Electrification of the BNSF Cajon Subdivision

Brian Yanity
January 19, 2025

Top: BNSF and UP trains on Sullivan's Curve, viewed from Cleghorn Road, Interstate 15 Exit 129 (at CP Cajon, MP 62.8), behind (2) 500 kV Southern California Edison (SCE) transmission lines, San Gabriel Mountains and Mount San Antonio in the background (November 16, 2024 photo)

Bottom: BNSF intermodal trains just north of State Route 138. In the background are (2) 287 kV Los Angeles Department of Water and Power (LADWP) transmission lines, the Mormon Rocks, Mount San Antonio and the San Gabriel Mountains (November 5, 2024 photo)

The BNSF Railway's Cajon Subdivision goes 81.4 miles from Barstow to San Bernardino, with 26 road bridges (including Yucca Ave. just east of the Barstow yard)[1] and one railroad overpass. The Cajon Pass between San Bernardino and Victorville is a prime opportunity for freight rail electrification. About 120 route miles and 330 track miles total is described in this report, including short portions of other subdivisions connecting to the Cajon Subdivision. The steep grade between San Bernardino (1,053') to Cajon Pass (3,777')[2] climbs over 2,700' in net elevation over a route length of less than 26 miles. The ruling grade is 2.2%. Such a grade is well-suited to an electric locomotive's many advantages in mountainous terrain, including better adhesion, greater power at low speeds, and regenerative braking downhill[3].

The BNSF Cajon Subdivision, part of the 'Southern Transcon' between Los Angeles and Chicago, is one of the busiest segments of freight railroad in North America. The 2023 Anacostia/Pacific Harbor Lines short haul rail study[4] gave a 2022 estimate that the BNSF Cajon Subdivision had an average of 66 freight trains per day, and 2 passenger trains (the Amtrak *Southwest Chief*). The 'practical capacity' of 99 trains per day was estimated based on the segment's current infrastructure, which includes long sections of double-track. The steep grades, combined with the freight train frequencies, means that Cajon Pass is responsible for a significant portion of all diesel fuel consumed by locomotives in Southern California.

BNSF Railway intends to grow traffic on the Cajon Subdivision and the rest of the Southern Transcon to Chicago, on which the railroad been making capacity investments[5]. BNSF's massive Barstow International Gateway (BIG) is under development on the west side of Barstow[6]. This proposed 'inland port' development is heavily tied to the Ports of LA/Long Beach freight traffic, utilizing the concept of "short-haul freight shuttle" trains between the Barstow area and the ports. The business model depends on the contents of international 40' containers to/from the ports being transloaded to 53' containers going to the rest of the USA. Port of LA/Long Beach-BIG short-haul rail would be a prime pilot application for electric freight trains.

The Union Pacific (UP) Railroad's railyard in Yermo is about 13 rail miles east of the BNSF Barstow yard. An agricultural transload service operated at the UP Yermo yard between 2012 and 2017. UP's special short-haul trains shuttled empty containers from the Ports of Los Angeles and Long Beach to Yermo. Bulk agricultural products from the Midwest arrived in hopper cars, and were transloaded at Yermo into 40' ocean containers for export. UP then carried the loaded containers to on-dock railyards at the ports

---

[1] https://goo.gl/maps/fT0BF

[2] It should be noted that Cajon Pass is designated by the railroad as "Summit" (MP 55.9), yet is separate from the nearby Cajon Summit traversed by Interstate 15.

[3] G.T. Fisher, "50 kV through the Rockies", *Railway Gazette International*, October 1971, pp. 380-383;
John G. Allen and Gregory L. Newmark, "The Life and Death of North American Rail Freight Electrification", *Transportation Research Record*, Vol. 2627, Issue 10, December 2018, pp 166-175: https://trid.trb.org/view/1493092 .

[4] https://www.anacostia.com/wp-content/uploads/2024/01/Anacostia-Feasibility-and-Benefits-of-Intermodal-Service-in-Short-Haul-Markets-Report-final-rev.pdf

[5] https://www.bnsf.com/news-media/railtalk/service/emporia-sub.html

[6] https://bnsfcalifornia.com/barstow-international-gateway-project/

for export to Asia. The Ports of LA/Long Beach-Yermo UP short haul rail service ran on the BNSF tracks between the Inland Empire and Dagget Junction via Barstow, as do currently about a dozen daily long-haul UP trains to Las Vegas and Salt Lake City. Yermo is often a crew change point for these UP long-haul trains. This is thanks to a shared-use agreement with BNSF's predecessor Santa Fe dating back to 1905. If such a Yermo-ports short-haul service were to be restarted, these trains could be run electric via BNSF Cajon Subdivision. The 1992 regional rail electrification study by the Southern California Regional Rail Authority proposed the Ports of LA/Long Beach freight corridor as one of the highest-priority "candidate routes" for electrification[7].

The current level of freight traffic on the BNSF Cajon Subdivision is well above what rail industry experts have calculated as a minimum level of freight rail traffic that economically justifies electrification. As described in this 2015 blog post by Paul Druce[8]:

> "[with social, environmental and economic benefits] combined, we see that it takes 21-29 bidirectional frequencies for benefits to match the costs of railroad electrification [for passenger rail]. In California, this would indicate that it would be justified to electrify Caltrain between San Jose and San Francisco. With increased service, electrification would also be justified on Metrolink's San Bernardino Line as well as LOSSAN between Burbank and Irvine (Metrolink and Pacific Surfliner) and Oceanside and San Diego (Coaster and Pacific Surfliner).
>
> For freight trains, the decreased fuel costs play a much larger role, and more importantly, the only one that the board of directors actually care about, resulting in break even at fewer frequencies. From the 2014 STB R-1 reports, we see that, for the Class I railroads, there is an average consumption of 6.92 gallons per train-mile; a comparable figure for electric traction would be 86.5 kWh per train-mile. Because of the significantly greater fuel consumption, the pay off is much quicker: Only 9 trains per day are needed in each direction with social benefits included or 15.4 when only considering fuel costs. Of course, private companies aren't going to be using Federal discount rates and will likely be seeking money on the open market. While this will be more expensive, it won't be enormously so. Union Pacific recently sold 40 year bonds at 3.875%; if I've done the math correctly, this would come out to $212,374 per mile of track, pushing the break even points to 10 and 17.3 frequencies. In Southern California, this would justify the electrification of the Alameda Corridor, Sunset Corridor, and Southern Transcon."

A 1978 Federal Railroad Administration study on freight rail electrification, used a metric for route evaluation not based simply on trains per day, but gross tons of freight per year. The positive rate of return scenarios (18- 21%) modelled were on routes with 70 million and 97 million gross tons per year, which work out to an average of about 19 and 27 freight trains per day (10,000 short tons each), respectively. A 1983 study, "Cost/Benefit Evaluation of Electrification of a U.S. Rail Network", concluded the best single 'surrogate' for main economic factors of rail electrification was annual fuel consumption per route-mile, although variables uncorrelated with fuel consumption (e.g. bridge clearance and signal and communication compatibility) were still significant cost factors[9]. It should be remembered that the 1970s-80s era North American coal railroads justified electrification on at most three heavy trains per day. The economics and energy efficiency of overhead contact system (OCS) heavy/frequent freight rail

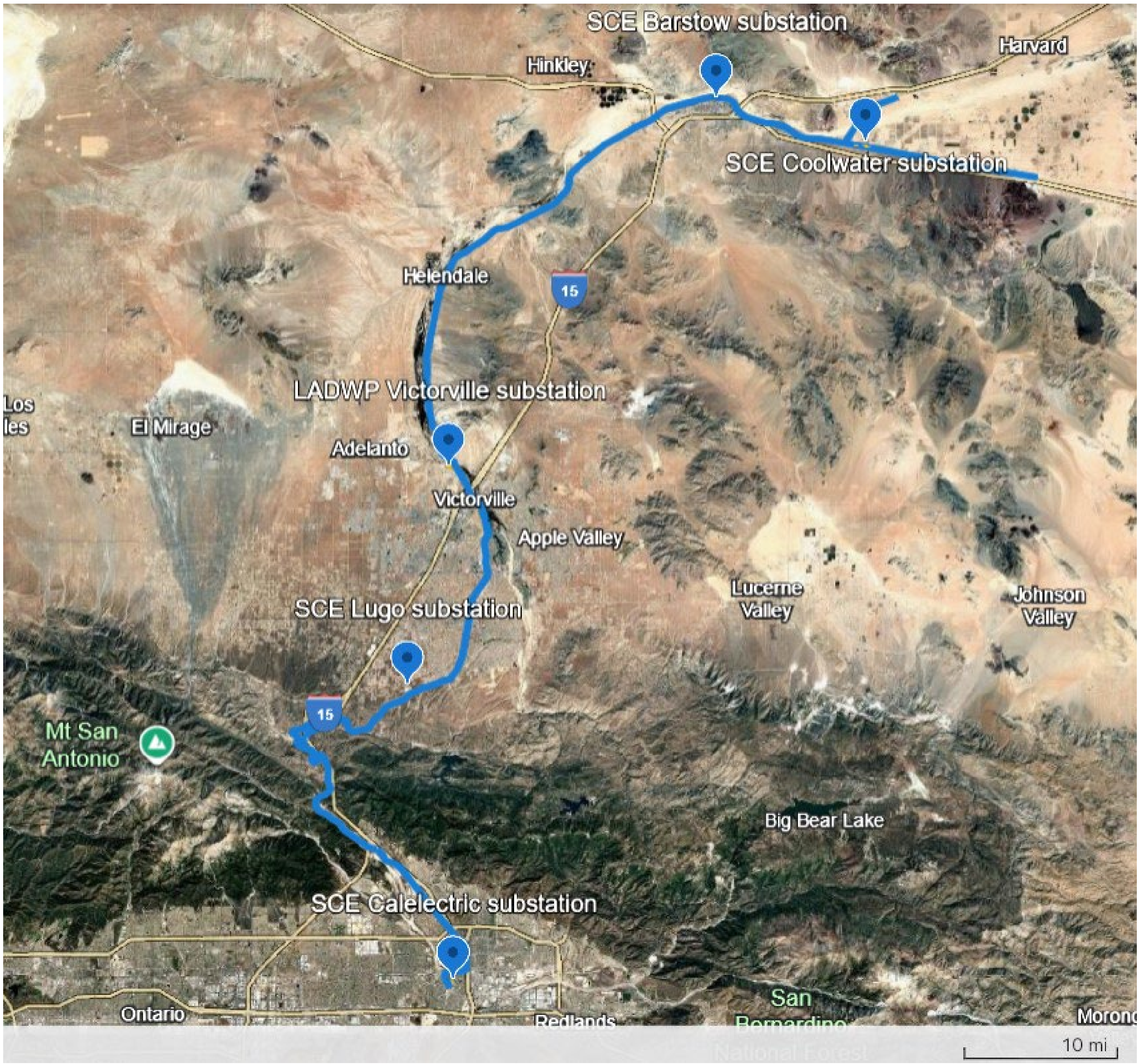
---

[7] https://libraryarchives.metro.net/dpgtl/Metrolink/1992-ExecSummary-SoCal-Accelerated-Rail-Electrification.pdf

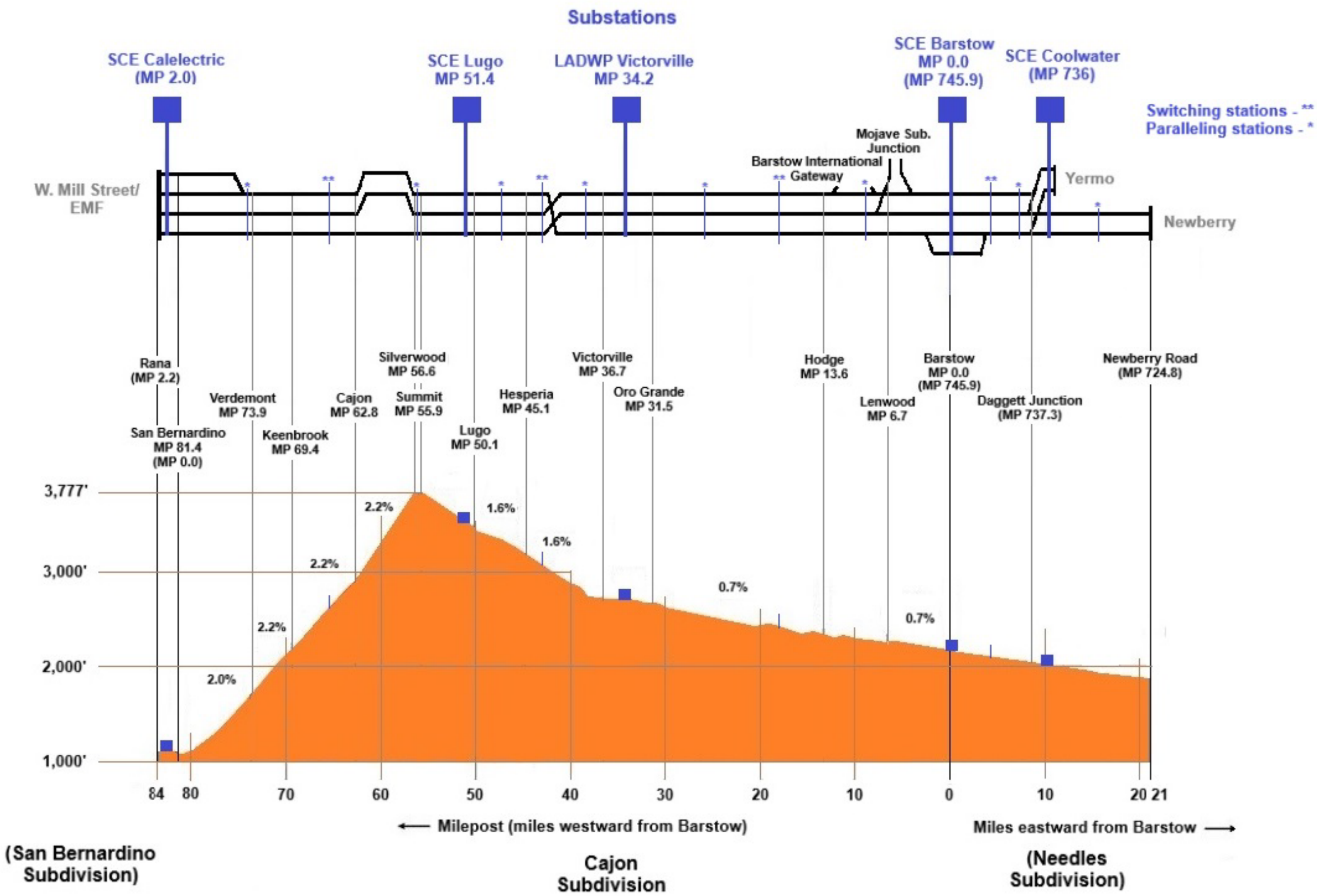
[8] https://reasonrail.blogspot.com/2015/09/a-cost-to-benefit-analysis-of-railroad.html

[9] C.H. Spenny and G.B. Mott, "Cost/Benefit Evaluation of Electrification of a U.S. Rail Network", Transportation Research Record 939, 1983.

electrification has proven in many applications around the world as having very positive return on investment, in large part due to a substantial reduction in operating and maintenance costs[10]. The operating and maintenance cost reduction is typically great enough long-term to offset the cost of OCS electrification while also driving improved bottom line results for rail operators (public and private).



[10] https://railtec.illinois.edu/wp/wp-content/uploads/2024_11_08-Hay-Seminar_Tyler-Dick_compressed.pdf



Working assumptions:

1. *50 kV overhead contact system (OCS) system*, with overhead catenary wire tall enough (about 23' above rail) to have sufficient vertical clearance for double-stack container trains.

   1A. *An OCS voltage of 50 kV, 60 Hz would have lower overall cost, and greater energy efficiency and power capacity than 25 kV.*

   Due to the heavy freight traffic of the line, steep grades and the high power requirements of the typical BNSF and UP freight trains on this segment, the higher power capacity of a 50 kV OCS offers many advantages. 50 kV requires fewer traction power substations and switching stations than 25 kV and so supporting infrastructure cost is less for the same amount of overall power capacity. There is also better train performance due to less voltage drop and less energy loss. It is assumed that electric freight locomotives moving at speed will be able to transition between 50 kV and standard 25 kV 60 Hz AC electrification system, to be installed in future by CHSRA on the LA to Fullerton segment of the San Bernardino Subdivision, as part of the California High Speed Rail project.

   50 kV requires half the current in the wire as on a 25 kV system for the same amount of power, and gives more margin of safety on very hot days (which is about half the year on the

Cajon Subdivision). Overheating is one of the most common cause of electrical equipment failures in general, and conductive properties of wire get worse with heat (which is quickly a vicious cycle as greater resistance creates more heat). So the less current in the wire needed to do the same job, the better.

1B. *OCS will have a minimum width of three mainline tracks on the Cajon Subdivision*

Overhead catenary structures will be wide enough for a minimum of three mainline tracks the entire length between San Bernardino and Barstow, even in sections which are currently still have only two tracks. The catenary structures will be wide enough for four mainline tracks in the sections where this exists and is proposed, such as in San Bernardino. Appendix A shows examples drawings and photographs of single-track and multi-track OCS structures.

It is assumed that the installation of the remaining gap in third mainline track (with sections of four mainlines) will be completed before or concurrently with electrification construction. Having three mainline tracks will enable two mainlines to remain open to normal train traffic while one track is closed for OCS construction. Another key cost factor- the type and spacing of catenary masts, is not discussed in this report.

1C. A contact wire (or conductor bar) height of about 23' (7 m) above top-of-rail, which is assumed to be sufficient clearance for 50 kV wire or conductor bar above the tallest double-stack (2 x 9' 6 1/2") 'high cube' double-well cars (20' 3"[11] or 6.2 m). It is assumed that a height of about 25' total overhead clearance, below an obstruction, is needed by 50 kV catenary wire in free air. This would allow up to 2' of vertical clearance between the energized wire and the overhead obstruction. However, the actual height above rail or the wire or conductor bar may vary, and even be less than 23' above top-of-rail, depending on total available overhead clearance and techniques to reduce electrical clearances needed from bridges and other structures. It is also assumed that no bridge structures or at-grade crossings will be significantly modified on the segment studied, as all appear by casual observation to have a minimum total overhead clearance of 2' above double-stacked 'high cubes' (see pgs. 23-25 and Appendix C). This needs to be verified with BNSF Railway or Caltrans records or field measurements.

This report does not examine any at-grade crossings, as it is assumed that 23' height of a 50 kV OCS is sufficient overhead clearance for road traffic.

---

11 https://web.archive.org/web/20210224215901/https://my.aar.org/OTLR/Documents/Section%201/Section1AppendixA_20200826.pdf

2. *Substations-*

The maximum electric power demand of the 120-mile San Bernardino, Barstow and Yermo/Newberry OCS electrification segment is assumed to be about 500 MVA[12]. This amount would be more than sufficient to power a worst-case scenario of a dozen 20,000 ton freight trains simultaneously going up the grades on this segment on a hot day (each pulling 30 MW off the OCS, plus some extra for yard operations in San Bernardino, Barstow and Yermo). At least 500 MVA of electric substation capacity will be needed, spread across the five proposed traction power substations. Each traction power substation is assumed to have three (3) transformers, each of 50-75 MVA capacity, to allow for redundancy and maintenance.

Five traction power substations, each with a transformer capacity of 150 MVA-250 MVA, will provide 50 kV power to the 120-(route) mile electrified segment. Four switching stations would be located roughly mid-way in between the five traction power substations, and eight smaller paralleling stations will be built along the 120-mile OCS segment.

2A. New traction power substations will connect to existing utility substations, owned by the electric utilities Southern California Edison (SCE) and Los Angeles Department of Water and Power (LADWP). There are many existing electric utility substations adjacent the BNSF Cajon Subdivision, so the existing electrical infrastructure should mostly be in place to handle the amount of power needed (up to roughly 500MVA/450 MW total) to be delivered to an electrified segment between San Bernardino, Barstow and Yermo/Newberry Springs.

2B. The substations shown in this report are located next to the tracks, but also appear to be surrounded by enough free space for a new, adjacent rail traction power substation to be built:

- A traction power substation up to 150 MVA in capacity has typically a 150' x 200' minimum footprint. It is worth exploring standardized 'modular' 50 kV traction power substations which could be installed on the grounds of, or adjacent to, existing utility substations. Paralleling and switching stations, also needed along the line, each take up a smaller space than a traction power substation.

- Switching station compound dimensions are typically about 80' x 160'. Switching stations are typically located about midway between traction power stations. Exact locations are to be determined. However, there appears to be ample vacant land next to the BNSF mainline in the areas where switching stations would be needed.

- Paralleling station compound dimensions are typically about 40' x 80'. Paralleling stations are typically spaced between switching and traction stations.

[12] A megawatt (MW), equivalent to one million watts, is a unit of real electrical power. A megavolt-ampere (MVA), equivalent to one million volt-amperes, is unit of overall electrical 'apparent power', including both real and reactive power. Substations and transformers are typically rated in MVA.

3. *Locomotives-*

It is assumed that 50 kV-capable electric freight locomotives, with sufficient tractive effort and horsepower, will be provided by established manufacturers. Siemens and Alstom are mass producing heavy-duty 25 kV electric freight locomotive drivetrains in India that could be adapted to North American standards. Due to their mass production, it would be easier to find parts, maintenance/repair support from the manufacturers. Two-section Alstom WAG-12 with 12,000 hp (2 x 6,000 hp) or Siemens single-section 9000 hp (6.7 MW) electric locomotive drivetrains developed for Indian Railways should offer the equivalent performance needed by US freight railroads. Four of the 9000 hp units would translate to 26.8 MW total max draw per train (or assuming five rounded to an average max load of about 30 MW). European and Asian electric locomotive drivetrains will need to be converted to American frame/trucks. Frames or other components could be repurposed from existing diesel-electric freight locomotives[13].

4. *Short-haul freight 'shuttle train' operations-*

BNSF's Barstow International Gateway (BIG) intermodal yard will be constructed between control points Lenwood (MP 6.7) and Hodge (MP 13.6). For the proposed BNSF BIG, the exact routing of new track connecting this facility to the BNSF mainline from has not yet been publicly released. Short-haul freight 'shuttle' trains between the Ports of LA/Long Beach and the Barstow area are a practical use-case for 'captive' electrified operations. For this report, the proposed electrification is extended to Yermo and Newberry Springs, respectively 12 and 21 route miles east of Barstow yard, as it is assumed that is where the diesel/electric equipment changes could happen. The existing Barstow BNSF yard is already full of existing activities. Yermo is an existing UPRR yard, but there is plenty of room for new yards/ siding tracks on vacant land south of the existing Yermo yard, and along the BNSF mainline to Newberry Springs. Future electrification along the BNSF Mojave Subdivision towards Hinkley and beyond is also possible, though not looked at in this report.

5. *No cost estimate is given in this report-*

This document's purpose is to show a plausible physical electric rail infrastructure layout and system configuration along the BNSF Cajon Subdivision (and extending to adjacent parts of other subdivisions), which can serve as a basis for detailed engineering design and planning. A large part of this is the identification of the existing major electric utility substations along the track, which appear to be the most feasible locations for traction power substations. This report will provide a starting point for rail electrification discussions with the electric utilities.

6. *Passenger trains-*

The only passenger trains currently using the BNSF Cajon Subdivision are two Amtrak *Southwest Chief* trains per day, one in each direction. Even if Amtrak were to electrify this train through Cajon Pass, along with additional future regional trains to Victorville, Barstow, and Las Vegas, the

[13] https://railtec.illinois.edu/wp/wp-content/uploads/UIUC-Hay-Seminar_Iden_20240927.pdf

combined electric energy demand of all passenger trains would be very small compared to that of freight trains.

