Electrification of the LOSSAN Rail Corridor between Anaheim and San Diego

Concept Paper
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Californians for Electric Rail
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The 127-mile Los Angeles-San Diego segment of the LOSSAN Rail Corridor is the second-busiest intercity passenger rail corridor in the United States. The state-supported Amtrak *Pacific Surfliner* runs 13 daily round trips between LA and San Diego, in addition to Southern California Regional Rail Authority (Metrolink) and North County Transit District (NCTD) Coaster trains on the northern and southern portions, respectively. Due to the frequent passenger traffic, and great potential for future passenger growth, electrification of LOSSAN between LA and San Diego has long been discussed[1]. The 2025 Electrolink white paper by Californians for Electric Rail estimated that electrification would reduce Amtrak *Surfliner* LA-San Diego trip time to 148 minutes, down from 176 minutes from diesel trains today[2]. Electrification of the 30-mile LA-Anaheim segment, on the right-of-way of the LA Metro Valley Subdivision and BNSF San Bernardino Subdivision, is planned for the LA-Anaheim segment of California High Speed Rail[3]. This concept paper looks at rail electrification infrastructure for a 25 kV overhead contact system (OCS), compatible with California HSR, or the 103 route-miles between Fullerton Junction[4] and San Diego Santa Fe Depot on the:

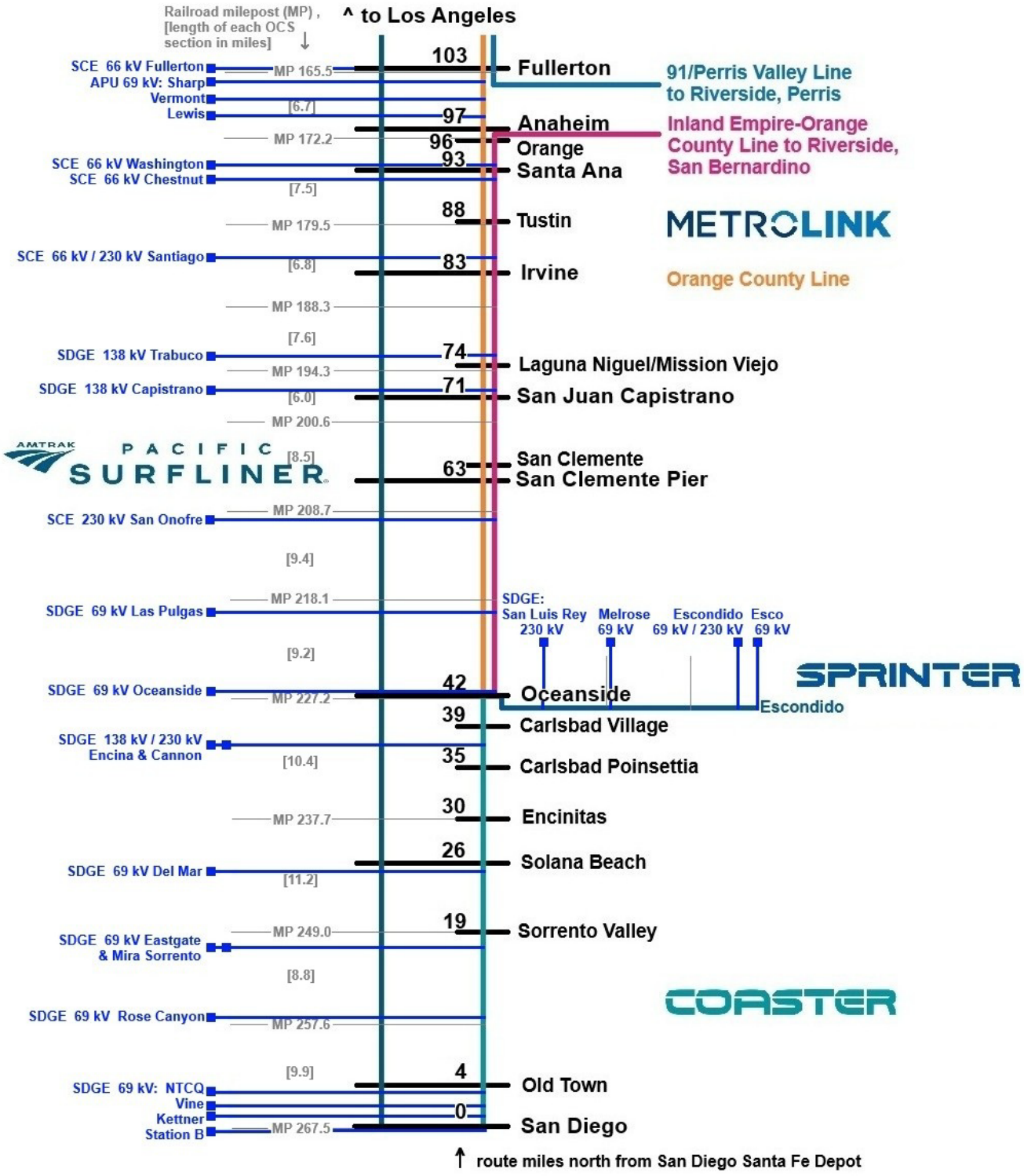
- Orange County Transportation Authority (OCTA) Orange Subdivision [42 miles]
- North County Transit District (NCTD) San Diego Subdivision [61 miles], which connects at Oceanside to the Escondido Subdivision [22 miles, hosting the Sprinter]

This document's purpose is to show a plausible physical electric rail infrastructure layout and system configuration between Anaheim and San Diego, 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 locating adjacent or nearby traction power substations. This report will provide a starting point for rail electrification discussions with the electric utilities.

Assuming that overhauled California cars would be able to operate into the 2040s, the *Pacific Surfliner* route can be reequipped with the intercity version of the Stadler KISS

[1] http://reasonrail.blogspot.com/2015/09/a-cost-to-benefit-analysis-of-railroad.html
[2] https://calelectricrail.org/wp-content/uploads/2025/09/electrolink-final-final.pdf
[3] https://hsr.ca.gov/program-areas/environmental-planning/environmental-documents/project-section-environmental-documents-tier-2/los-angeles-to-anaheim-project-section-environmental-documents/
[4] Between Fullerton Jct. and Anaheim ARTIC station-with 6 miles of overlap with LA-Anaheim CHSR section.

