacuation routes are necessary. The Grand Jury recommends that affected communities come together to form a Benefit Assessment District to address their safety needs.

While this report focused on the areas affected by the 2008 wildfires, the Grand Jury is equally concerned about other communities in the Butte County foothill areas, including Cohasset, Berry Creek, Forbestown, Forest Ranch, and others.

Evacuation Routes from Paradise

Paradise currently has approximately 30,000 residents. There are four available southbound evacuation routes from Paradise, Skyway, Neal, Clark and Pentz Roads. There are no adequate northbound evacuation routes.

During the Humboldt Fire Incident, Skyway, Neal and Clark Roads were closed to all civilian traffic. This left only Pentz Road available for evacuation, with only one southbound lane being used. It took three hours to travel eleven miles from Paradise to Highway 70. Pentz Road has limited emergency pull off areas for temporarily parking disabled vehicles.

Skyway below Paradise is an existing high-capacity road. If the fire fuel were removed in a few areas adjacent to the road between Paradise and Chico, and the grassed median and shoulders were disked in the late spring each year, the availability of this high-capacity evacuation route would be improved.

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