Brightline West, which will follow the Interstate 15 right-of-way through Cajon Pass, is slated to open in 2028. It will be powered by 25 kV OCS electrification. This report assumes that the Brightline West 25 kV OCS system will be separate from the 50 kV OCS system proposed for the BNSF. However, since Brightline West's routing along Interstate 15 is not far from some of the same large electric utility substations identified in this report, potential opportunities for co-utilization of power grid infrastructure could be explored. Brightline West is planning to build a traction power substation in Ivanpah near the California-Nevada state line, tied to local solar power generation.

Amtrak #4, the *Southwest Chief*, from Chicago to Los Angeles via San Bernardino, passing under I-15 Main 3 bridge. When following schedule, the westbound #4 travels through Cajon Pass area before sunrise. This train, seen in mid-morning, is running several hours late (November 5, 2024 photo).

7. *Signals and communication systems* used by the BNSF Railway, UPRR, and Amtrak will need to be evaluated in the context of electromagnetic interference from a 50 kV OCS system, and mitigation measures recommended.

Next steps:

In addition to engineering design and cost estimates, a technical study is needed on performance and economics of electric locomotive operations between Barstow and San Bernardino, and beyond to both Yermo/Newberry Springs and the Ports of LA and Long Beach. Such a study needs to evaluate how electrification could increase throughput (trains per day) on the Cajon Subdivision while reducing operating and maintenance costs.

OCS sections

	Segment	# of tracks	Length (miles)	
			Route	Track
0	W. Mill St. to San Bernardino Depot	4	2.0	8.0
1	San Bernardino Depot to West 5th St.	4	0.5	2.0
2	W 5th to W 9th St.	4	0.5	2.0
3	W 9th St to W Base Line St.	4	0.4	1.6
4	W Base Line St to N Highland Ave.	4	1.3	5.2
5	N Highland Ave to Glen Helen Pkwy.	4	7.7	30.8
6	Glen Helen Pkwy to CP Cajon	3	8.4	25.2
7A	CP Cajon to SR 138- Mains 1 & 2	2	2.7	5.4
7B	CP Cajon to SR 138- Main 3	1	1.5	1.5
8A	SR 138 to I15- Mains 1 & 2	2	1.8	3.6
8B	SR 138 to I15- Main 3	1	0.8	0.8
9A	I15 to CP Silverwood- Mains 1 & 2	2	3.3	6.6
9B	I15 to CP Silverwood- Main 3	1	3.3	3.3
10	CP Silverwood to Main St., Hesperia	3	11.3	33.9
11	Main St., Hesperia to Bear Valley Rd.	3	3.8	7.6
12	Bear Valley Rd. to Green Tree Blvd.	3	2.2	6.6
13A	Green Tree Blvd. to Mojave Narrows Jct. (Over)	2	1.4	2.8
13B	Green Tree Blvd. to Mojave Narrows Jct. (Under)	1	1.4	1.4
14	Mojave Narrows Jct. to Hwy 18	3	1.2	3.6
15	Hwy 18 to I15, Victorville	3	1.1	3.3
16	I15, Victorville to Vista Rd., Helendale	3	13.9	41.7
17	Vista Rd., Helendale to Hinkley Rd.	3	11.3	33.9
18	Hinkley Rd. to Lenwood Rd.	3	4.8	14.4
19	Lenwood Rd. to SR 58	3	1.7	5.1
20	SR 58 to N 1st Ave.	3	4.0	12
21	N 1st Ave to Yucca Ave.	3	1.3	3.9
22	Yucca Ave to Daggett Jct.	3	7.8	23.4
23	Daggett Jct. to Yermo	2	4.9	9.8
24	Daggett Jct. to Newberry Rd.	2	12.7	25.4
	TOTAL		**~120**	**~330**

The proposed electrified section includes the entirety of the 81.4 mile BNSF Cajon Subdivision but also small portions of the BNSF San Bernardino Subdivision (2 route miles between San Bernardino Depot and West Mill Street bridge), the BNSF Needles Subdivision (21 miles between Barstow and Newberry Road), and the UP Los Angeles Subdivision (4.9 Miles between Daggett Junction and 2nd Street crossing at East end of UP Yermo railyard).

Note that segments listed in the above table are based mostly on street crossings (including over and underpasses), with direct distances measured in Google Earth, and not BNSF milepost numbers for the Cajon Subdivision. Select milepost (MP) numbers are shown for select control points on the table above. Route miles do not include yard sidings. Google Earth images of each, with segment length measurements, are shown in Appendix B.

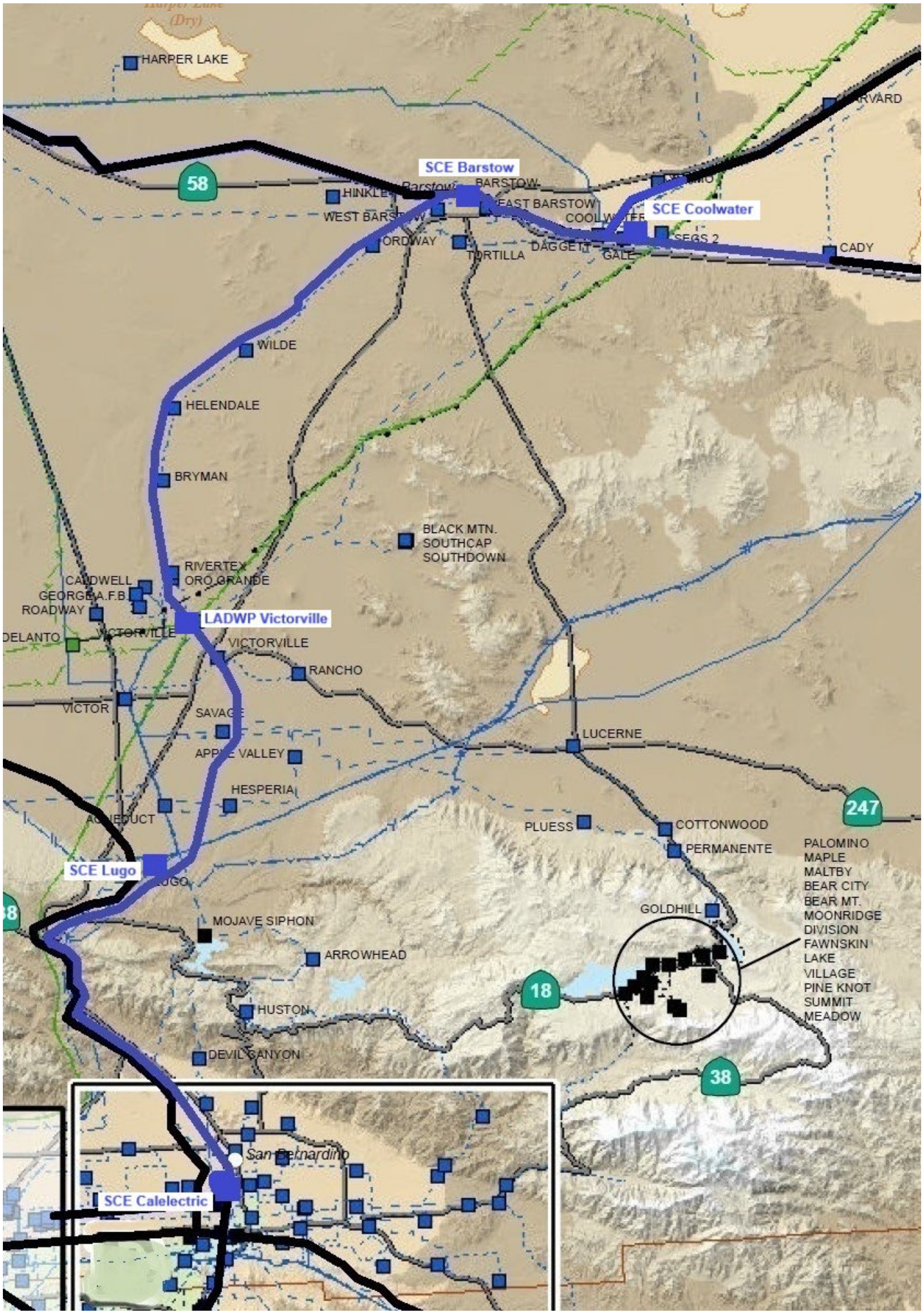
The wide disparity in lengths of discreet track segments for this high-level study is due to the fact that bridges are used as delineators between many OCS sections. While the vast majority of the bridges appear to be high enough for overhead catenary wire (50 kV at 25' above top-of-rail), several may require conductor bars or electrical clearance reduction techniques (as described on pgs. 23-26). Many of the bridges were observed in the field to appear to be sufficiently greater than 25' above top-of-rail, so are not used as OCS segment delineators as catenary wire would go under them with sufficient clearance. In addition to select bridges, control points Cajon (MP 62.8) and Silverwood (MP 56.6) delineate discreet segments of overhead catenary wire, because the Main 3 track splits from Mains 1 & 2 at these locations.

The total track length count of 330 miles assumes that there will be a minimum of three mainline tracks the entire length of the BNSF Cajon Subdivision. Significant track capacity projects, to add 3rd and 4th tracks, are underway. For example, 4.3 miles of new fourth main track between San Bernardino yard/station to State Street/University Parkway will soon be completed[14]. However, this analysis assumes the 4th main track would be extended a further 5.8 miles (northwest) in San Bernardino from State Street/University Parkway to Glen Helen Parkway. In 2023, BNSF received a $50 million state grant for the High Desert Operational Efficiency Project (the Project) to construct approximately 11.2 miles of new 3rd track mainline from MP 41.8 (near Bear Valley Road in Hesperia) to Milepost 53.0 (about three track miles east of Cajon Summit) on the Cajon Subdivision[15].

[14] https://www.bnsf.com/news-media/news-releases/newsrelease.page?relId=bnsf-railway-advances-track-efficiency-improvements-in-san-bernardino

[15] https://catc.ca.gov/-/media/ctc-media/documents/programs/Senate-Bill-1/TCEP/fact-sheets/factsheets/6-high-desert-capacity-enhancement-fs.pdf

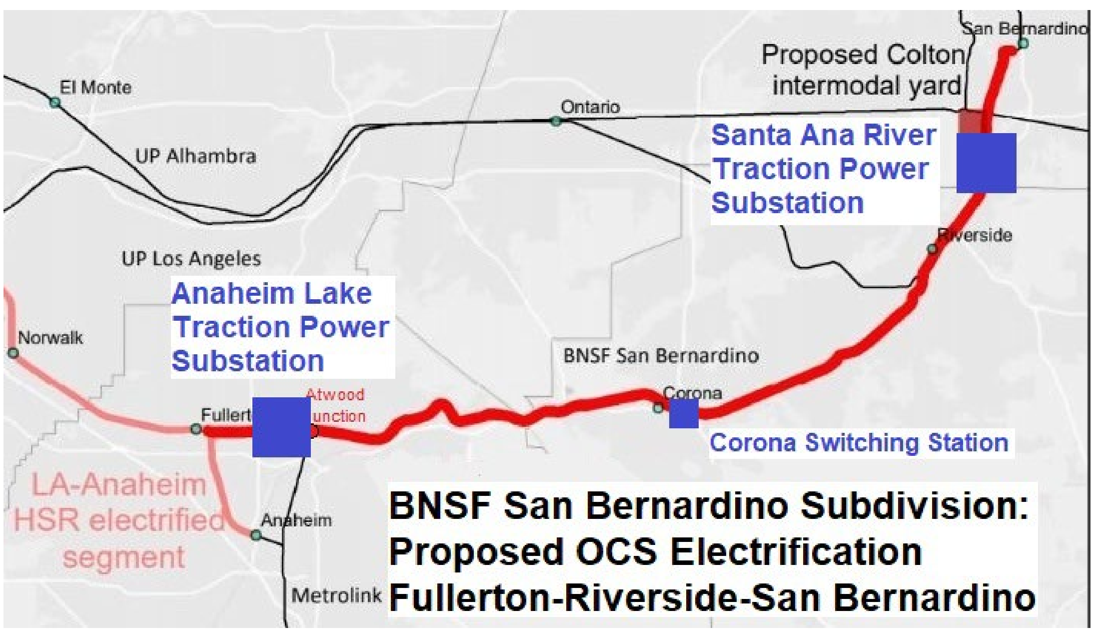
Substations



Primary substations along San Bernardino-Barstow-Yermo/Newberry electrified track segment, annotated on transmission grid background map, by California Energy Commission.

Electrifying operations on the BNSF Cajon Subdivision, nearby connecting tracks and the four associated Class I railyards, will require several hundred MW of 'at-wheel' electric power, spread among five traction power substations each with 150-200 MVA capacity, as described above. Efficient and cost-effective utilization of existing power grid infrastructure is key for economical rail electrification, so it is best for new traction power substations to be built as close as possible to existing major electric utility substations. Thankfully many existing large electric utility substations exist along the BNSF mainlines between San Bernardino, Barstow and Yermo/Newberry Springs. The substations are all owned and maintained by Southern California Edison (SCE), with the exception of the major Los Angeles Department of Water and Power (LADWP) transmission substation at Victorville. Power grid studies will be needed.

The five primary substations identified are existing major electric transmission substations that fortuitously happen to be adjacent to the track. While the substations may require some upgrades, and new adjacent traction power substations built next to them, the basic power grid infrastructure is in place for powering an OCS electrification of the Cajon Subdivision. SCE's Lugo and LADWP's Victorville substations are the main connection points between the power grids of Southern California and Nevada (including Hoover Dam), and SCE's Coolwater substation has several hundred MW each of both local solar and battery energy storage already feeding right into it. A prior report on electrifying the BNSF San Bernardino Subdivision between Fullerton and San Bernardino[16] proposed connecting a traction power substation on the south shore of the Santa Ana River in Grand Terrace to SCE's large Vista substation nearby (see map below). This is about 4 track miles south of the SCE Calelectric substation, featured in this report. Therefore, SCE Vista substation could be feasibly serve as backup power source for electrifying the BNSF Cajon Subdivision.



The five primary traction power substation sites, in an order of south to north [with distances from track given in feet], are described below:

[16] https://calelectricrail.org/wp-content/uploads/2024/11/SoCal-IE-rail-electrification-BY-appendices-2023.08.29.pdf

SCE Calelectric (San Bernardino) [2,000'], connects to (7) 115 kV transmission circuits

SCE Calelectric substation, potential traction power substation and construction laydown areas (May 1, 2022 photo)

Located at CP Mill, just east of the Inter Rail Transport automobile transport railyard facility, south of the BNSF San Bernardino yard and J.B. Hunt intermodal yard, and just north of Metrolink's Eastern Maintenance Facility.

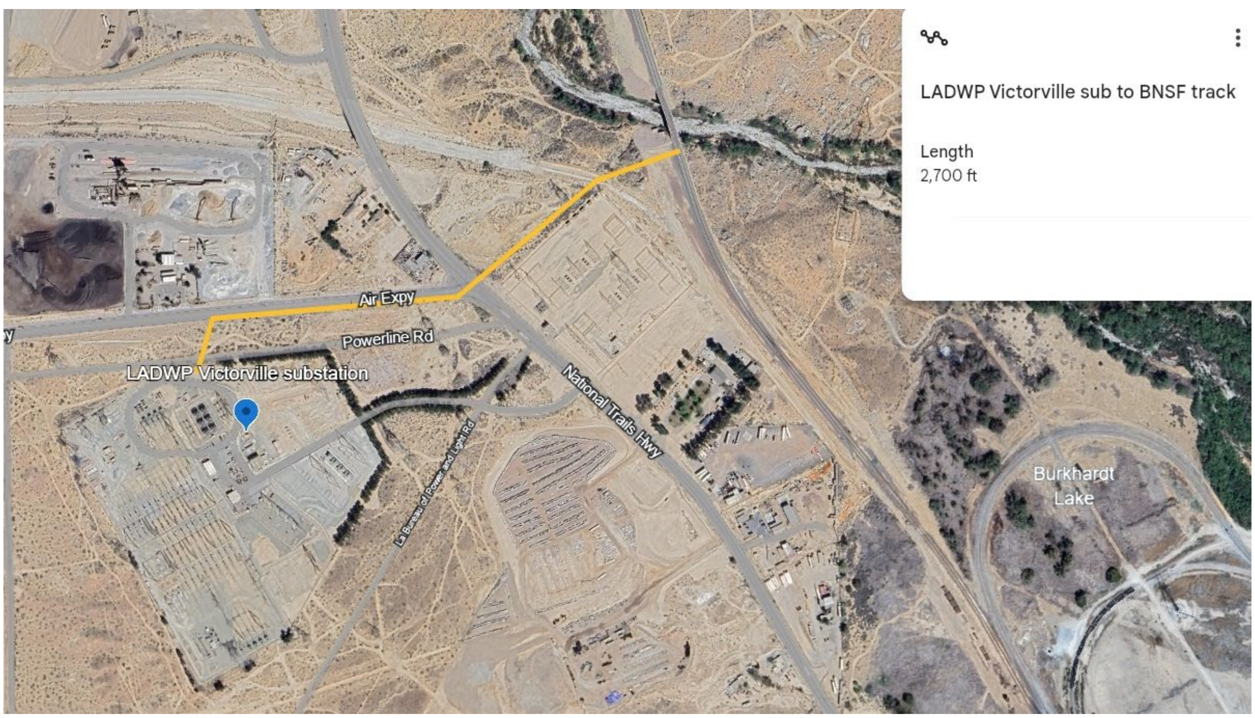

Calectric laydown area
SCE Calectric Sub
Lytle Creek Channel
Distance
0.5 mi
< Metrolink Eastern Maintenance Facility

SCE Lugo (Hesperia) [1,200’], connects to (8) 500 kV and (6) 230 kV transmission circuits (including to SCE’s large Eldorado and Mojave substations in Nevada).

SCE Lugo substation (November 5, 2024 photo)

LADWP Victorville [2,700'] connects to (6) 500 kV and (3) 287 kV transmission circuits (including Path 46 to Mead substation/Hoover Dam in Nevada)

LADWP Victorville substation (November 5, 2024 photo)



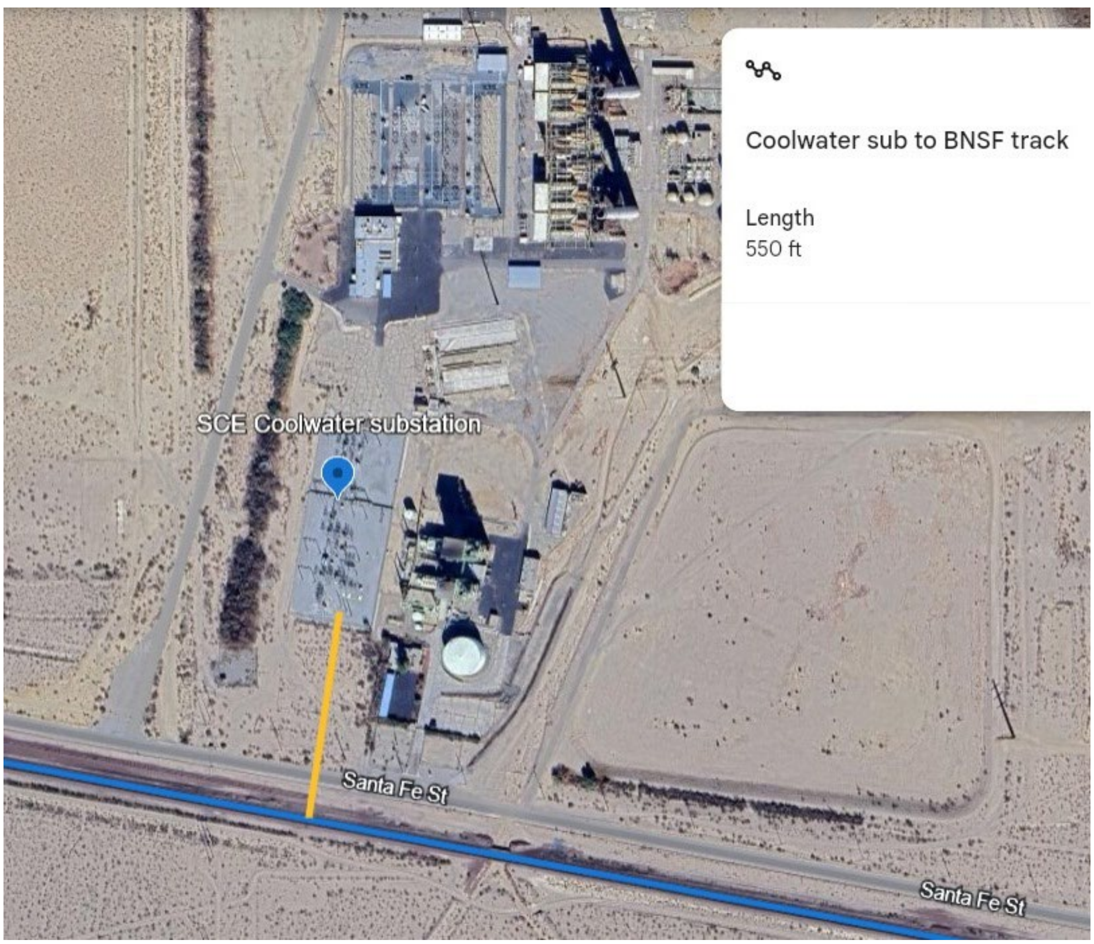
SCE Barstow [1,000’] connects to several 33 kV circuits

SCE Barstow substation (November 5, 2024 photo)

Even if Coolwater is the primary power feeder for OCS in the greater Barstow area, a feeder from SCE Barstow substation would still be beneficial for supporting yard operations at least since it is adjacent to the existing BNSF railyard. Even a small traction power substation at this location could power a pilot development focused on battery-electric yard switcher locomotives.

SCE Coolwater (Daggett) [550'], connecting to (5) 115 kV and (2) 230 kV transmission (and 33 kV sub-transmission) circuits, including connections to local large-scale solar generation and battery storage.