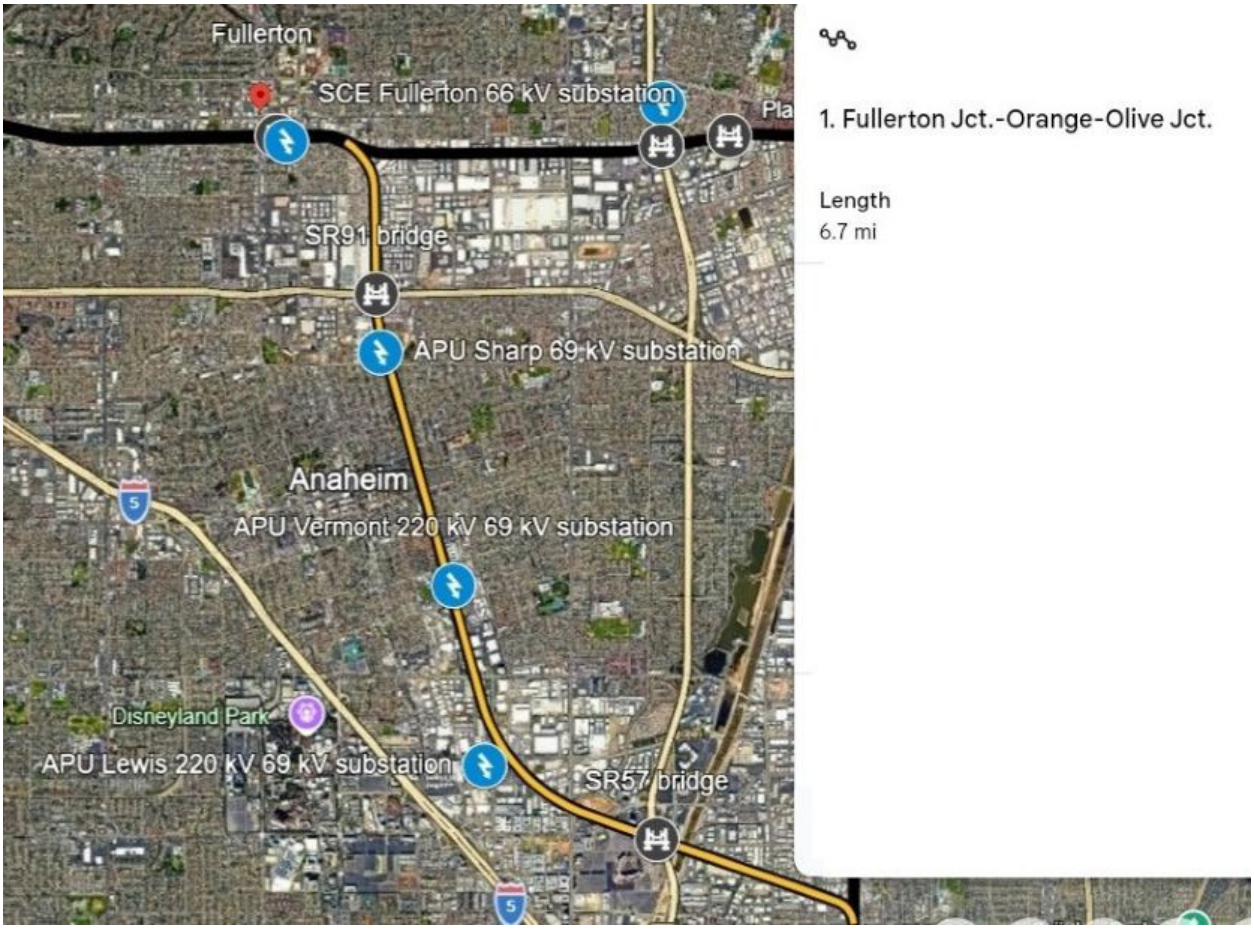
battery/overhead catenary cars (the same model as Caltrain uses), and Metrolink and Coaster using the 'regional' version of KISS, or similar bilevel EMU rolling stock. This also spreads out the capital expenditure over more years and fully utilizes the service life of the Surfliner and California car fleet.