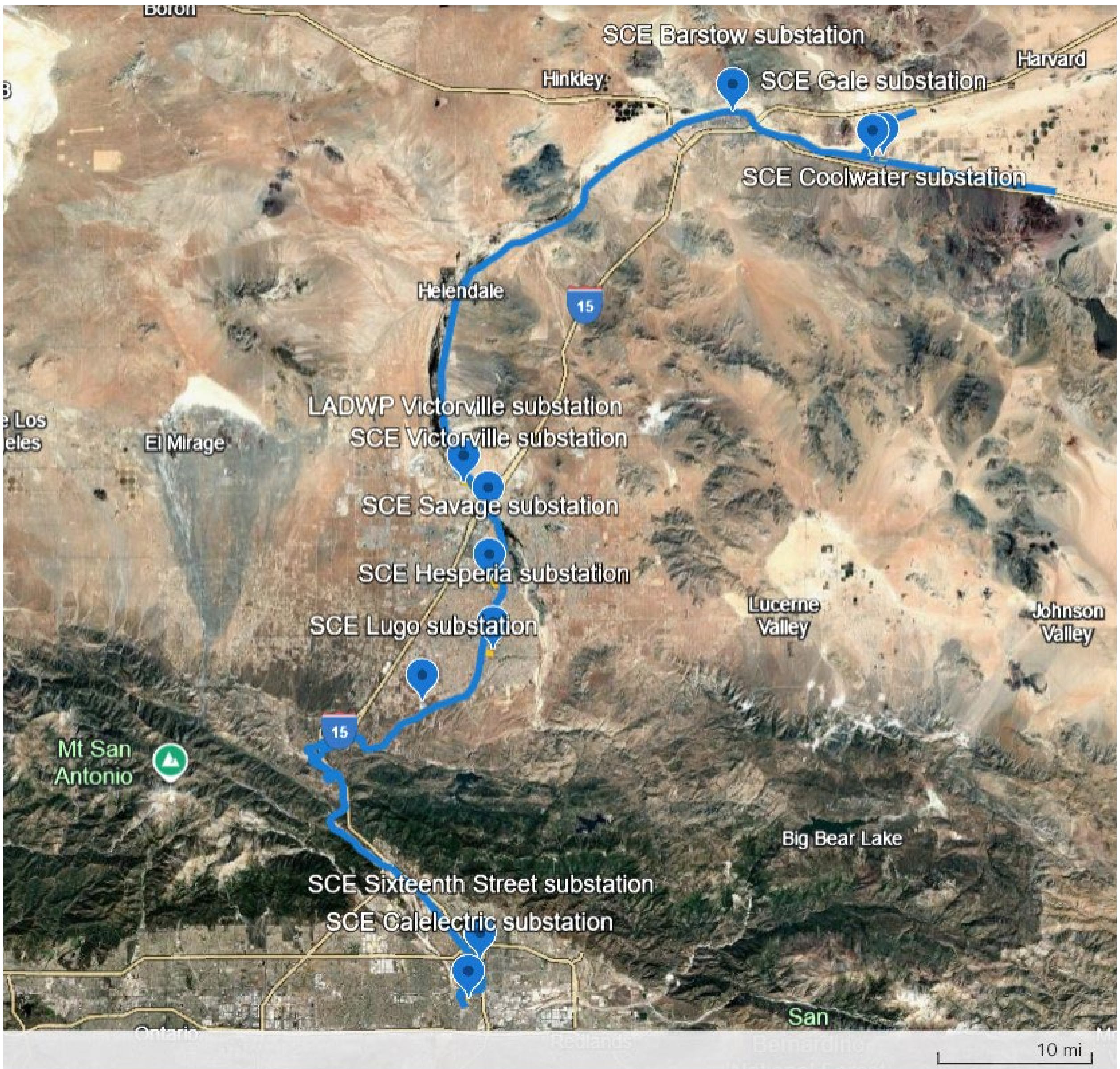
SCE Coolwater complex, including substations, directly behind intermodal train on BNSF Needles Subdivision (November 5, 2024 photo)



Coolwater is actually two substations- 115 kV and 220 kV, both with much greater capacity than the 33 kV Barstow substation. These were originally built for now-decommissioned coal and gas-fired power plants on the property, and remain an important transmission hub for the regional power grid. SCE has plans for expansion of Coolwater's capacity. Several hundred megawatts each from local solar generation and battery energy storage (the Daggett Solar+Storage and Sunray Solar projects) is already directly connected to Coolwater.

Secondary (backup) traction power substation sites, south to north [distances from track]:

- SCE Sixteenth Street , San Bernardino [50’] (traction power substation would be in lot along tracks, about 200’ north of existing SCE substation)
- SCE Hesperia [3,900’]
- SCE Savage (Victorville) [4,200’]
- SCE Victorville [940’]
- SCE Gale [250’]



The existing SCE substations listed below, while each less than ½ mile from the BNSF mainline tracks, are likely too small (or limited in spare capacity) to support a new, adjacent traction power substation. Listed south to north:

- Oro Grande
- Rivertex (Oro Grande)
- Bryman
- Helendale
- Wilde
- Ordway (Lenwood)
- West Barstow
- East Barstow
- Daggett
- Yermo
- Cady

Bridges

There are 26 road bridges and one railroad overpass between Yermo/Newberry Springs and San Bernardino. [Federal Highway Administration's LTBP InfoBridge minimum vertical under clearance in the public database[17]], Google Earth maps and photos of the bridges are cataloged in Appendix C.

San Bernardino-

1. West 5th Street
2. West 9th Street
3. Base Line Street [25.4']
4. West 16th Street
5. Massachusetts Avenue [26.8']
6. Highland Avenue
7. Mount Vernon Avenue
8. State Route 210 [27', 23.9', 24.9']
9. State Street/University Parkway [24.6']
10. Palm Avenue [25.8']
11. Glen Helen Parkway
12. I-15 Devore [25', 24.6']

Cajon-

13. SR 138 Cajon (Mains 1 and 2) [24.0']
14. SR 138 Cajon (Main 3) [24.1']
15. I-15 Cajon (Mains 1 and 2) [22.5']
16. I-15 Cajon (Main 3) [23.1']

Hesperia-

17. Main Street [23.6']

Victorville-

18. Bear Valley Road [23.2']
19. Green Tree Boulevard
20. Railroad overcrossing, north of Green Tree Boulevard
21. D Street [24.9']
22. Mineral Road [23.6']
23. I-15 Victorville [24.2', 27.4']

Barstow-

24. Lenwood Road [24.2']
25. State Route 58 [25', 25', 23.8']
26. North 1st Avenue [new bridge opened in July 2024]
27. Yucca Avenue [24.3']

[17] https://infobridge.fhwa.dot.gov/

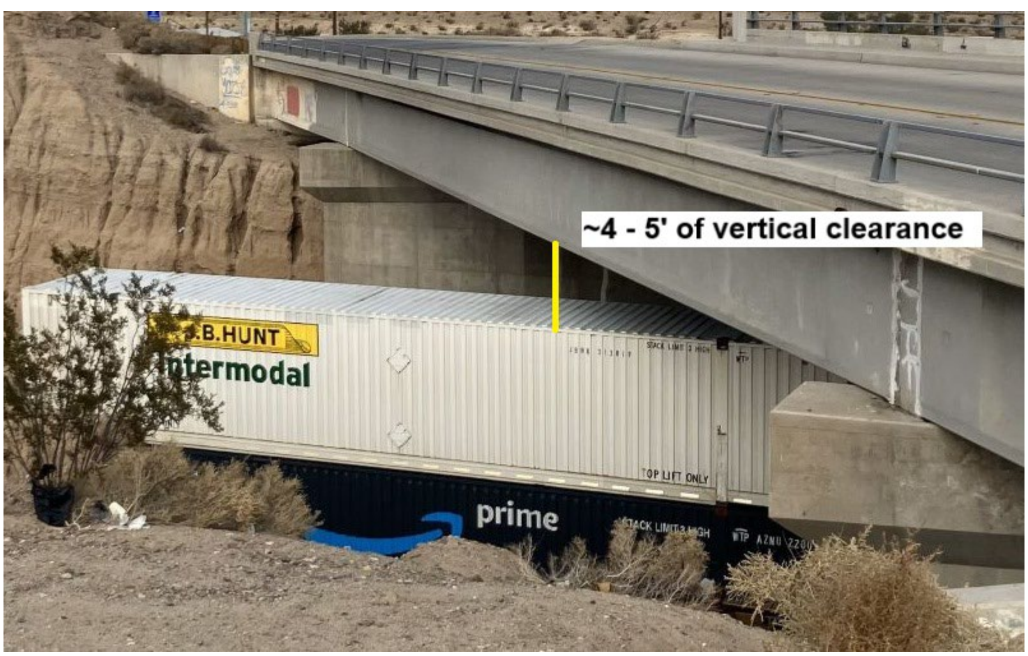
There appear to be only a handful of (six or less) ‘tight spots’ at several of the bridges along the 120 route miles studied in this report. Field measurements of the bridge heights above the rails would need to confirm the exact clearances, if BNSF Railway or Caltrans do not already have these measurements. The absolute tightest spot (Interstate 15 – Mains 1 and 2 bridge at Cajon, shown in photo below) could be less than 3’. If a significant interference issue were to be caused by the overhead catenary structures and wire at the locations of bridges or at-grade crossings (i.e. if 2’ of overall vertical clearance is insufficient), that could not be mitigated with modern methods (conductor bars, special insulation structures, etc.), this would not be an insurmountable obstacle. It is common practice around the world for electric trains to coast through short unelectrified sections, unpowered on a ‘dead’ (permanently grounded or neutral)[18] section.

The good news is, like the Alameda Corridor and BNSF San Bernardino Subdivision, none of the clearances of all the existing bridges on the route appear to "dealbreakers". While the vast majority of the bridges appear to be high enough for conventional overhead catenary wire (50 kV at 25’ above top-of-rail), several may require conductor bars, or electrical clearance-reduction techniques, if the total vertical clearance to the bridge obstruction proves to be very tight. Of the handful of ‘tight spot’ bridges, the tightest clearances observed (see photos below) are in the ~2 to ~4 foot range, above double stack of two "high cubes". These should be able to be mitigated with special insulators/voltage-controlled clearances or even neutral sections, at the lowest bridges, without significant modifications to the bridge or track.

Interstate 15 – Mains 1 and 2 bridge at Cajon (November 16, 2024 photo)

[18] Short unelectrified sections, with pantograph-up – would typically be Permanently Earthed Sections (PES – using UK terminology) – rather than Neutral Sections. A PES would just be cabled from one electrified section to another, with an grounded section of conductor bar or catenary (contact wire run in parallel) in between. A neutral section would typically be fed separately on either side to separate different electrical phases/or power fed from different traction power substations.

Interstate 15 – Main 3 bridge at Cajon (November 16, 2024 photo)



BNSF double-stacked 'high-cube' container train under Yucca Avenue bridge, Barstow (December 4, 2023 photo)

Mineral Road and D Street bridges, Victorville (September 15, 2023 photo)

OCS wire under bridges:

Several new technologies are allowing tighter clearances for electric wires going under bridges[19]:

- Under-cable support structures
- Conductor bars
- Insulating covers/coatings (combined with surge arresters), incl. voltage-controlled clearances
- Permanently-grounded or Neutral sections (some of which already required by AC OCS electrification systems)

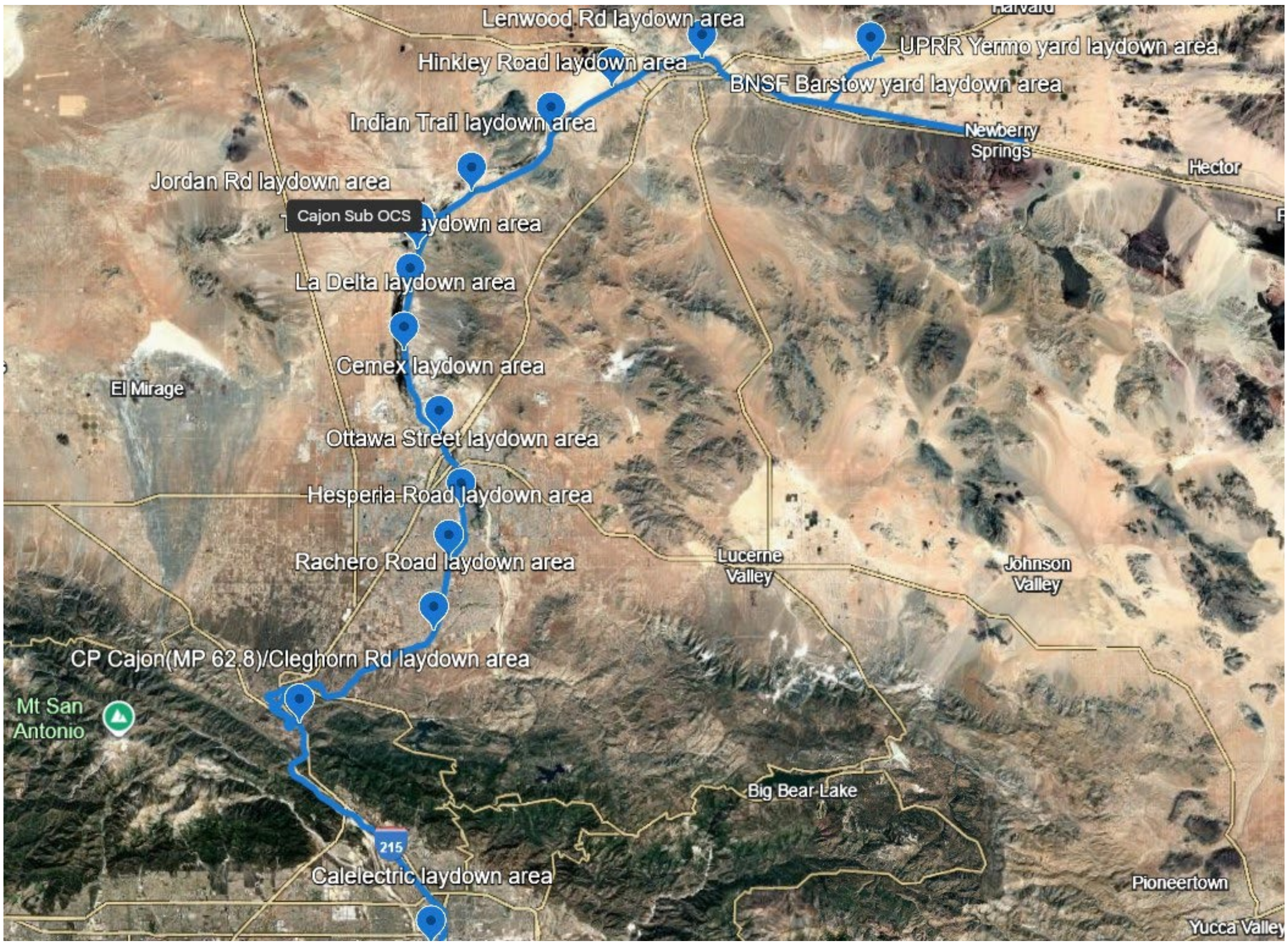
[19] https://www.thepwi.org/wp-content/uploads/2021/10/Journal-2021-10-Vol139-Pt4_Voltage-controlled-clearances.pdf

https://www.railengineer.co.uk/overcoming-the-clearance-issue/

Conductor bar on a European OCS system passing under a low bridge (photo: Furrer+Frey)

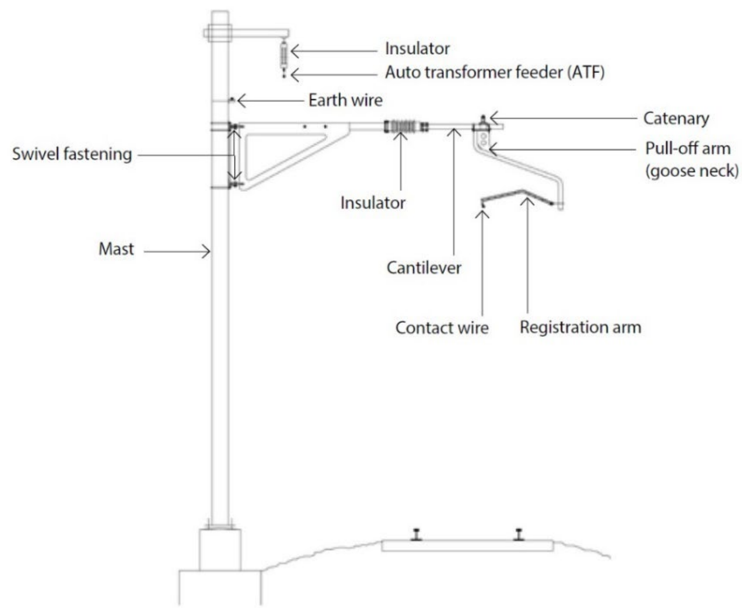
Construction staging/laydown areas

Critical for economic construction of rail electrification schemes is having sufficient construction staging and laydown areas next to the track. A preliminary survey on Google Earth (below) shows there appears to be a sufficient number of vacant lots adjacent to the tracks for this purpose.



Appendix A:
Examples of OCS Structures

Typical New single post assembly with single overhead wire:



OLE mast, cantilever and associated equipment (in this case Series One)

Source: Network Rail (UK)

Along the route studied, the supporting structures are assumed to be steel or composite masts (poles).

- Pole foundation options:
    - Poured concrete in holes augered or dug with a backhoe.
    - Precast concrete
    - Driven steel pile
- Pole structural components:
    - Cross arm
    - Pull-off arm
    - Misc. fittings

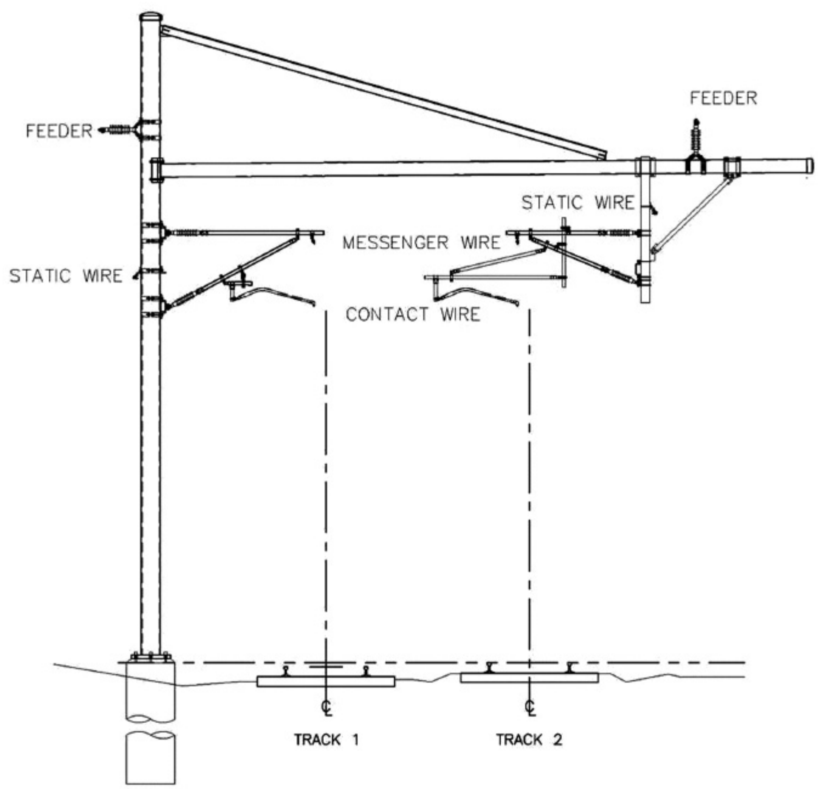
Mechanical -

- Cantilevers-swivel (one per pole)
- Tensioning spring mechanism (two per 1-mile section)

Electrical components-

- Parallel (autotransformer) feeder wire
- Ground return (static) wire- electrically connected to the track

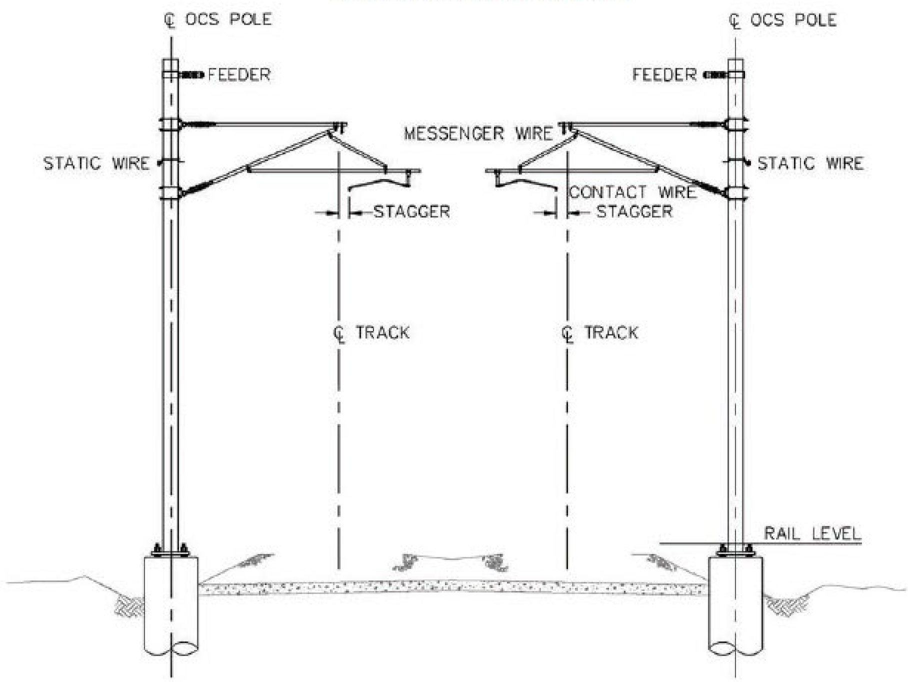
- Messenger (catenary) wire- maintains the contact wire at the correct height above the rail (part of electrical circuitry)
- Contact wire- delivers power to the pantograph.
- Droppers that hold the contact wire from the catenary wire.
- Insulators



Source: JPB Staff.

Figure 2-7
OCS Two Track Cantilever
Peninsula Corridor Electrification Project

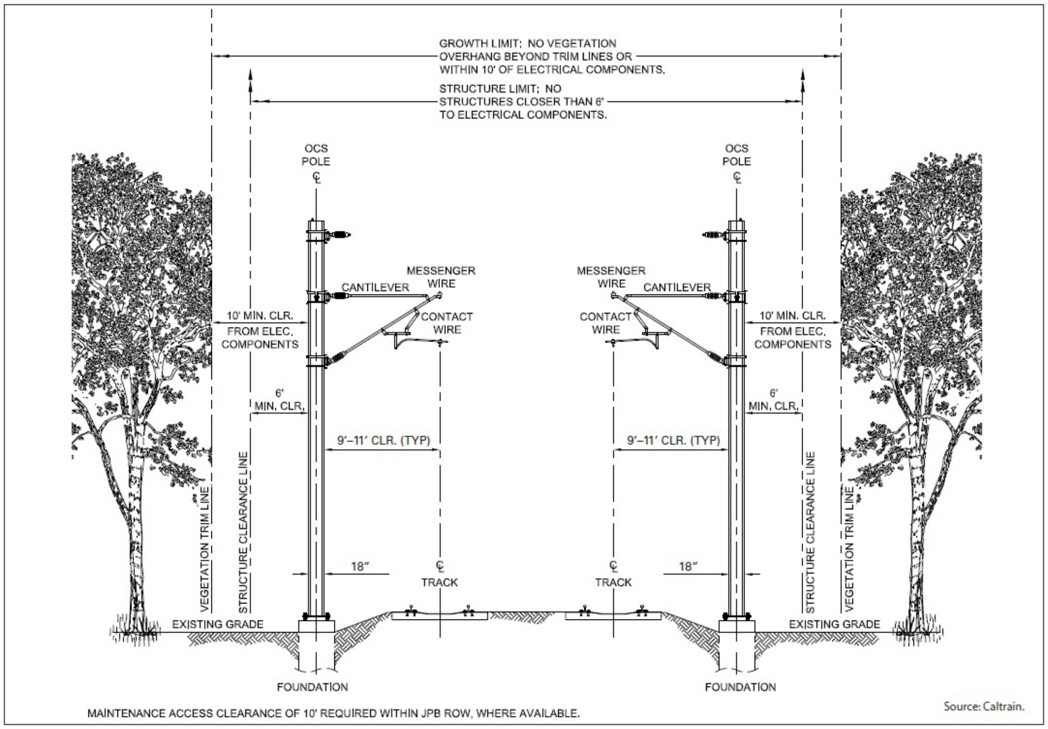
Amtrak's North End Electrification



Source: JPB Staff.

Figure 2-3
OCS Two Track Arrangement with Side Pole Construction
Peninsula Corridor Electrification Project

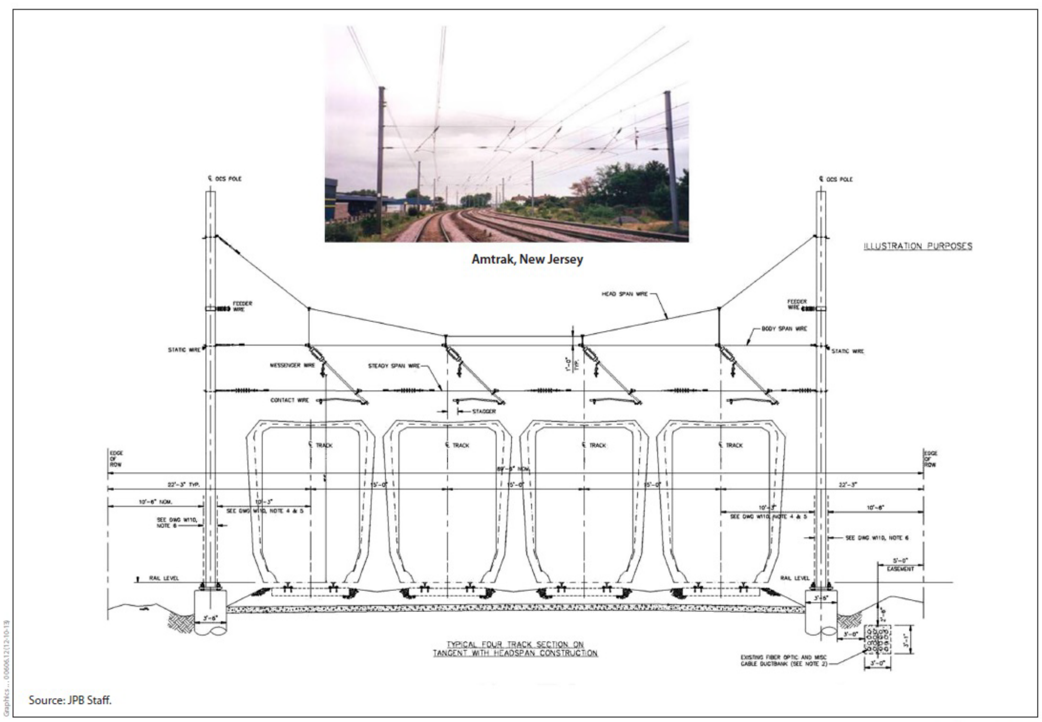
Appendix A: Examples of OCS Structures



Source: Caltrain.

Note: This figure replaces Figure 2-8 from the Draft EIR.

Figure 2-8
Vegetation Clearance
Peninsula Corridor Electrification Project

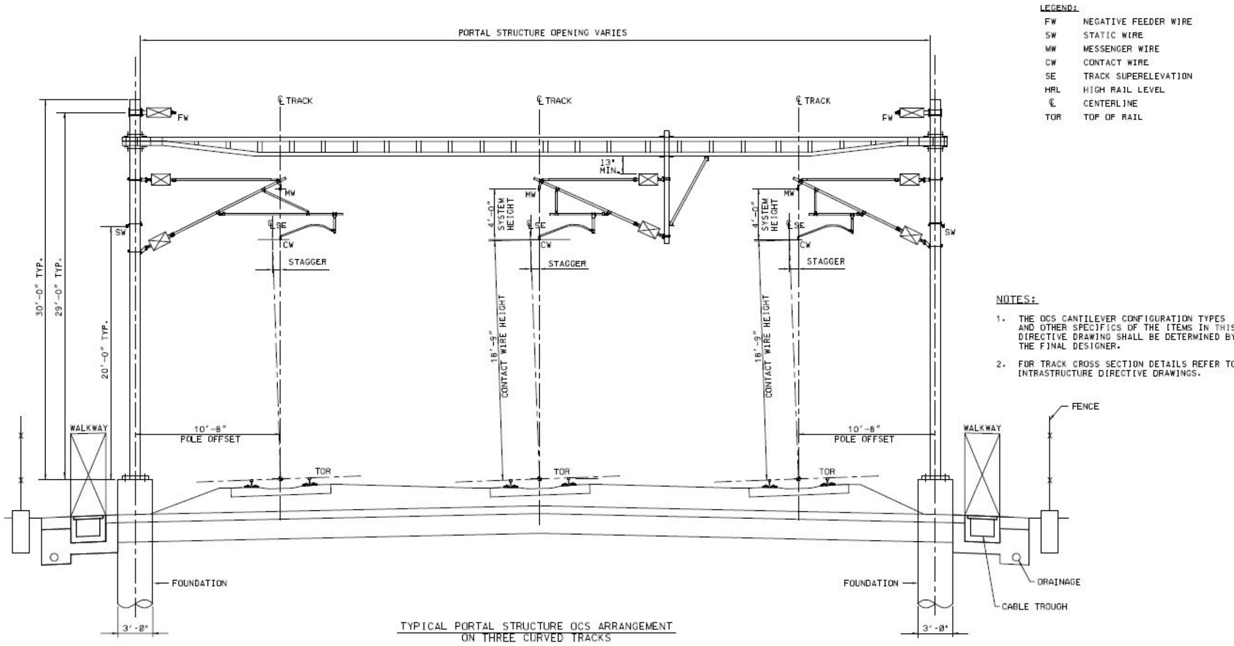


Source: JPB Staff.

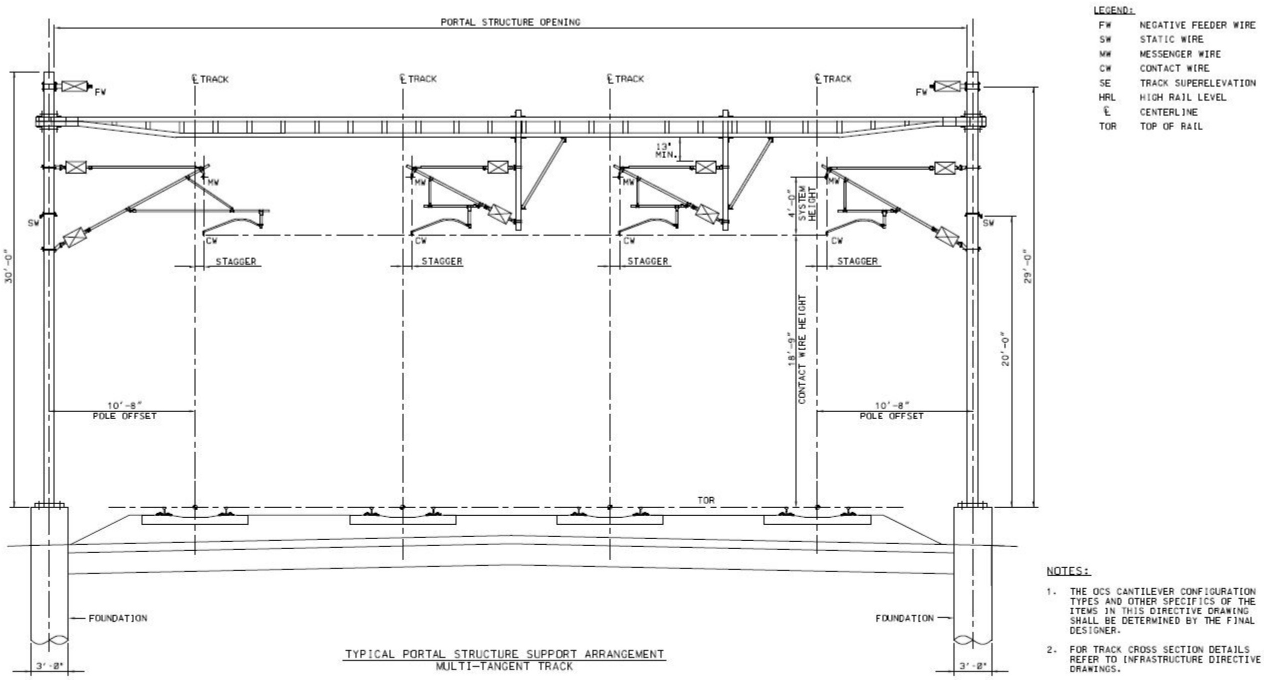
Figure 2-6
OCS Multi-Track Arrangement with Headspan Construction
Peninsula Corridor Electrification Project

Examples of OCS configuration of three-track mixed use, similar to Fullerton-Riverside-San Bernardino-

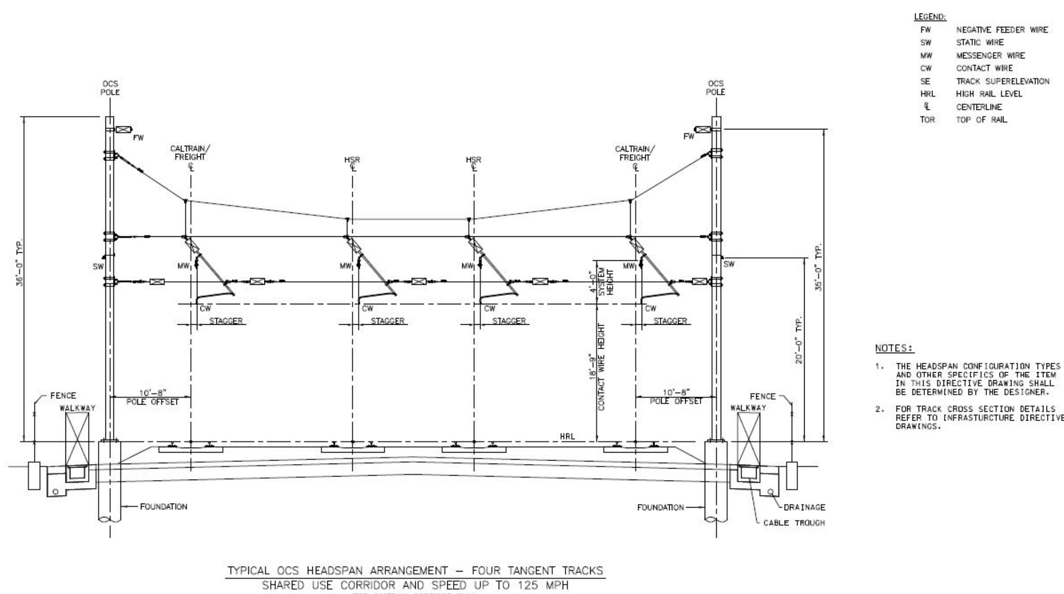
Note that the three reference 'directive drawings' shown below from the *Technical Memorandum (TM) 3.2.1 – OCS Requirements,* for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010, are for 25 kV OCS with an overhead clearance of 16'9" above the top of rail, or lower than needed for double-stack container trains. The structure and wire heights would be higher (contact wire height of 23' above the top of rail) for a 50 kV San Bernardino-Barstow-Yermo/Newberry OCS, due to the need to accommodate double-stack container trains, and a higher voltage.



"Typical portal structure OCS arrangement on three curved tracks, speed up to 125 MPH",
Drawing TM 3.2.1-F from *Technical Memorandum (TM) 3.2.1 – OCS Requirements,*
for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010



"Typical portal structure arrangement, multi-tangent track, speed up to 125 MPH", Drawing TM 3.2.1-G from *Technical Memorandum (TM) 3.2.1 – OCS Requirements,* for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010



"Typical OCS headspan arrangement, four tangent tracks shared use corridor, speed up to 125 MPH", Drawing TM 3.2.1-M from *Technical Memorandum (TM) 3.2.1 – OCS Requirements,* for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010

Appendix B:
San Bernardino-Yermo/Newberry
Track Segment Summary

	Segment	# of tracks	Length (miles)	
			Route	Track
0	W. Mill St. to San Bernardino Depot	4	2.0	8.0
1	San Bernardino Depot to West 5th St.	4	0.5	2.0
2	W 5th to W 9th St	4	0.5	2.0
3	W 9th St to W Base Line St	4	0.4	1.6
4	W Base Line St to N Highland Ave	4	1.3	5.2
5	N Highland Ave to Glen Helen Pkwy	4	7.7	30.8
6	Glen Helen Pkwy to CP Cajon	3	8.4	25.2
7A	CP Cajon to SR 138- Mains 1 2	2	2.7	5.4
7B	CP Cajon to SR 138- Main 3	1	1.5	1.5
8A	SR 138 to I15- Mains 1 2	2	1.8	3.6
8B	SR 138 to I15- Main 3	1	0.8	0.8
9A	I15 to CP Silverwood- Mains 1 2	2	3.3	6.6
9B	I15 to CP Silverwood- Main 3	1	3.3	3.3
10	CP Silverwood to Main St., Hesperia	3	11.3	33.9
11	Main St., Hesperia to Bear Valley Rd.	3	3.8	7.6
12	Bear Valley Rd. to Green Tree Blvd.	3	2.2	6.6
13A	Green Tree Blvd. to Mojave Narrows Jct. (Over)	2	1.4	2.8
13B	Green Tree Blvd. to Mojave Narrows Jct. (Under)	1	1.4	1.4
14	Mojave Narrows Jct. to Hwy 18	3	1.2	3.6
15	Hwy 18 to I15, Victorville	3	1.1	3.3
16	I15, Victorville to Vista Rd., Helendale	3	13.9	41.7
17	Vista Rd., Helendale to Hinkley Rd.	3	11.3	33.9
18	Hinkley Rd. to Lenwood Rd.	3	4.8	14.4
19	Lenwood Rd. to SR 58	3	1.7	5.1
20	SR 58 to N 1st Ave	3	4.0	12
21	N 1st Ave to Yucca Ave	3	1.3	3.9
22	Yucca Ave to Daggett Jct.	3	7.8	23.4
23	Daggett Jct. to Yermo	2	4.9	9.8
24	Daggett Jct. to Newberry Rd.	2	12.7	25.4
	TOTAL		**~120**	**~330**

The wide disparity in lengths of discreet track segments for this high-level study is due to the fact that bridges are used as delineators between many OCS sections. While it is likely that many of the bridges are high enough for overhead catenary wire (50 kV at 25' above top-of-rail), some may require conductor bars, or even a break in the overhead contact system entirely. Some bridges were observed in the field to appear to be sufficiently greater than 25' above top-of-rail, so are not used as OCS segment delineators as catenary wire would go under them with sufficient clearance. In addition to select bridges, control points Cajon (MP 62.8) and Silverwood (MP 56.6) delineate discreet segments of overhead catenary wire, because Main 3 track splits from Mains 1 & 2 at these locations.

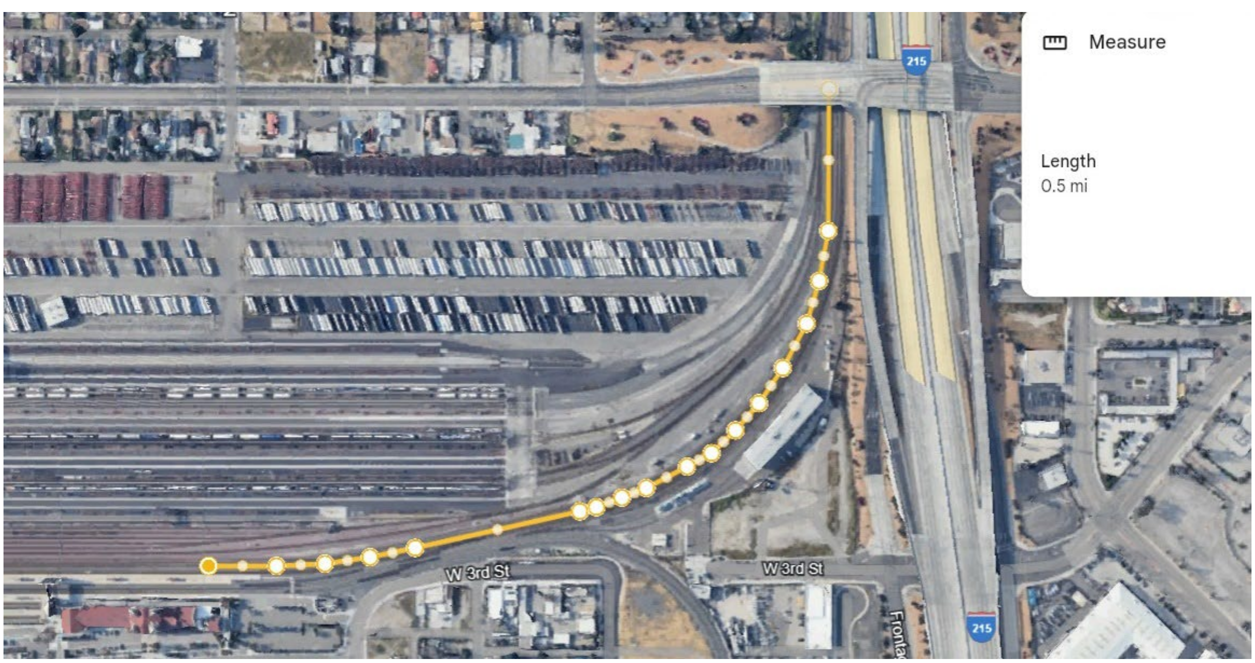
For the total track length count of 330 miles, it is assumed that there will be a minimum of three mainline tracks the entire length of the BNSF Cajon Subdivision. Significant track capacity projects, to add 3rd and 4th tracks, are underway. For example, 4.3 miles of new fourth main track between San Bernardino yard/station to State Street/University Parkway will soon be completed[1]. However, this analysis assumes the 4th main track would be extended a further 5.8 miles (northwest) from State Street/University Parkway to Glen Helen Parkway. In 2023, BNSF received a $50 million state grant for the High Desert Operational Efficiency Project (the Project) to construct approximately 11.2 miles of new 3rd track mainline from MP 41.8 (near Bear Valley Road in Hesperia) to Milepost 53.0 (about three track miles east of Cajon Summit) on the Cajon Subdivision[2].

[1] https://www.bnsf.com/news-media/news-releases/newsrelease.page?relId=bnsf-railway-advances-track-efficiency-improvements-in-san-bernardino

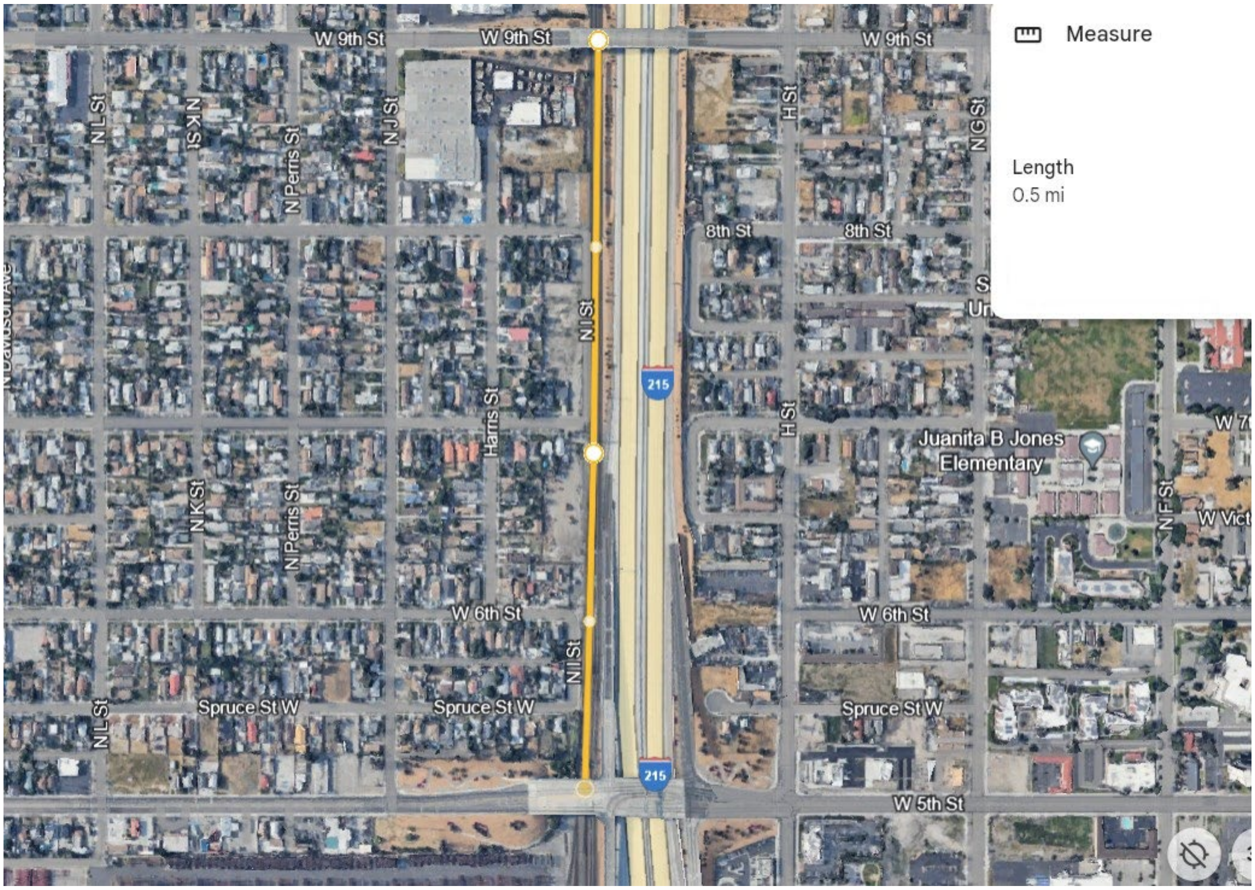
[2] https://catc.ca.gov/-/media/ctc-media/documents/programs/Senate-Bill-1/TCEP/fact-sheets/factsheets/6-high-desert-capacity-enhancement-fs.pdf

0. San Bernardino Station to W. 5th Street
2.0 miles

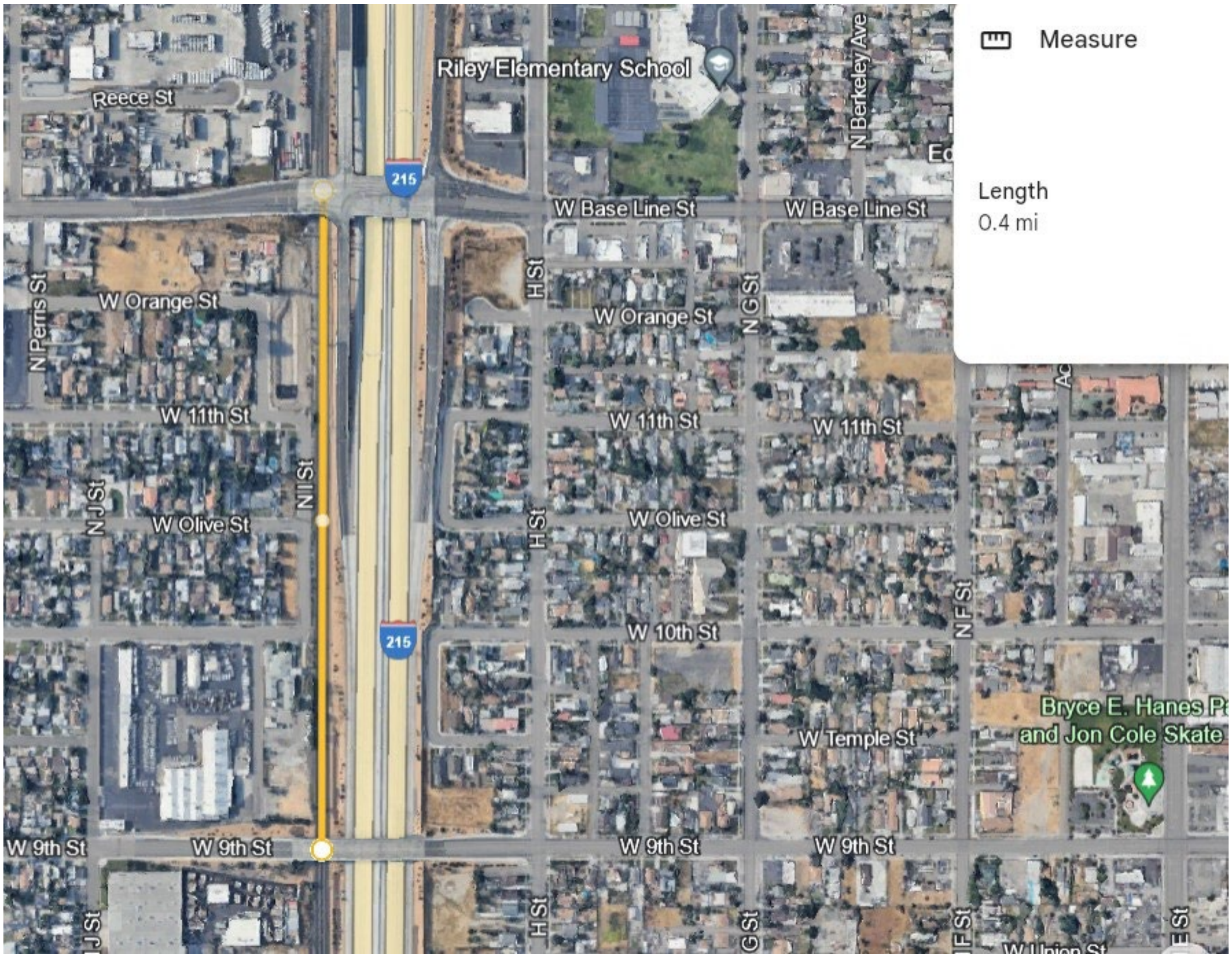
1. San Bernardino Station to W. 5th Street
0.5 miles