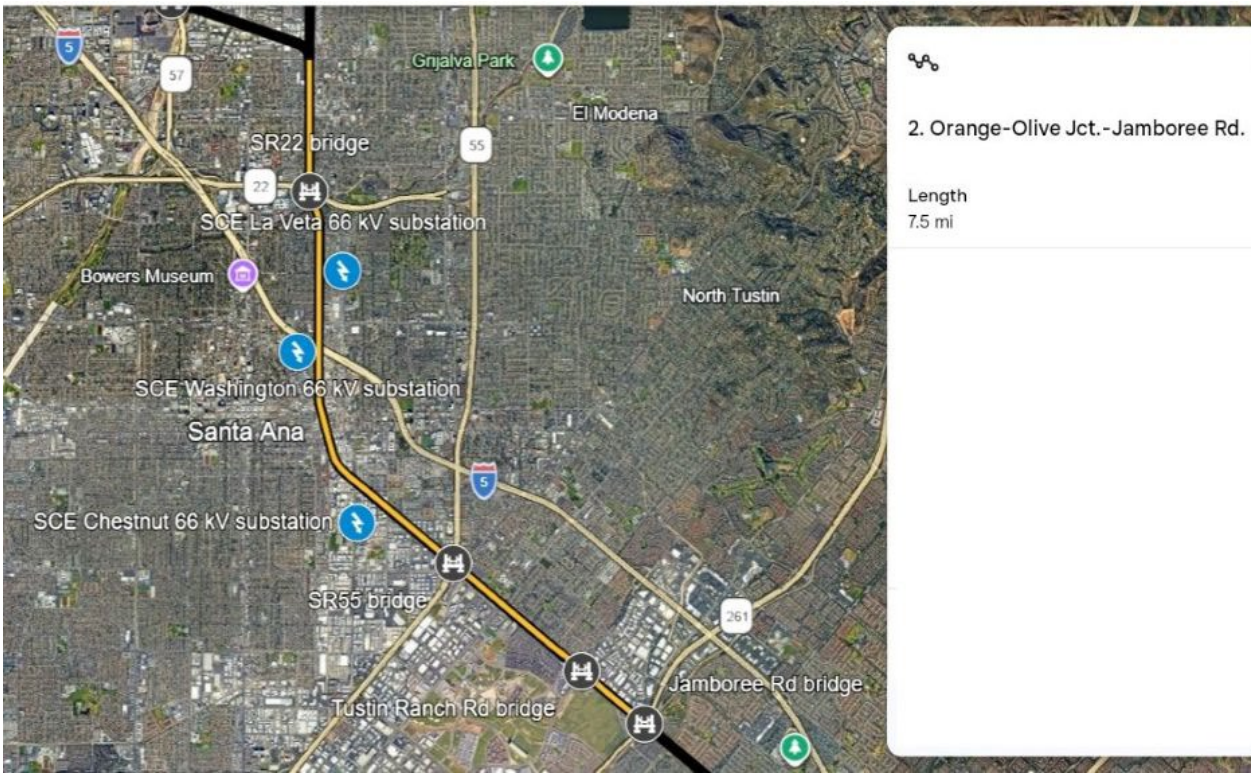


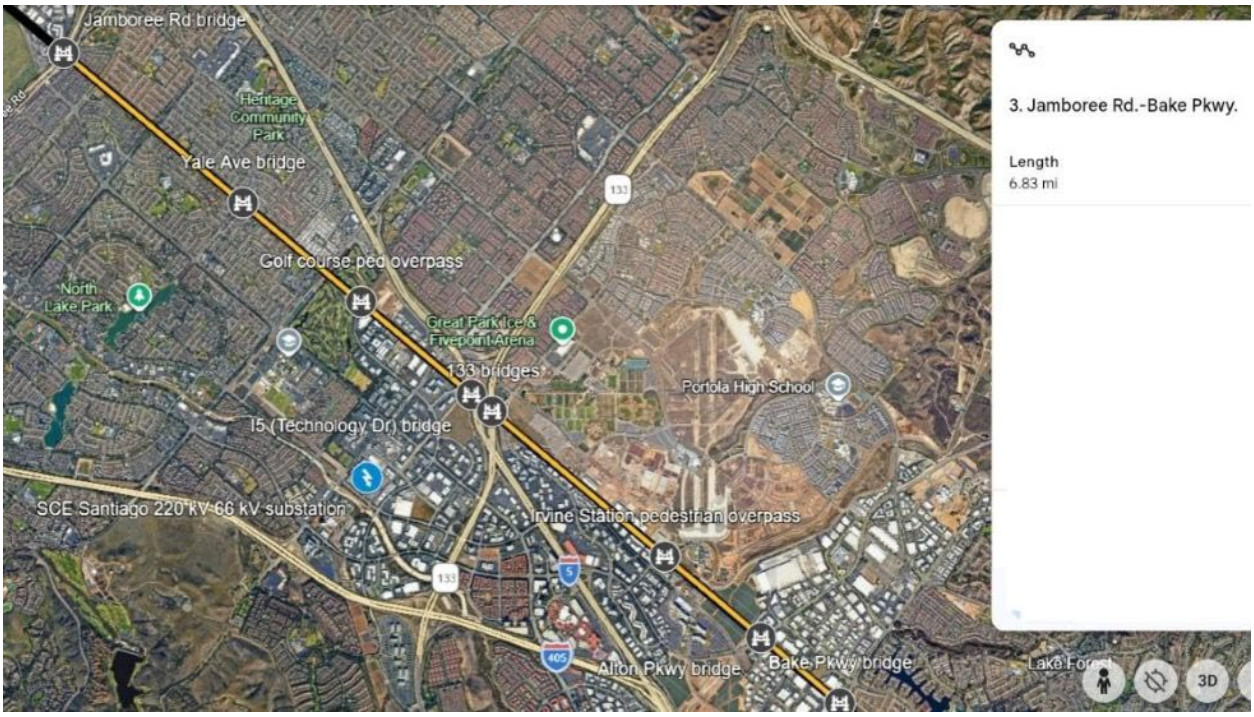
OCS sections

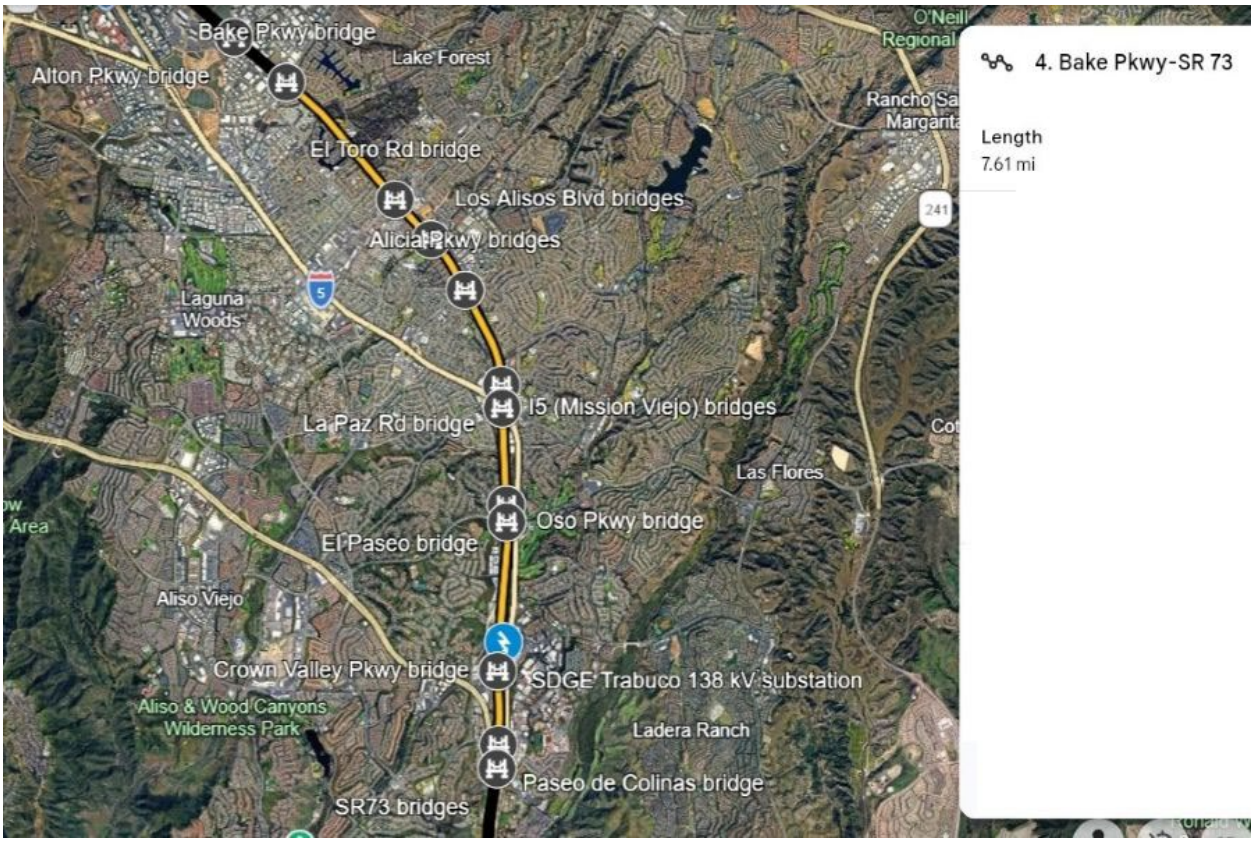
The segment boundaries listed below do not necessarily correspond to proposed possible locations of switching stations (located generally midway between traction power substations). They are proposed to provide a general guide to the scale of OCS sections between Anaheim and San Diego. Google Earth images of each, with segment length measurements, are shown below. Route miles do not include yard sidings, sections of double track, sidings, or industrial lead tracks. Much of the route is currently single-tracked, but it is assumed the entire Anaheim-San Diego LOSSAN rail corridor will eventually be double tracked. The location of existing and traction power substations and sections where inland tunnel bypasses are planned (San Clemente, Del Mar, Miramar) can be 'future proof' in that substation locations will not need to change with the new track alignment. Also, the coastal single-track sections currently in need of realignment further inland, San Clemente and Del Mar, do not need OCS installed as they are short enough (under 9 miles) to be covered by battery power between OCS sections.

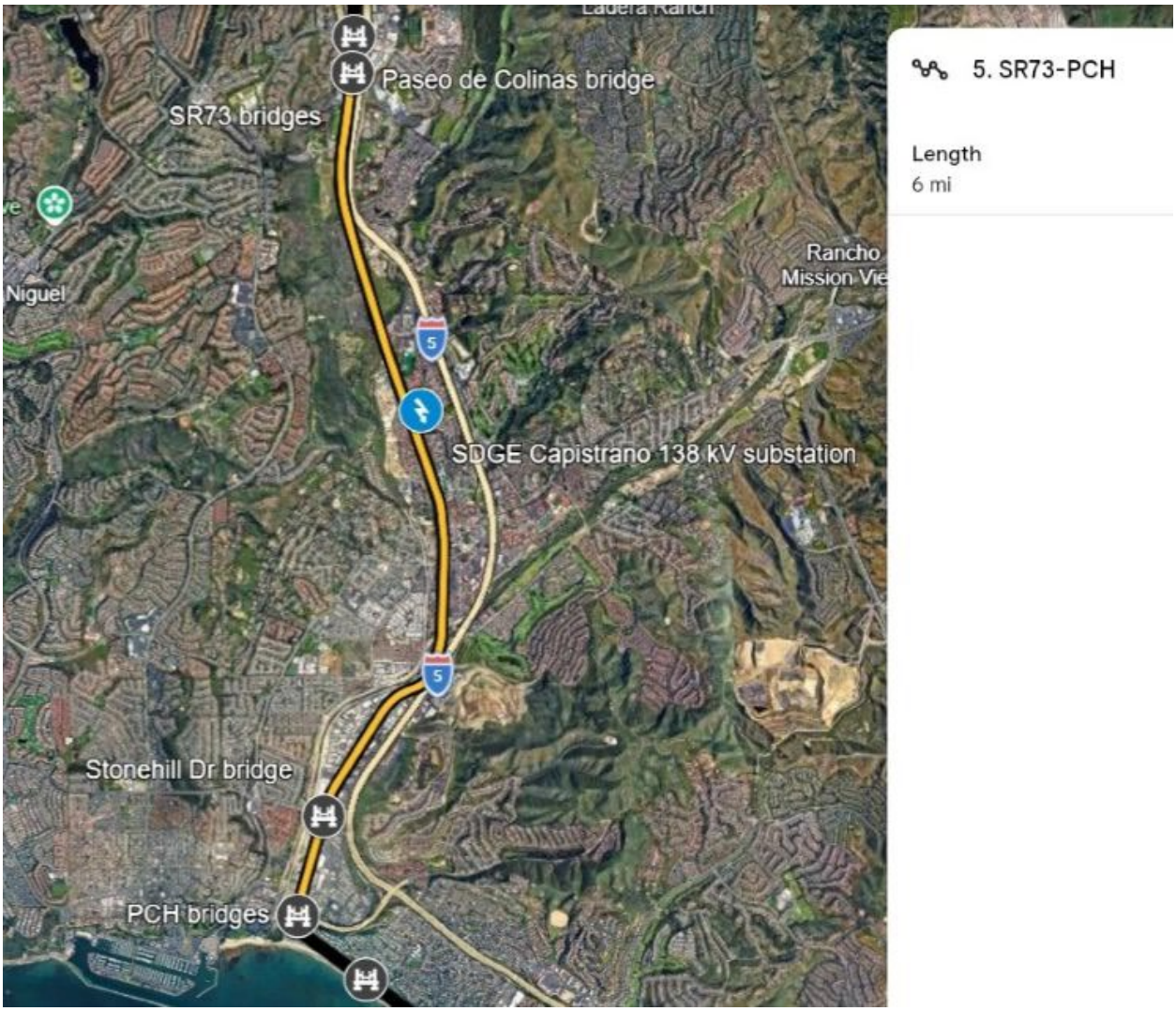
	LOSSAN Segment	**Route miles**
1	Fullerton Jct. - Orange-Olive Jct.	6.7
2	Orange-Olive Jct. - Jamboree Rd.	7.5
3	Jamboree Rd. - Bake Pkwy	6.8
4	Bake Pkwy - SR73	7.6
5	SR73 - Pacific Coast Hwy	6.0
6	Pacific Coast Hwy - San Onofre	8.5
7	San Onofre - Pulgas	9.4
8	Pulgas - Esco Jct.	9.2
9	Esco Jct. - Encinitas	10.4
10	Encinitas - Sorrento Valley	11.2
11	Sorrento Valley - SR52	8.8
12	SR52 - San Diego Depot	9.9
		102
	NCTD Escondido Sub. (Sprinter)	**Route miles**
1	Esco Jct.-Melrose Dr.	8.3
2	Melrose Dr.-Palomar College	7.4
3	Palomar College-Esco	6.6
		22.3