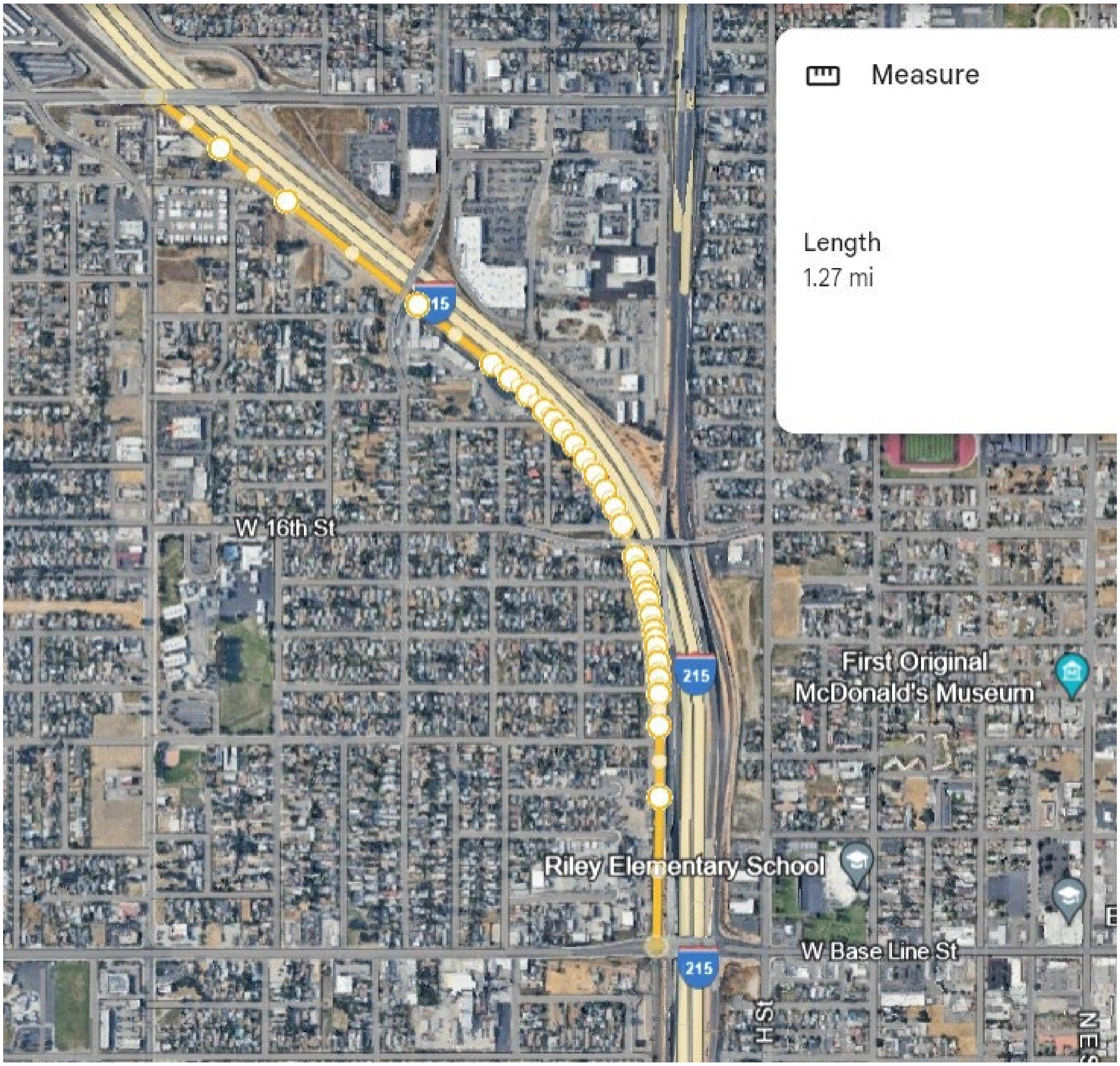
2. W 5th to W 9th St - 0.5 miles



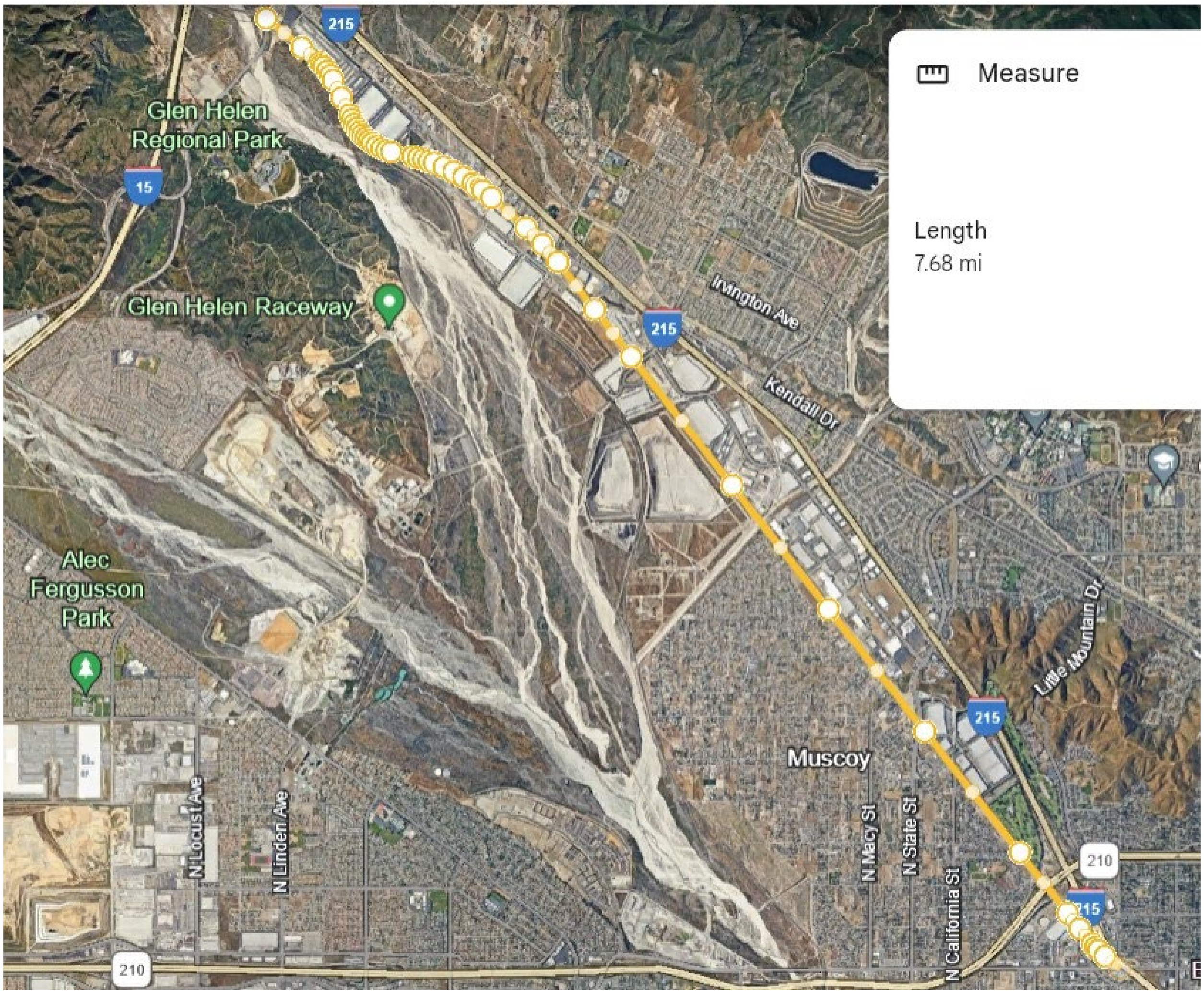
3. W 9th St to W Base Line St - 0.4 miles



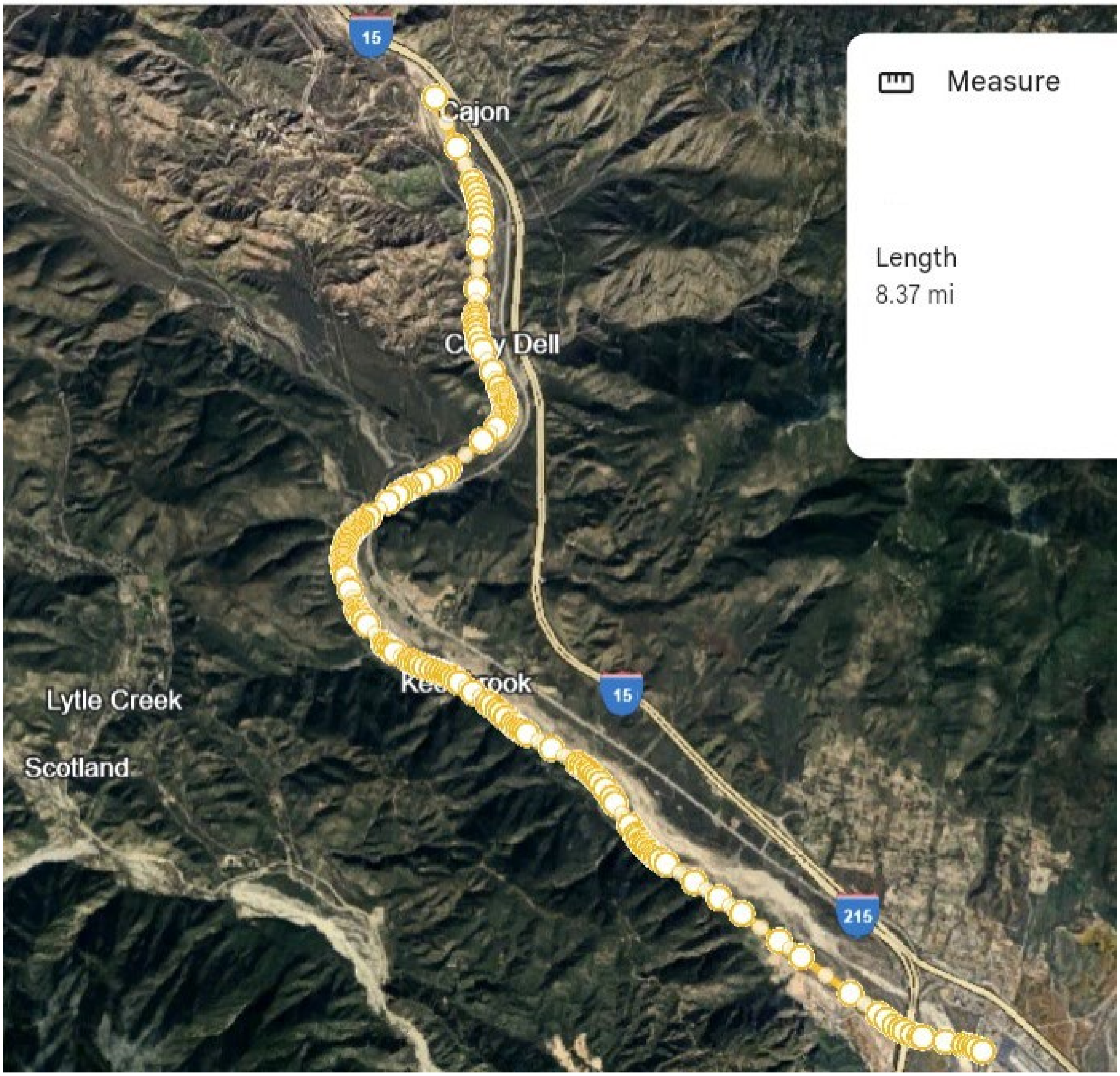
4. **W Base Line St to N Highland Ave - 1.3 miles**



5. N Highland Ave to Glen Helen Pkwy - 7.7 miles

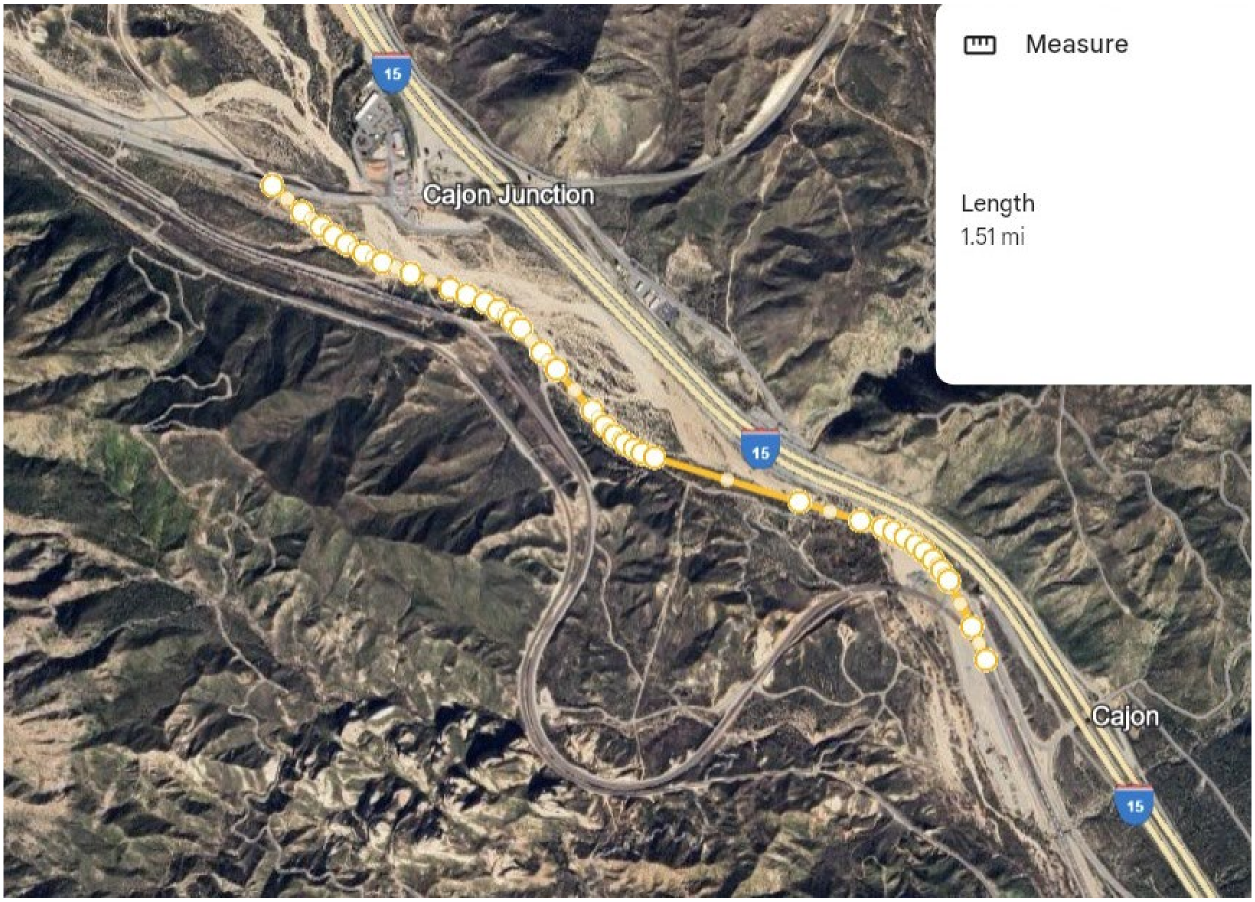


6. Glen Helen Pkwy to CP Cajon – 8.4 miles



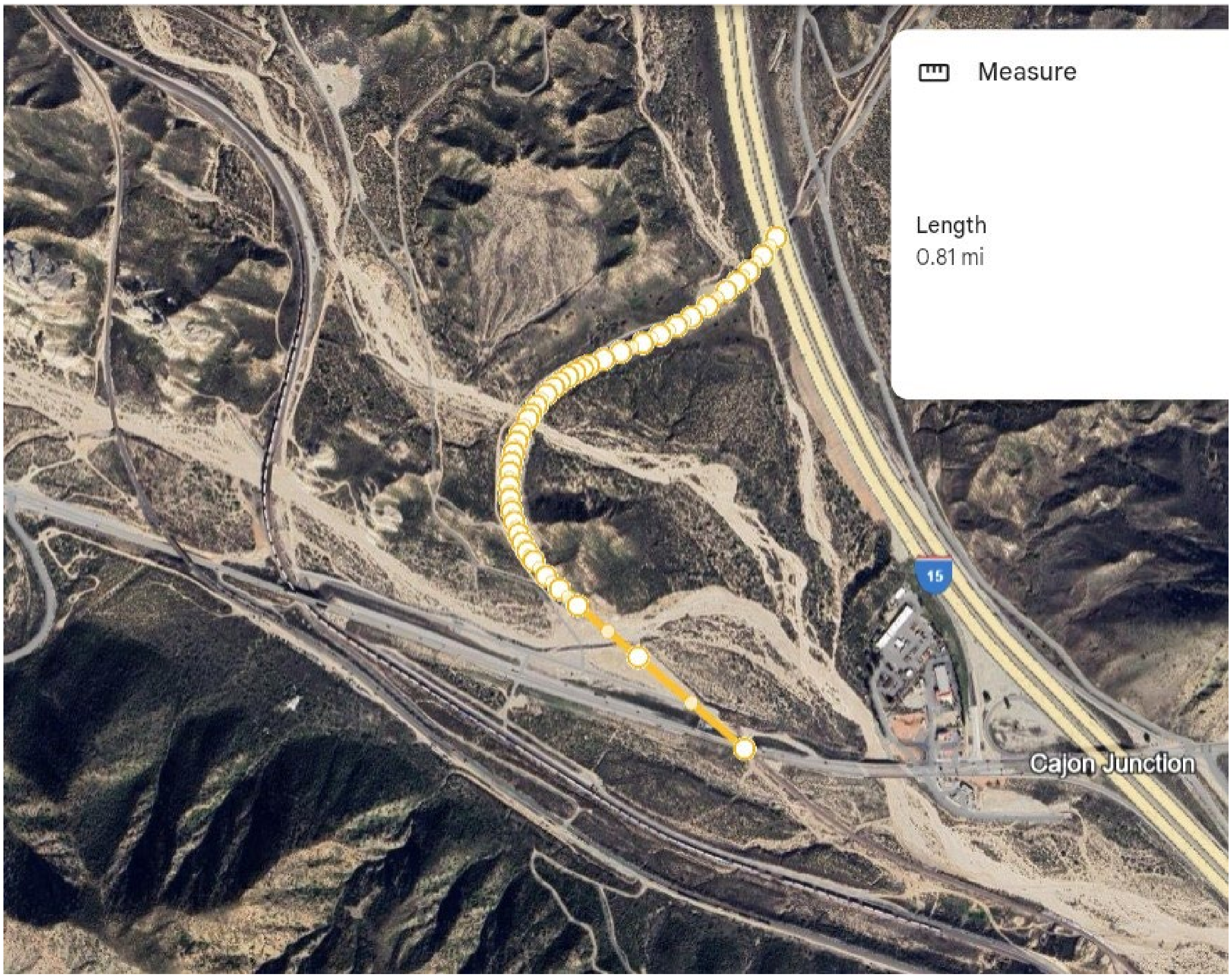
7A. CP Cajon to SR 138- Mains 1 2 – 2.7 miles