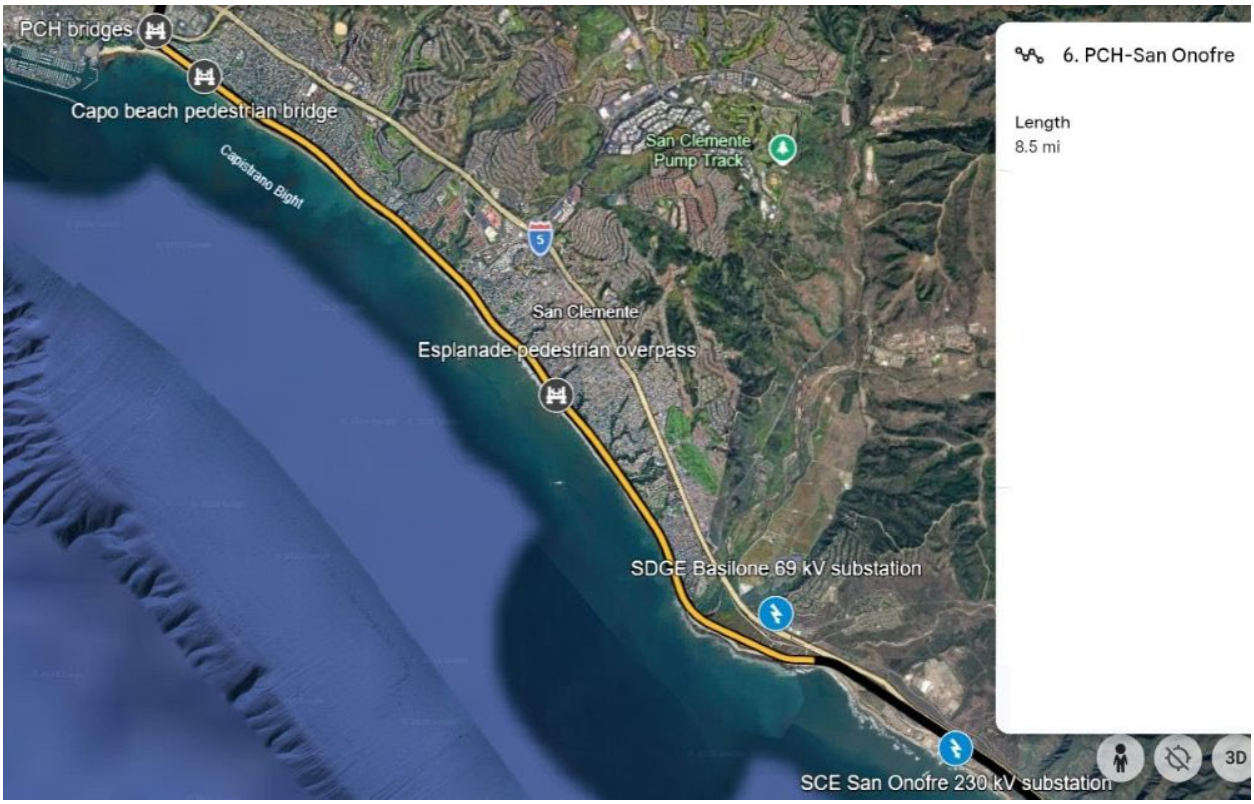

Fullerton
SCE Fullerton 66 kV substation
SR91 bridge
APU Sharp 69 kV substation
Anaheim
APU Vermont 220 kV 69 kV substation
Disneyland Park
APU Lewis 220 kV 69 kV substation
SR57 bridge
1. Fullerton Jct.-Orange-Olive Jct.
Length
6.7 mi


Gnjalva Park
El Modena
SR22 bridge
SCE La Veta 66 kV substation
Bowers Museum
North Tustin
SCE Washington 66 kV substation
Santa Ana
SCE Chestnut 66 kV substation
SR55 bridge
Jamboree Rd bridge
Tustin Ranch Rd bridge
2. Orange-Olive Jct.-Jamboree Rd.
Length
7.5 mi

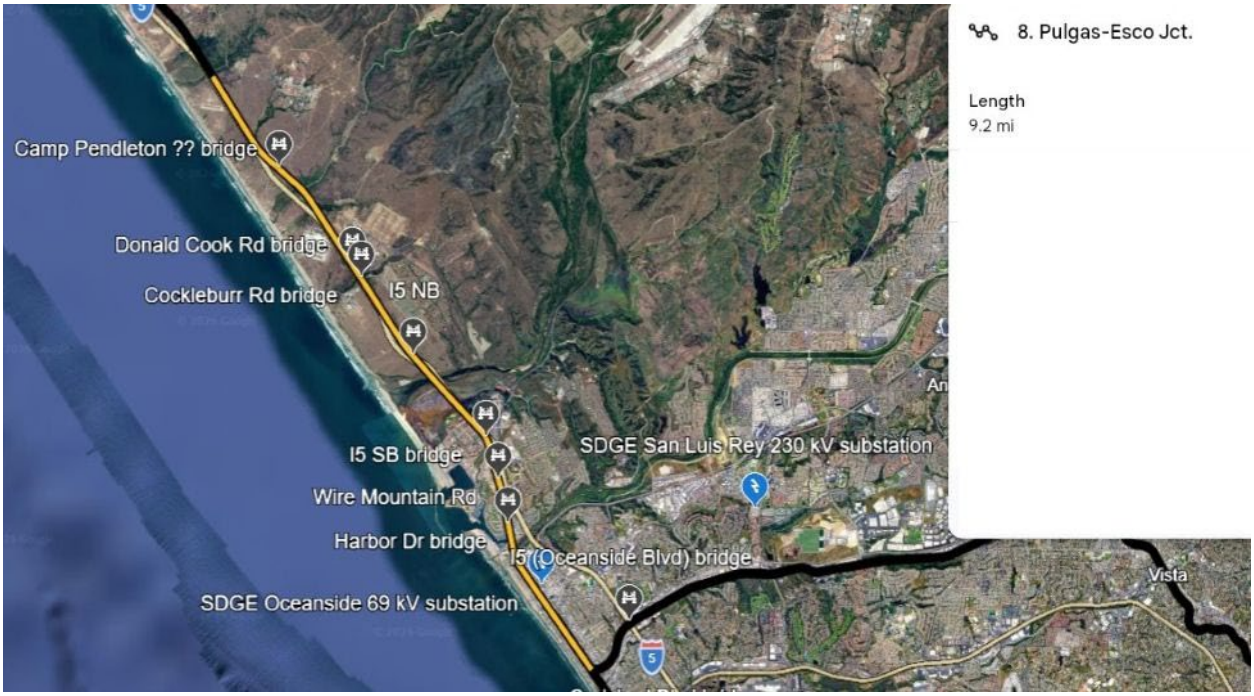

Jamboree Rd bridge
Heritage Community Park
Yale Ave bridge
Golf course ped overpass
North Lake Park
Great Park Ice & Fivepoint Arena
133 bridges
Portola High School
I5 (Technology Dr) bridge
SCE Santiago 220 kV-66 kV substation
Irvine Station pedestrian overpass
Alton Pkwy bridge
Bake Pkwy bridge
3. Jamboree Rd.-Bake Pkwy.
Length
6.83 mi
3D

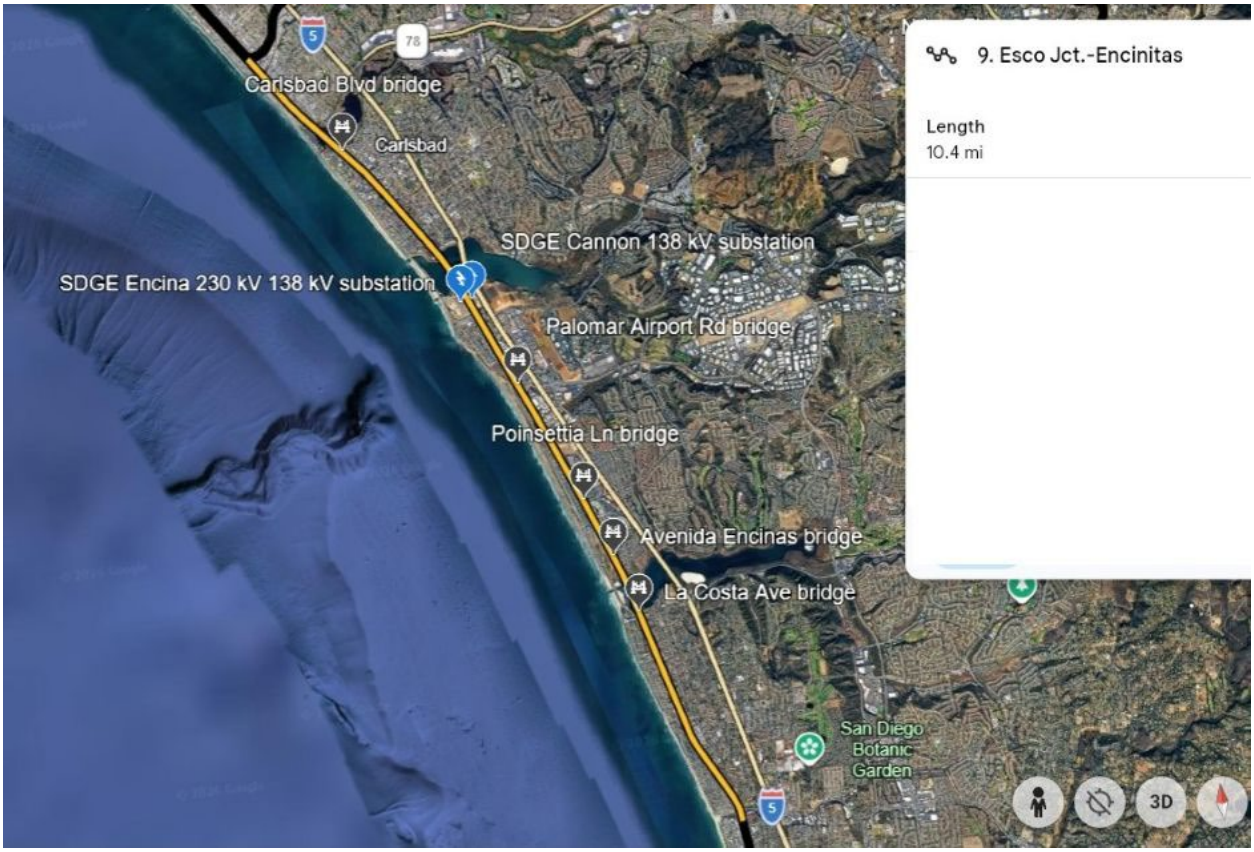

Bake Pkwy bridge
Alton Pkwy bridge
Lake Forest
El Toro Rd bridge
Los Alisos Blvd bridges
Alicia Pkwy bridges
Laguna Woods
I5 (Mission Viejo) bridges
La Paz Rd bridge
Las Flores
Oso Pkwy bridge
El Paseo bridge
Aliso Viejo
Crown Valley Pkwy bridge
SDGE Trabuco 138 kV substation
Aliso & Wood Canyons Wilderness Park
Ladera Ranch
Paseo de Colinas bridge
SR73 bridges
4. Bake Pkwy-SR 73
Length
7.61 mi