7B. CP Cajon to SR 138- Main 3 - 1.5 miles

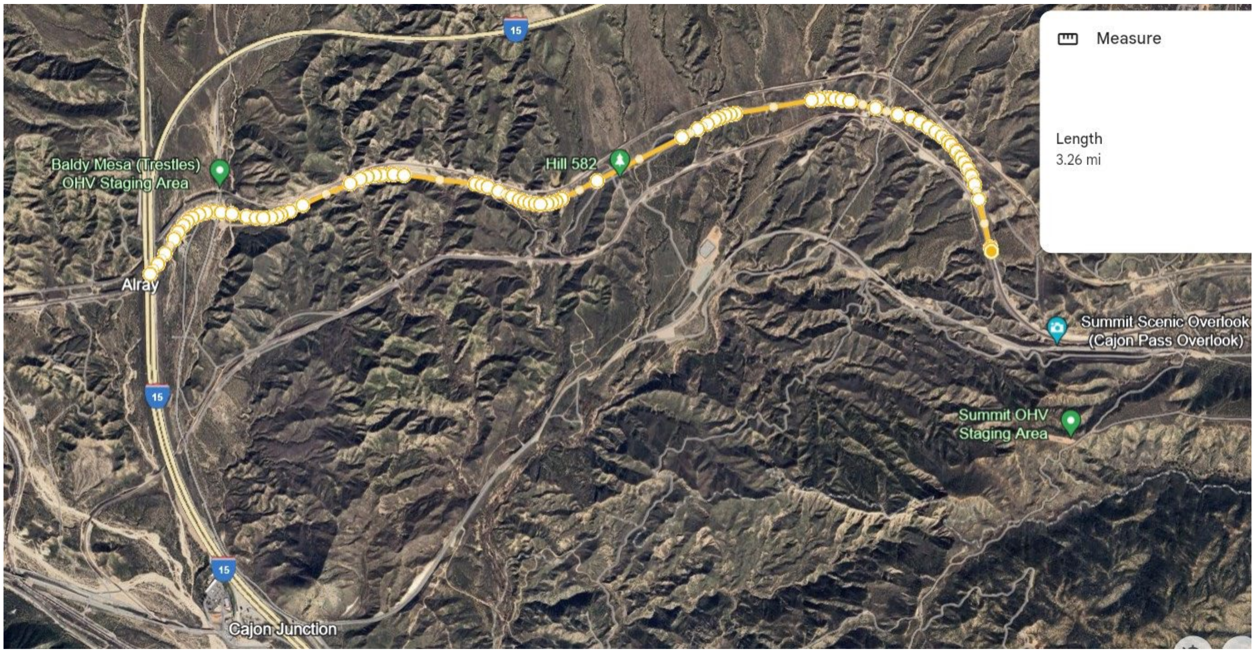


8A. SR 138 to I15- Mains 1 2 - 1.8 miles

8B. SR 138 to I15- Main 3 - 0.8 miles

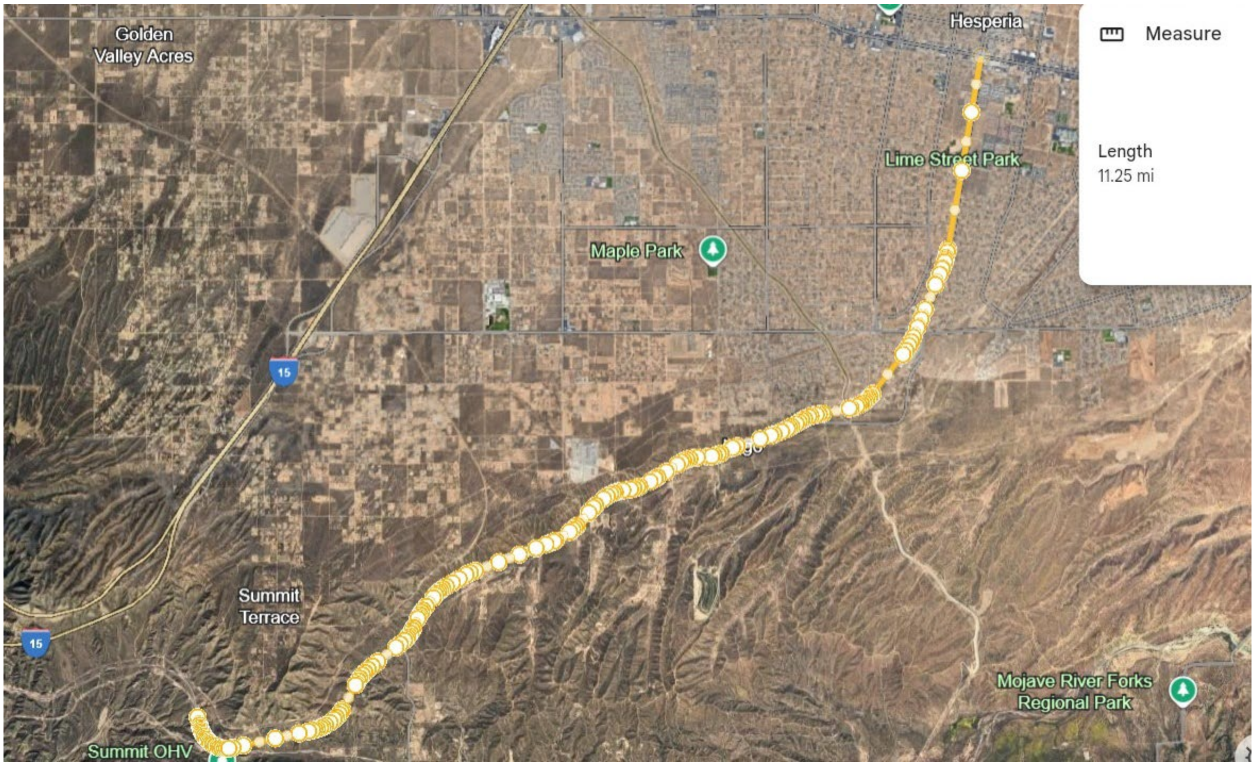


9A. I15 to CP Silverwood- Mains 1 2 - 3.3 miles

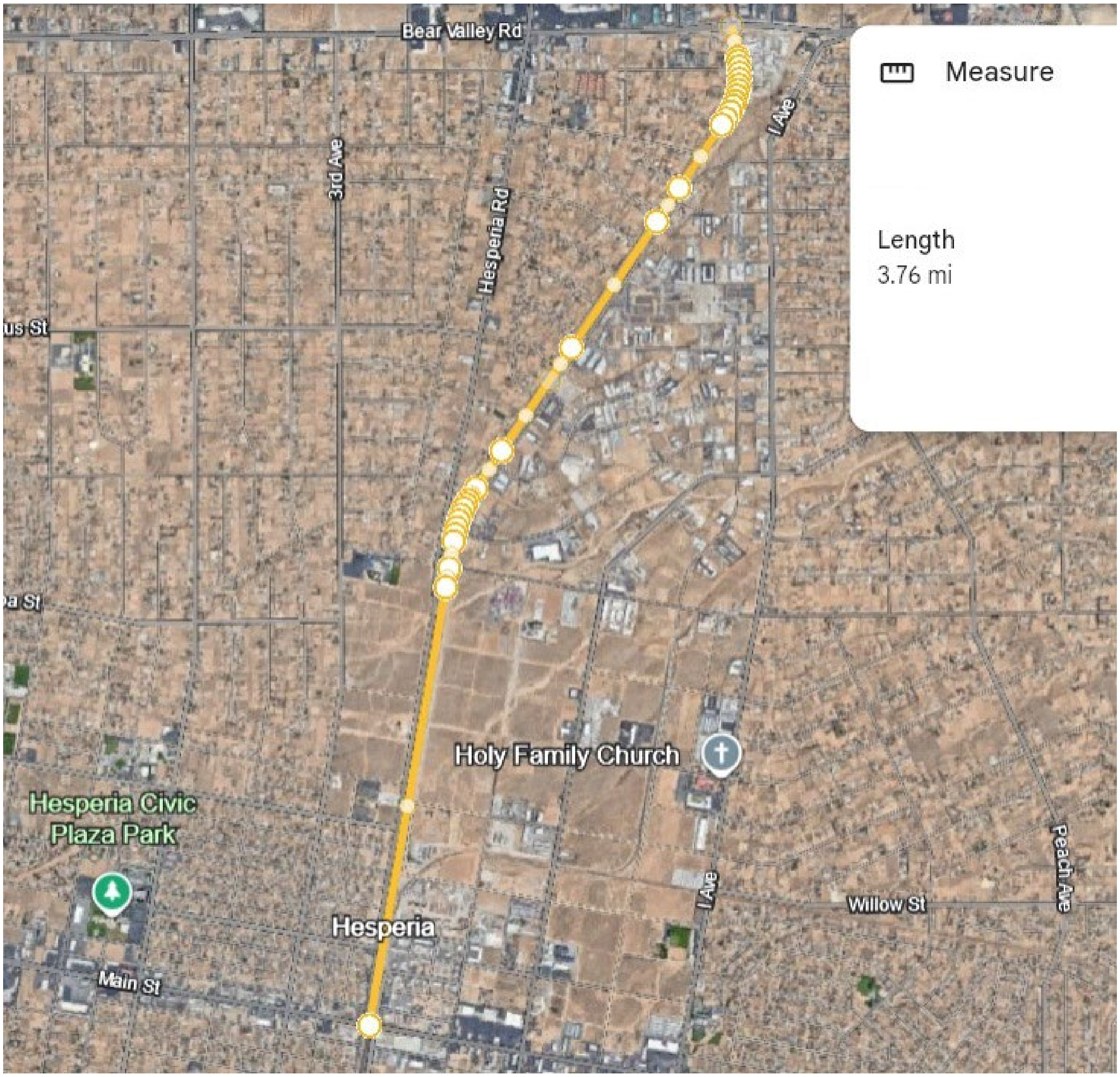


9B. I15 to CP Silverwood- Main 3 - 3.3 miles

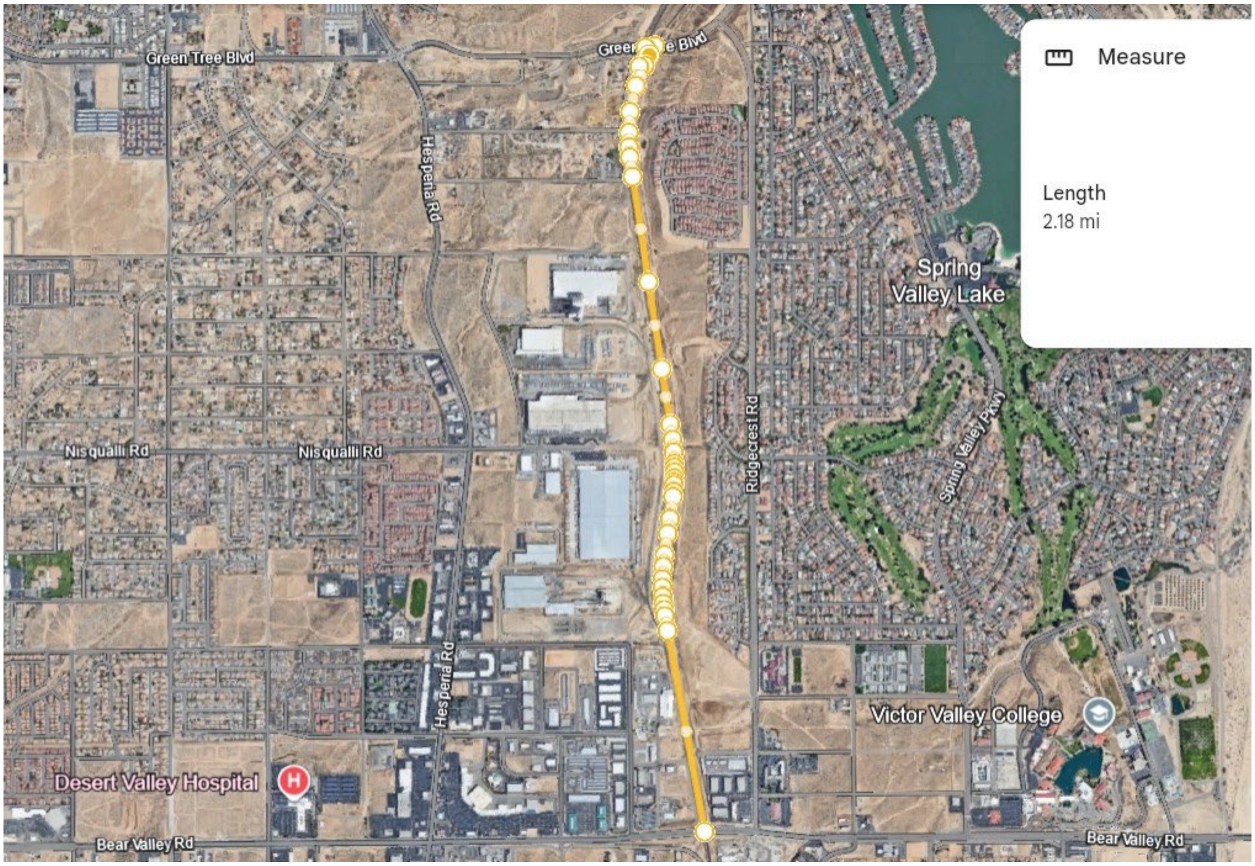
10. CP Silverwood to Main St., Hesperia - 11.3 miles



11. Main St., Hesperia to Bear Valley Rd. - 3.8 miles

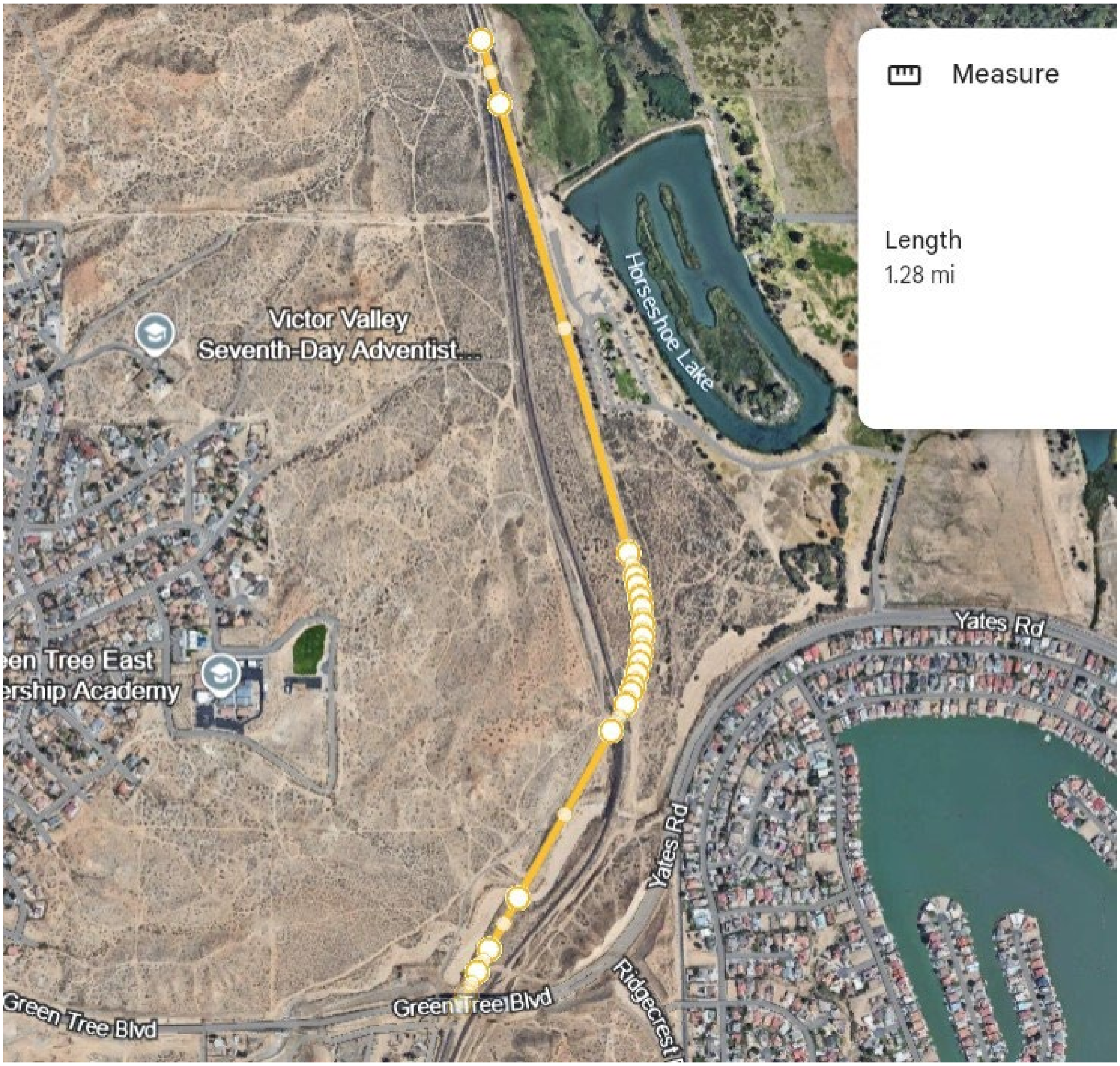


12. Bear Valley Rd. to Green Tree Blvd. - 2.2 miles

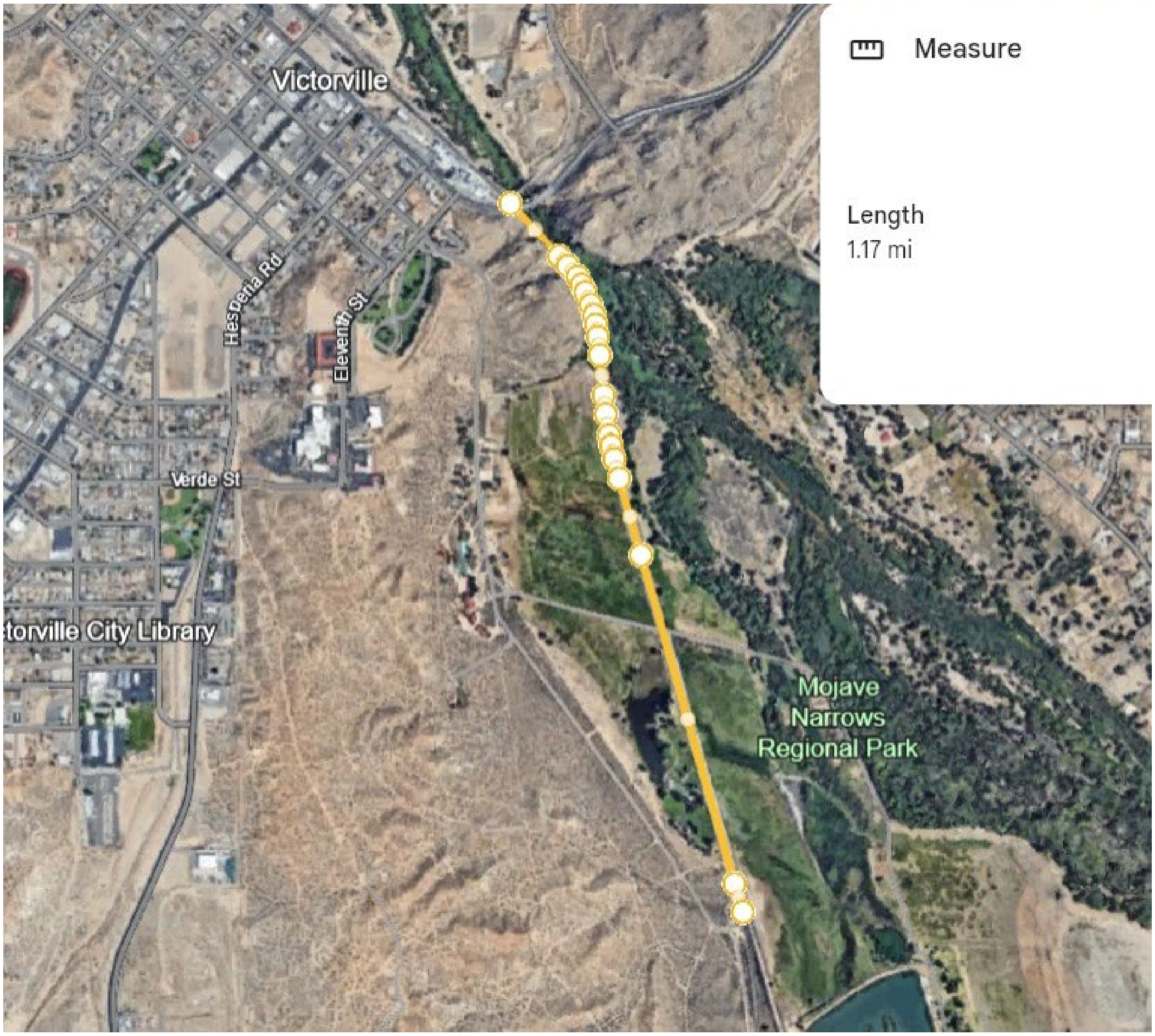


13A. Green Tree Blvd. to Mojave Narrows Jct. (OVER) - 1.3 miles

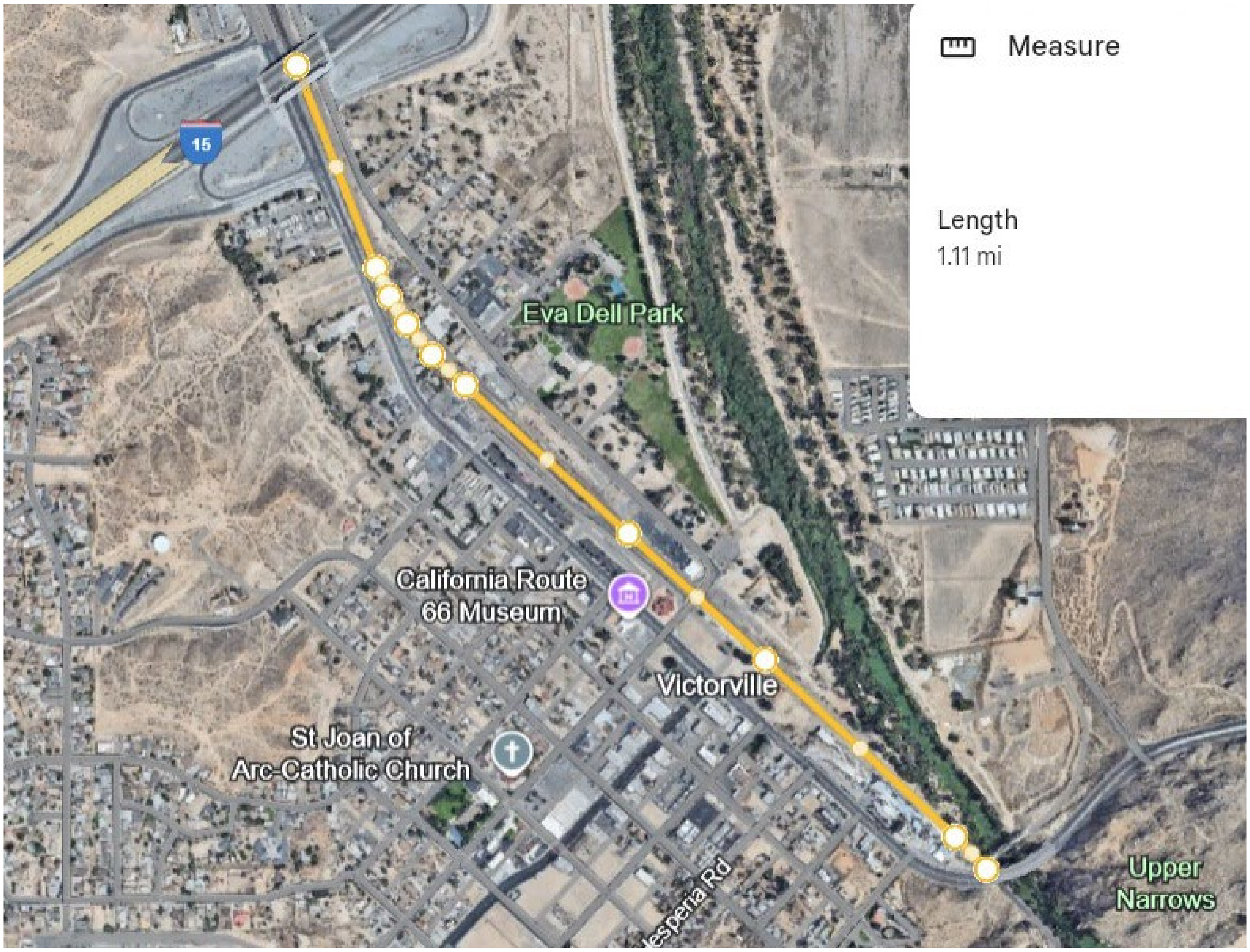
13B. Green Tree Blvd. to Mojave Narrows Jct. (UNDER) - 1.3 miles



14. Mojave Narrows Jct. to Hwy 18 - 1.2 miles



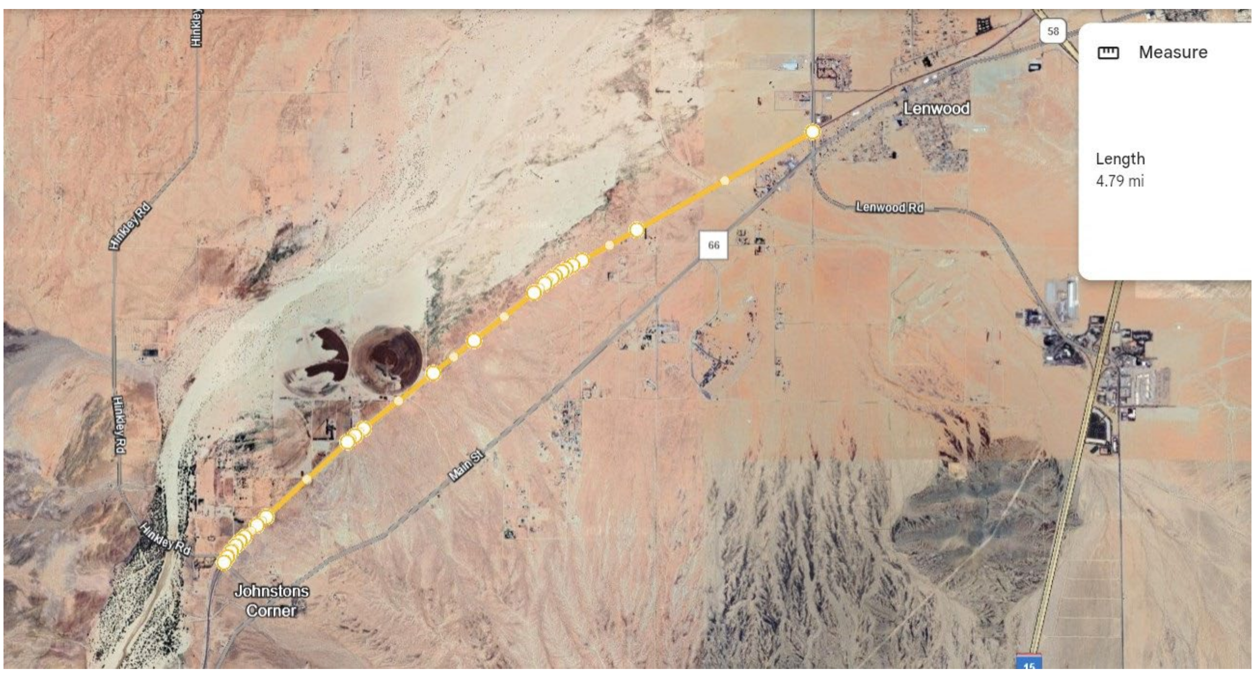
15. Hwy 18 to I15, Victorville - 1.1 miles