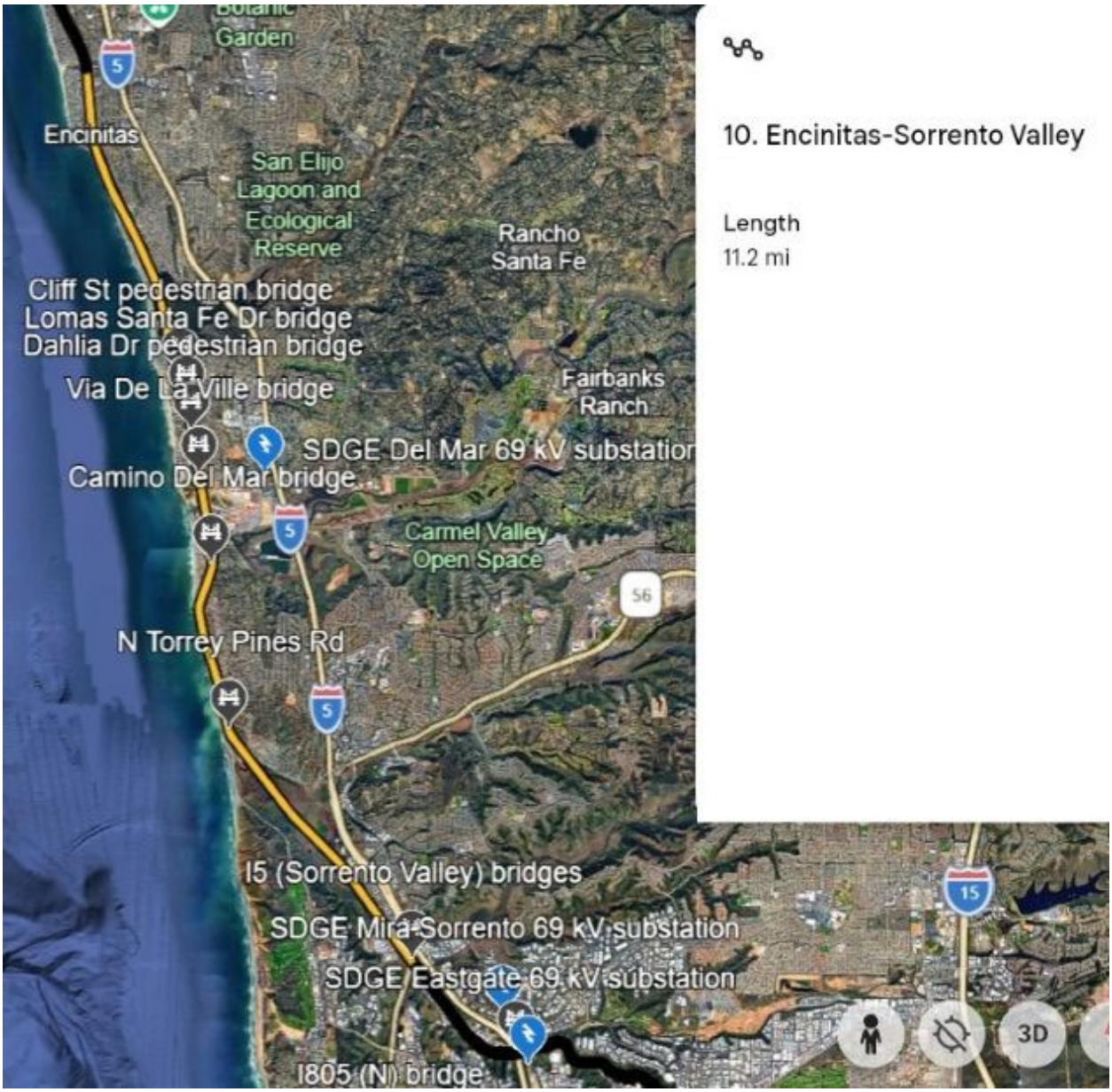

Paseo de Colinas bridge
SR73 bridges
Niguel
Rancho
Mission Vie
5
SDGE Capistrano 138 kV substation
5
Stonehill Dr bridge
PCH bridges
5. SR73-PCH
Length
6 mi


PCH bridges
Capo beach pedestrian bridge
Capistrano Bight
San Clemente Pump Track
San Clemente
Esplanade pedestrian overpass
SDGE Basilone 69 kV substation
SCE San Onofre 230 kV substation
6. PCH-San Onofre
Length
8.5 mi
3D


SDGE Basilone 69 kV substation
Old Pacific Hwy bridge
SCE San Onofre 230 kV substation
Agra
I5 (Vista Point) bridges
SDGE Las Pulgas 69 kV substation
Camp Pendleton ? bridge
7. San Onofre-Pulgas
Length
9.4 mi

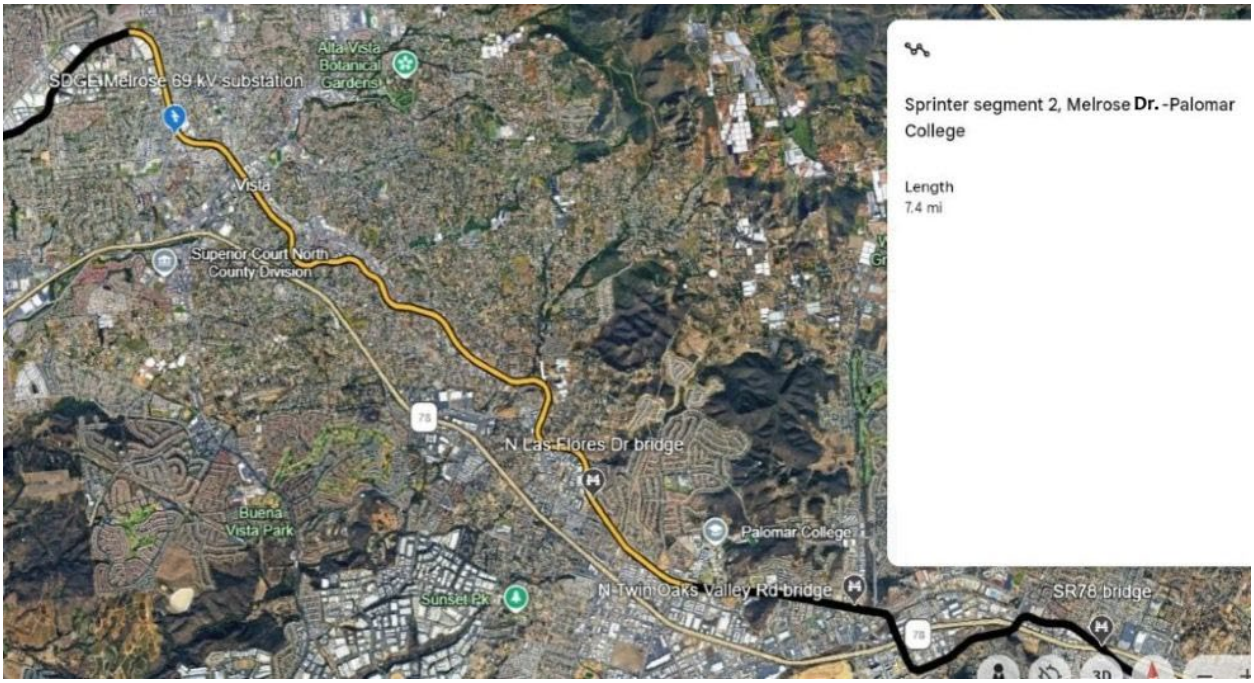

8. Pulgas-Esco Jct.
Length
9.2 mi
Camp Pendleton ?? bridge
Donald Cook Rd bridge
Cockleburr Rd bridge
I5 NB
I5 SB bridge
SDGE San Luis Rey 230 kV substation
Wire Mountain Rd
Harbor Dr bridge
I5 (Oceanside Blvd) bridge
SDGE Oceanside 69 kV substation
Vista