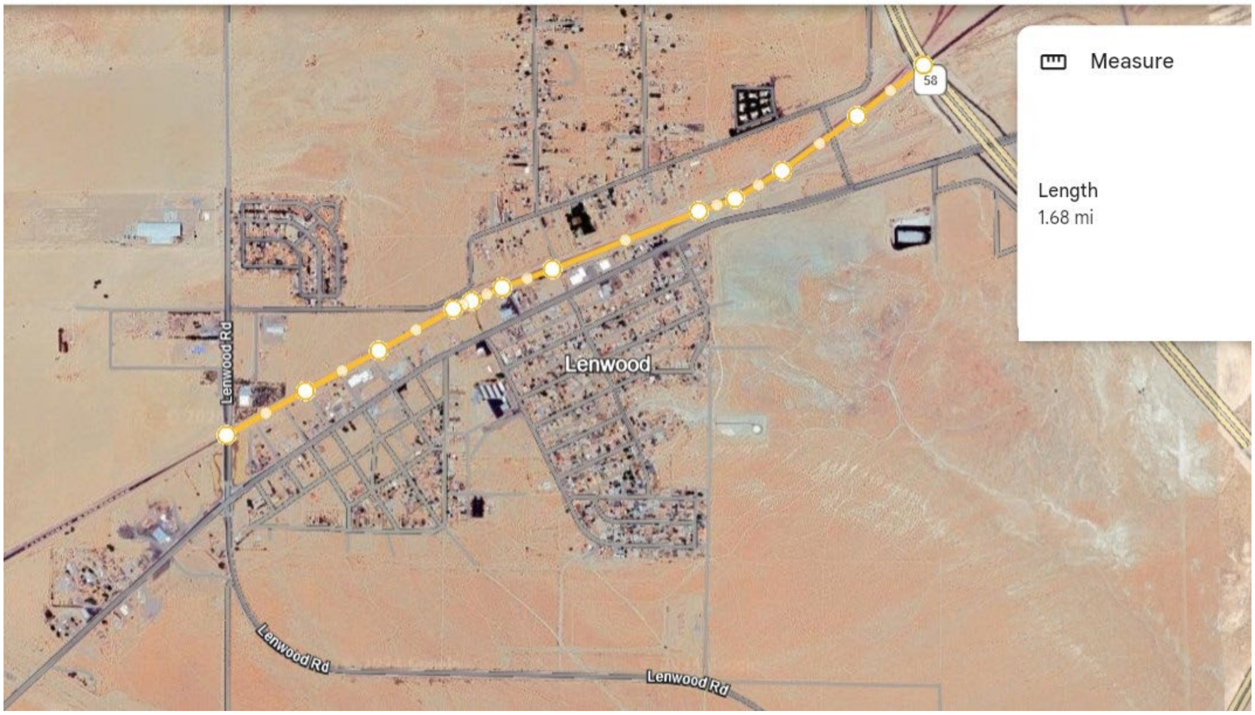
16. I15, Victorville to Vista Rd., Helendale - 13.9 miles

17. Vista Rd., Helendale to Hinkley Rd. - 11.3 miles

18. Hinkley Rd. to Lenwood Rd. - 4.8 miles



19. Lenwood Rd. to SR 58 -1.7 miles



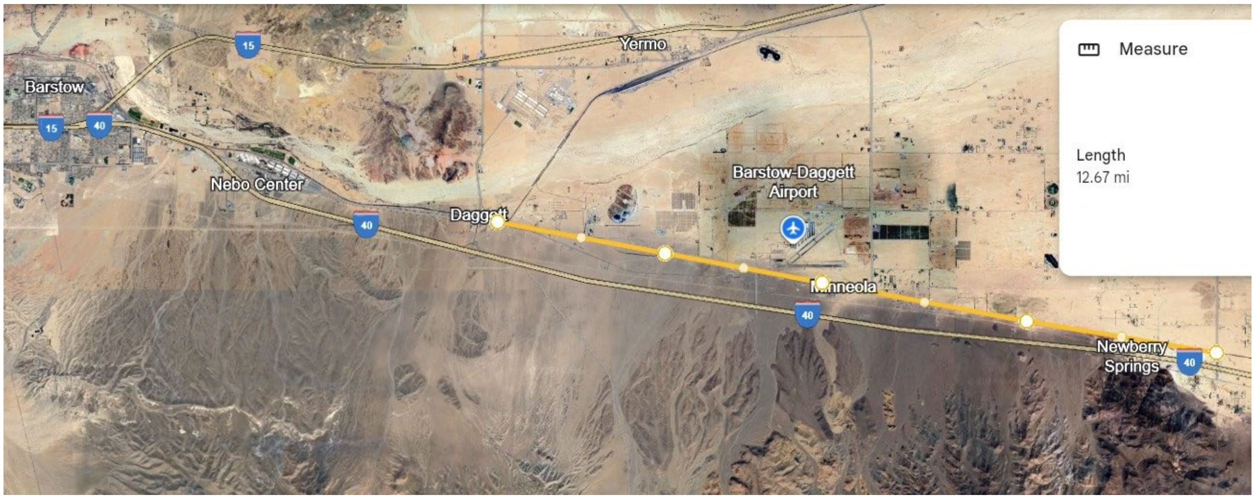
20. SR 58 to N 1st Ave - 4.0 miles

21. N 1st Ave to Yucca Ave - 1.3 miles

22. Yucca Ave to Daggett Jct. - 7.8 miles

23. Daggett Jct. to Yermo - 4.9 miles

24. Daggett Jct. to Newberry - 12.7 miles



Appendix C:

Cajon Subdivision

Bridges over BNSF Mainline

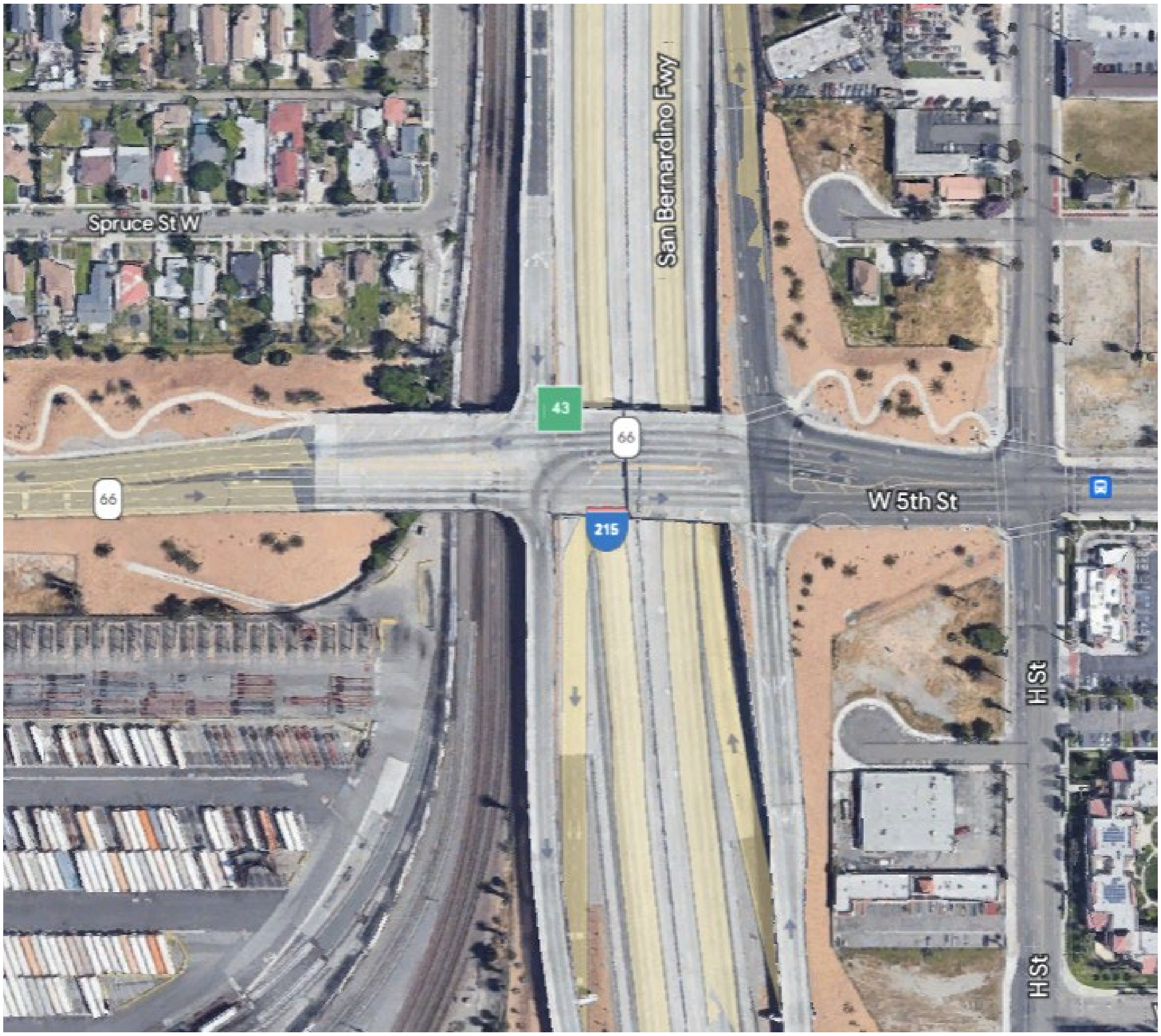
There are 26 road bridges and one railroad overpass between Daggett and San Bernardino.

All of them appear to be sufficiently high enough for 50 kV (with neutral sections, special insulators, etc at the lowest bridges), without modifications to the bridge or track. Many of them looked like they were built in the past 30 years or so, in the era of the double-stacked container train. [Federal Highway Administration's LTBP InfoBridge minimum vertical under clearance in the public database[1]],

1. **W. 5th St. (San Bernardino)**
2. **W. 9th St. (San Bernardino)**
3. **W. Base Line St. (San Bernardino)**
4. **W. 16th St. (San Bernardino)**
5. **N. Massachusetts Ave. (San Bernardino)**
6. **W. Highland Ave. (San Bernardino)**
7. **N. Mt. Vernon Ave. (San Bernardino)**
8. **SR 210 (San Bernardino)**
9. **N. State St./University Parkway (San Bernardino)**
10. **Palm Ave. (San Bernardino)**
11. **Glen Helen Parkway (San Bernardino)**
12. **I-15 (Devore)**
13. **SR 138 Cajon (Mains 1 and 2)**
14. **SR 138 Cajon (Main 3)**
15. **I-15 Cajon (Mains 1 and 2)**
16. **I-15 Cajon (Main 3)**
17. **Main St. (Hesperia)**
18. **Bear Valley Road (Victorville)**
19. **Green Tree Blvd. (Victorville)**
20. **Railroad overcrossing north of Green Tree Blvd. (Victorville)**
21. **D St. (Victorville)**
22. **Mineral Rd. (Victorville)**
23. **I-15 (Victorville)**
24. **Lenwood Rd. (Barstow)**
25. **SR 58 (Barstow)**
26. **N. 1st. Ave. (Barstow)**
27. **Yucca Ave (Barstow)**

[1] https://infobridge.fhwa.dot.gov/

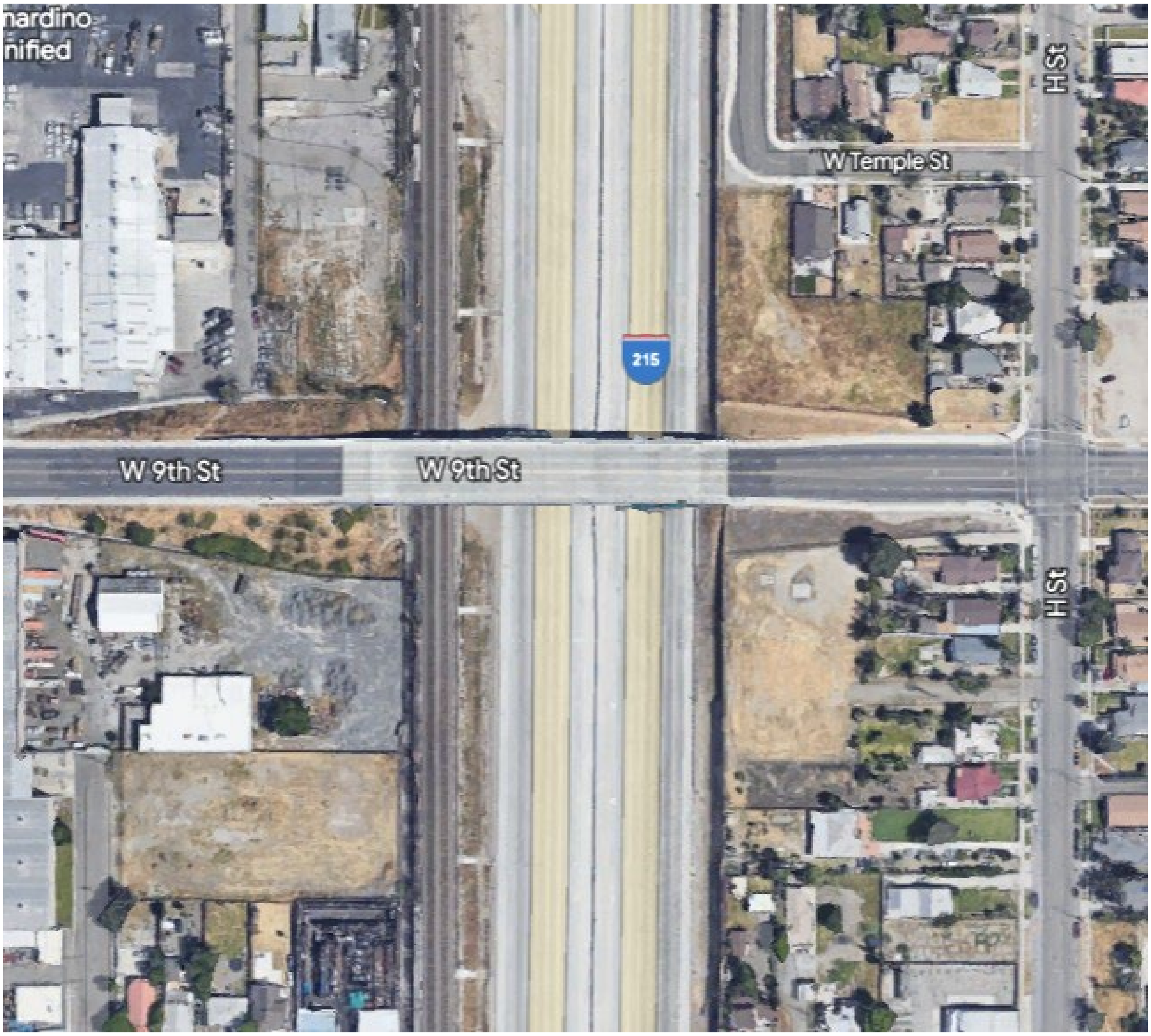
1. W. 5th St. (San Bernardino)



Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

W. 5th Street bridge, San Bernardino (February 16, 2024 photo)

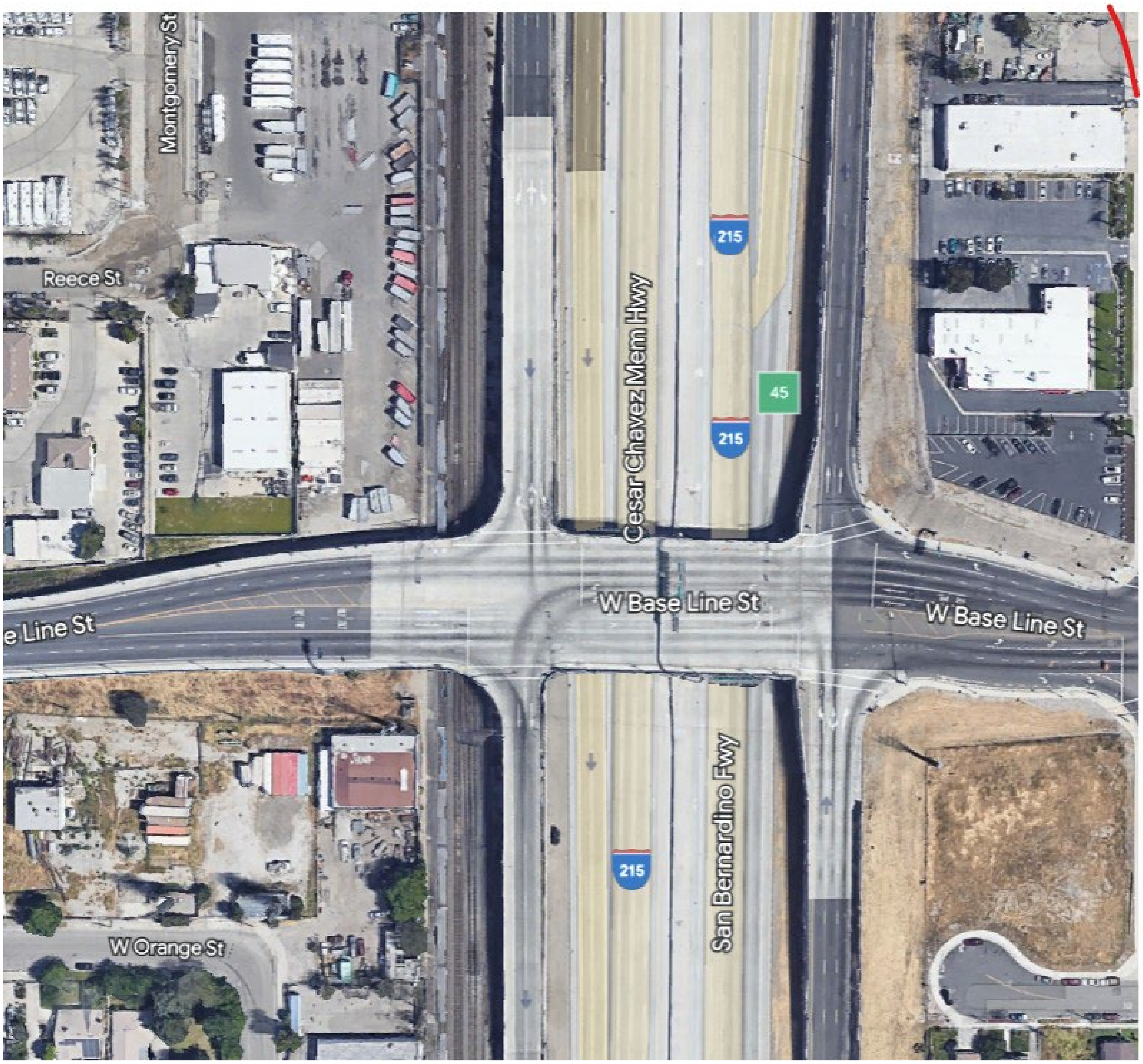
2. W. 9th St. (San Bernardino)



Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

W. 9th Street bridge, San Bernardino (February 16, 2024 photo)

3. W. Base Line St. (San Bernardino)



Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

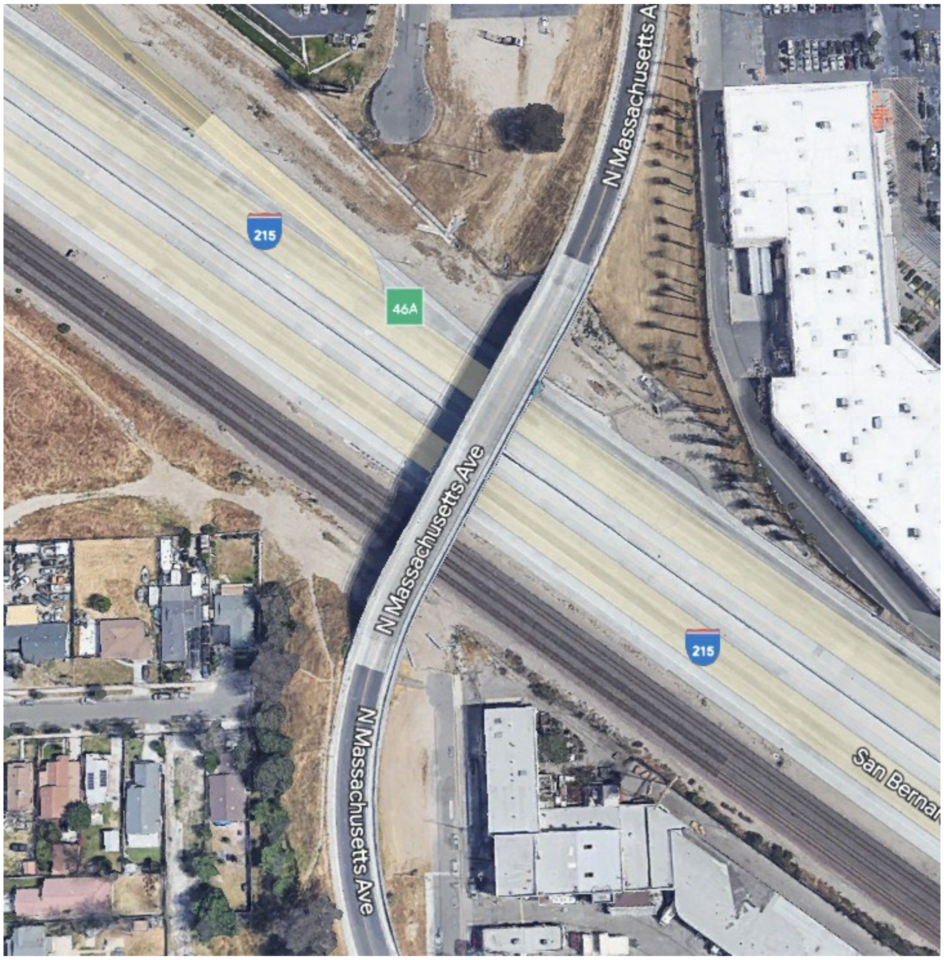
[25.4’]

Base Line Street bridge, San Bernardino (February 16, 2024 photo)

4. W. 16th St. (San Bernardino)

West 16th Street bridge, San Bernardino (February 16, 2024 photo)

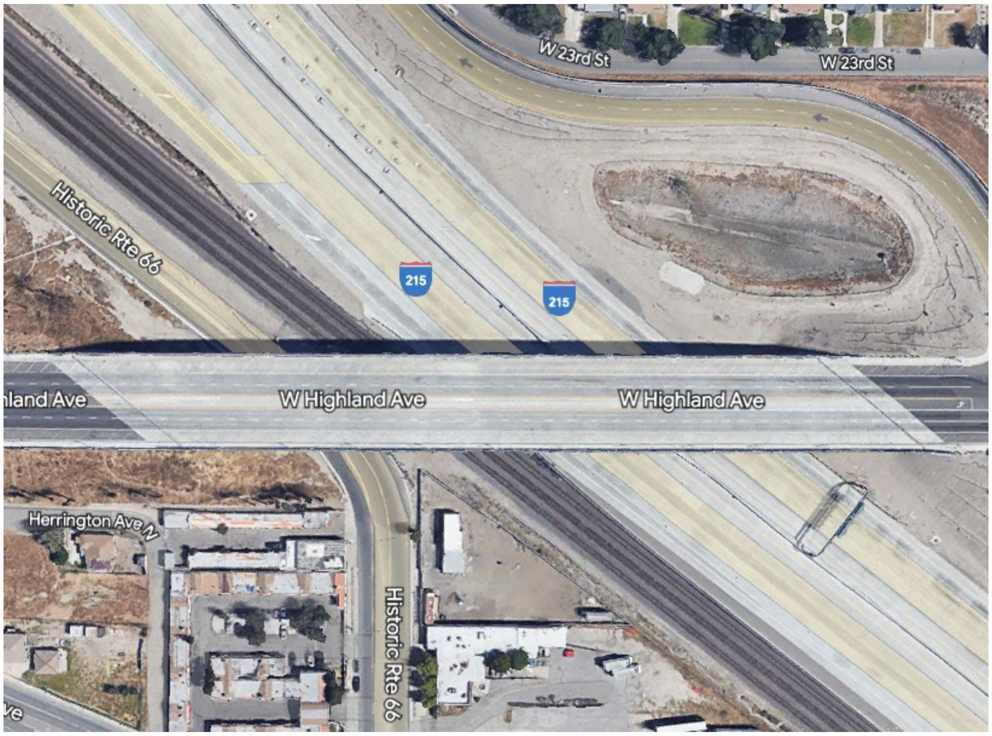
5. N. Massachusetts Ave. (San Bernardino)



[26.8’]

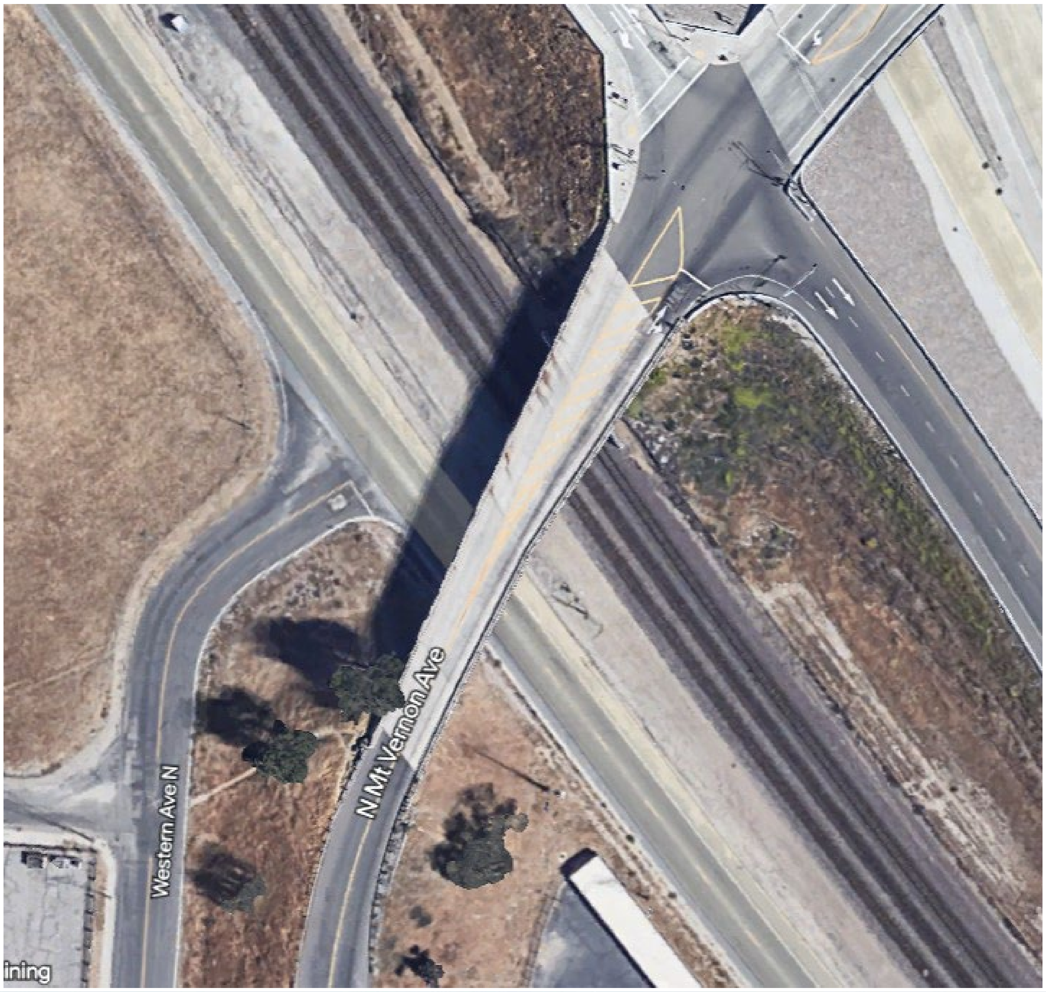
Massachusetts Avenue bridge, San Bernardino (February 16, 2024 photo

6. W. Highland Ave. (San Bernardino)



Highland Avenue bridge, San Bernardino (February 16, 2024 photo)

7. N. Mt. Vernon Ave. (San Bernardino)



N. Mt. Vernon Avenue bridge, San Bernardino (February 16, 2024 photo)

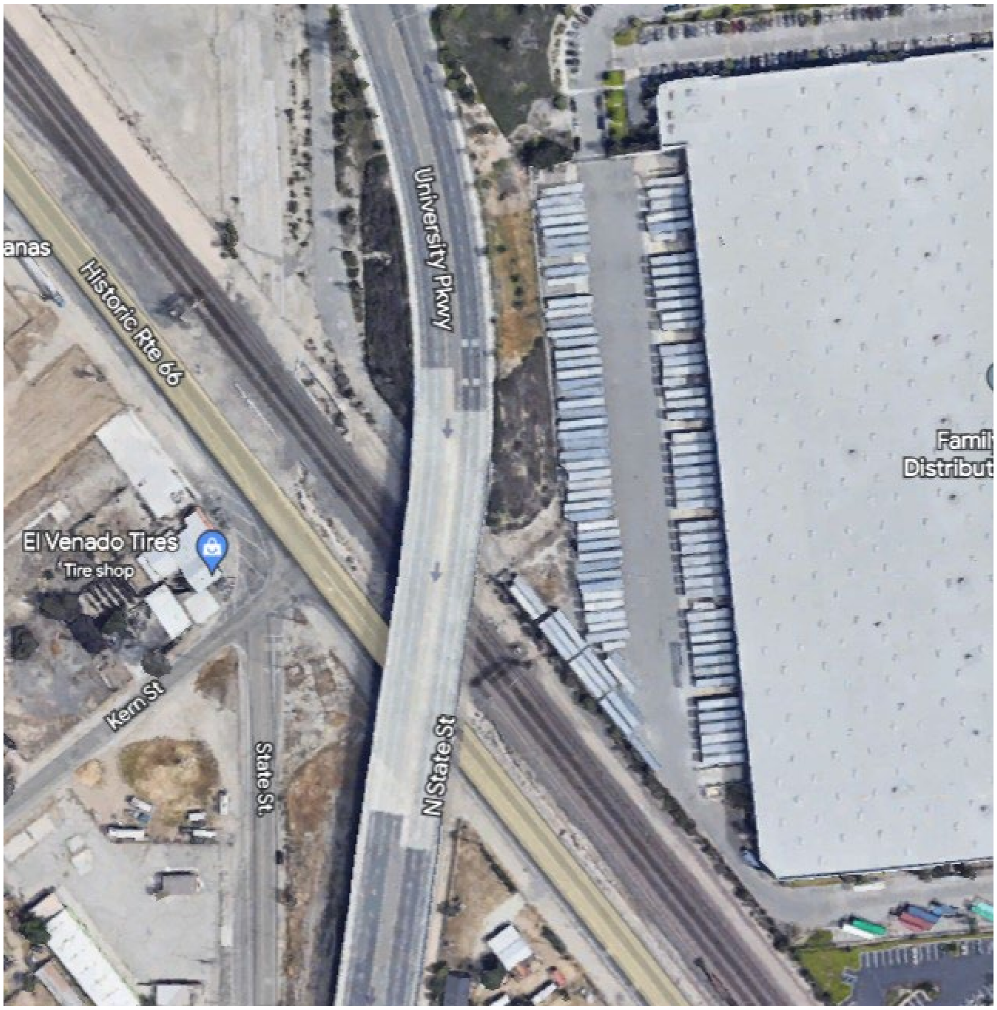
8. SR 210 (San Bernardino)

Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

[27’, 23.9’, 24.9’]

SR 210 bridges, San Bernardino (February 16, 2024 photos)

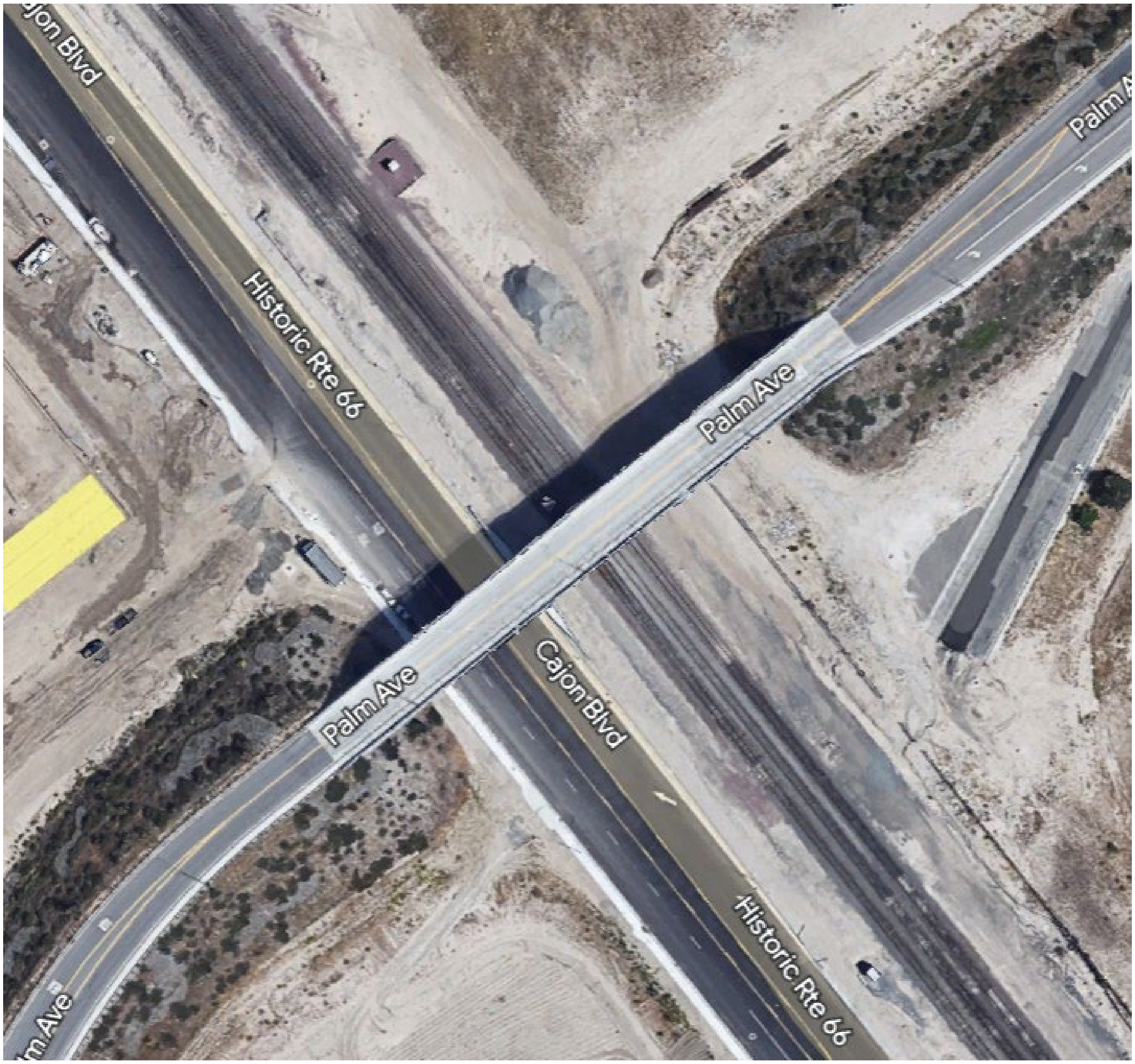
9. N. State St./University Parkway



[24.6’]

N. State Street/University Parkway bridge, San Bernardino (February 16, 2024 photo)

10. Palm Ave. (San Bernardino)



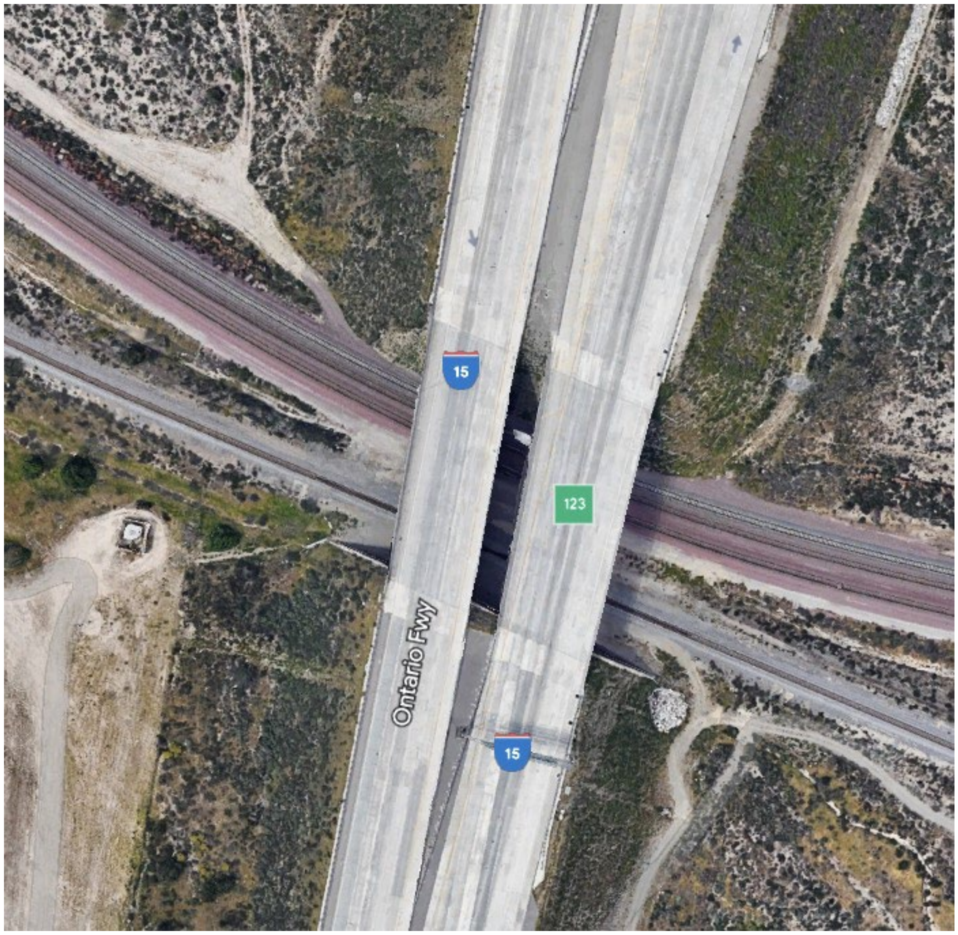
Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

[25.8’]

Palm Avenue bridge, San Bernardino (February 16, 2024 photos)

11. Glen Helen Parkway (San Bernardino)

12. I-15 (Devore)



[25’, 24.6’]

I-15 bridge, Devore (September 15, 2023 photo)

Cajon-area bridges

13. SR 138 Cajon (Mains 1 and 2)

[24.0’]

SR 138 – Mains 1 and 2 bridge at Cajon (November 5, 2024 photos)

14. SR 138 Cajon (Main 3)

[24.1’]

SR 138 - Main 3 bridge at Cajon (November 5, 2024 photos)

15. I-15 Cajon (Mains 1 and 2)

[22.5’]

Interstate 15 – Mains 1 and 2 bridge at Cajon (November 16, 2024 photos)

16. I-15 Cajon (Main 3)

Interstate 15 –Main 3 bridge at Cajon (November 5, 2024 photo)

[23.1’]

Interstate 15 – Main 3 bridge at Cajon (November 16, 2024 photo)

17. Main St. (Hesperia)

[23.6’]

Main Street Hesperia (September 15, 2023 photo)

18. Bear Valley Road (Victorville)

[23.2’]

Bear Valley Road (September 15, 2023 photo

19. Green Tree Blvd. (Victorville)

Green Tree Boulevard bridge (September 15, 2023 photo)

20. Railroad overcrossing, north of Green Tree Blvd. (Victorville)

(September 15, 2023 photo)

21. D St. (Victorville)

22. Mineral Rd. (Victorville)

Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

Mineral Road [23.6’] and D Street [24.9’] bridges, Victorville (September 15, 2023 photo)

23. I-15 (Victorville)

[24.2’, 27.4’]

I-15 bridge, Victorville (September 15, 2023 photo)

24. Lenwood Rd. (Barstow)

[24.2’]

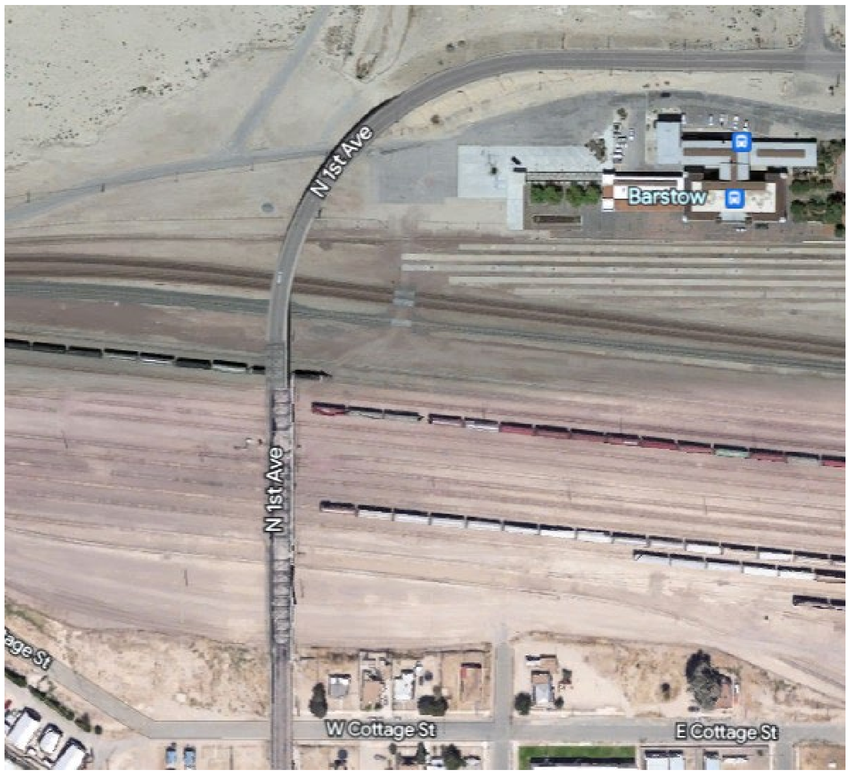
Lenwood Road bridge (December 4, 2023 photo)

25. SR 58 (Barstow)

[25’, 25’, 23.8’]
State Route 58 bridge (December 4, 2023 photo)

26. N. 1st. Ave. (Barstow)

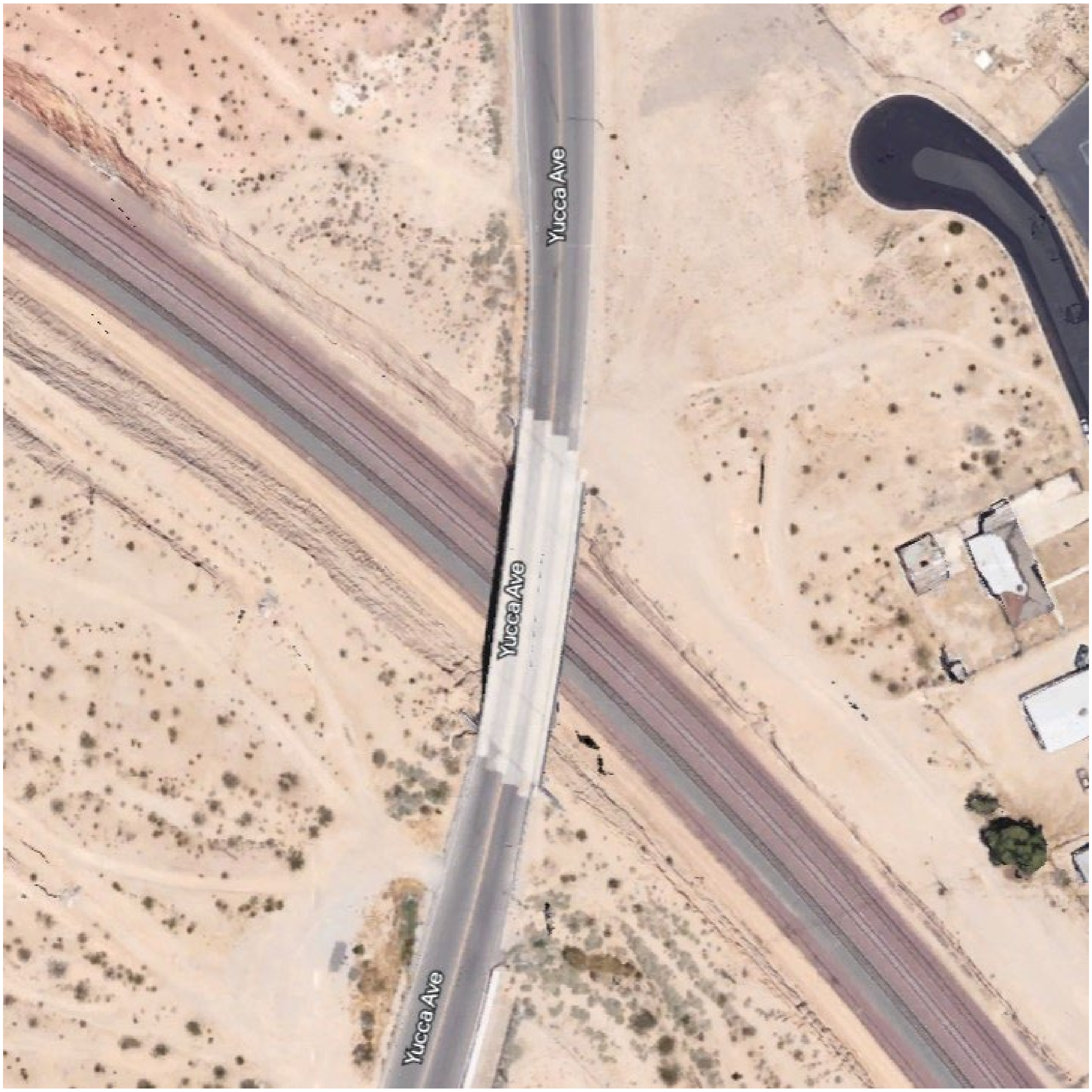
New bridge opened in July 2024, Google Earth imagery below not yet updated and shows old bridge.



Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

North 1st Avenue bridge (November 5, 2024 photo)

27. Yucca Ave (Barstow)



Appendix C: San Bernardino-Barstow bridges over the BNSF mainline

[24.3’]

Yucca Avenue bridge (December 4, 2023 photo)