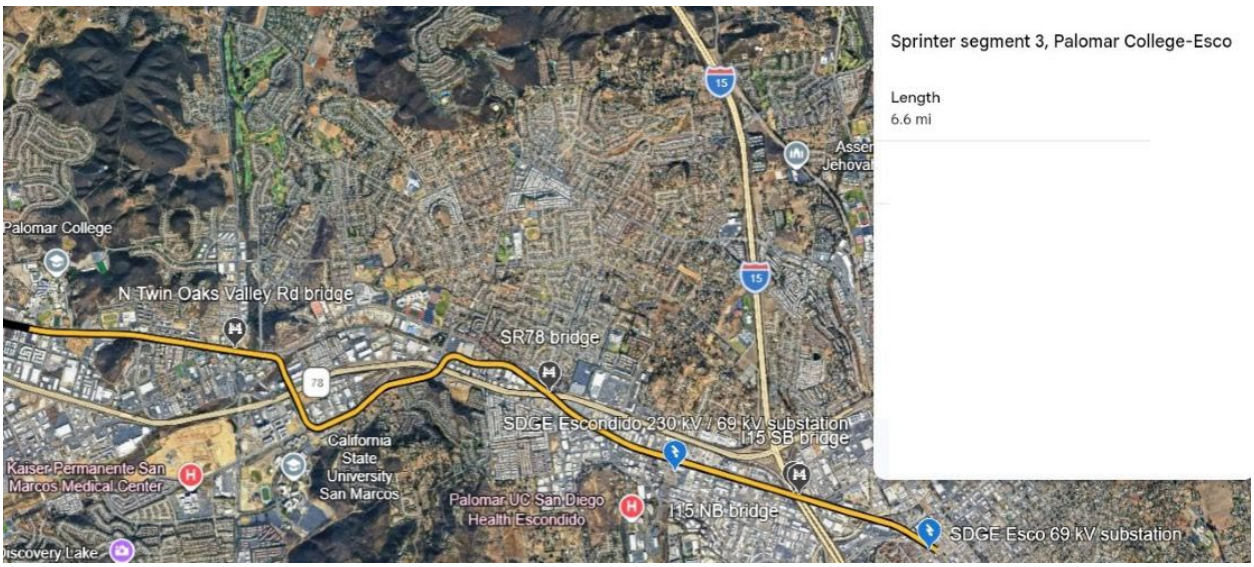

9. Esco Jct.-Encinitas
Length
10.4 mi
Carlsbad Blvd bridge
Carlsbad
SDGE Cannon 138 kV substation
SDGE Encina 230 kV 138 kV substation
Palomar Airport Rd bridge
Poinsettia Ln bridge
Avenida Encinas bridge
La Costa Ave bridge
San Diego Botanic Garden
3D


Botanic Garden
Encinitas
San Elijo Lagoon and Ecological Reserve
Rancho Santa Fe
Cliff St pedestrian bridge
Lomas Santa Fe Dr bridge
Dahlia Dr pedestrian bridge
Via De La Ville bridge
Fairbanks Ranch
SDGE Del Mar 69 kV substation
Camino Del Mar bridge
Carmel Valley Open Space
N Torrey Pines Rd
I5 (Sorrento Valley) bridges
SDGE Mira Sorrento 69 kV substation
SDGE Eastgate 69 kV substation
I805 (N) bridge
10. Encinitas-Sorrento Valley
Length
11.2 mi
3D


I5 (Sorrento Valley) bridges
SDGE Mira Sorrento 69 kV substation
SDGE Eastgate 69 kV substation
I805 (N) bridge
University of California San Diego
I805 (S) bridge
Birch Aquarium
Genesee Ave bridge
SDGE Rose Canyon 69 kV substation
SR52 bridges
Blue Line viaduct
Kaiser Permanente San Diego Medical Ctr
11. Sorrento Valley-SR52
Length
8.8 mi
Blue Line viaduct
SR52 bridges
Kate Sessions Memorial Pk
De Anza Cove Park
Clairemont Dr bridge
Sea World Dr bridge
SDGE Old Town 230 kV 69 kV substation
I5 I8 interchange bridges
I5 (Old Town S.) bridge
SDGE NTCQ 69 kV substation
SDGE Vine 69 kV substation
SDGE Kettner 69 kV substation
Balboa Park
I5 Pacific Hwy exit bridge
SDGE Station B 69 kV substation
12. SR52-San Diego Depot
Length
9.9 mi


I5 SB bridge
SDGE San Luis Rey 230 kV substation
SDGE Melrose 69 kV substation
Wire Mountain Rd
Harbor Dr bridge
SDGE Oceanside 69 kV substation
Vista
I5 (Oceanside Blvd) bridge
Carlsbad Blvd bridge
Carlsbad
SDGE Encina 230 kV 138 kV substation
SDGE Cannon 138 kV substation
LEGOLAND® California Resort
Lake San Marcos
Sprinter segment 1, OTC-Melrose Dr.
Length
8.3 mi


SDGE Melrose 69 kV substation
Alta Vista Botanical Gardens
Vista
Superior Court North County Division
N Las Flores Dr bridge
Buena Vista Park
Palomar College
Sunset Ex
N Twin Oaks Valley Rd bridge
SR78 bridge
Sprinter segment 2, Melrose Dr. -Palomar College
Length
7.4 mi



Substations

The maximum electric power demand of the ~100-mile Anaheim-San Diego OCS electrification segment is assumed to be about 200 MW[5]. This amount would be more than sufficient to power a worst-case scenario of thirty (30) fast passenger trains (each pulling 5 MW off the OCS, plus some extra for up to two freight trains and yard/switching operations). At least 200 MVA of total electric substation capacity will be needed, spread across six or more proposed traction power substations. Individual traction power substations could have a capacity range between 5 and 30 MW one to three (3) transformers, each of 5-10 MVA capacity, to allow for redundancy and maintenance. The capacity of each traction power substation may vary based on capacity available at the particular power grid interconnection point/electric utility substation.

- A traction power substation up to 50 MVA in capacity has typically a 100' x 200' minimum footprint. It is worth exploring standardized 'modular' 25 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, and serve as a phase break so that power supplies from each traction power

[5] 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.

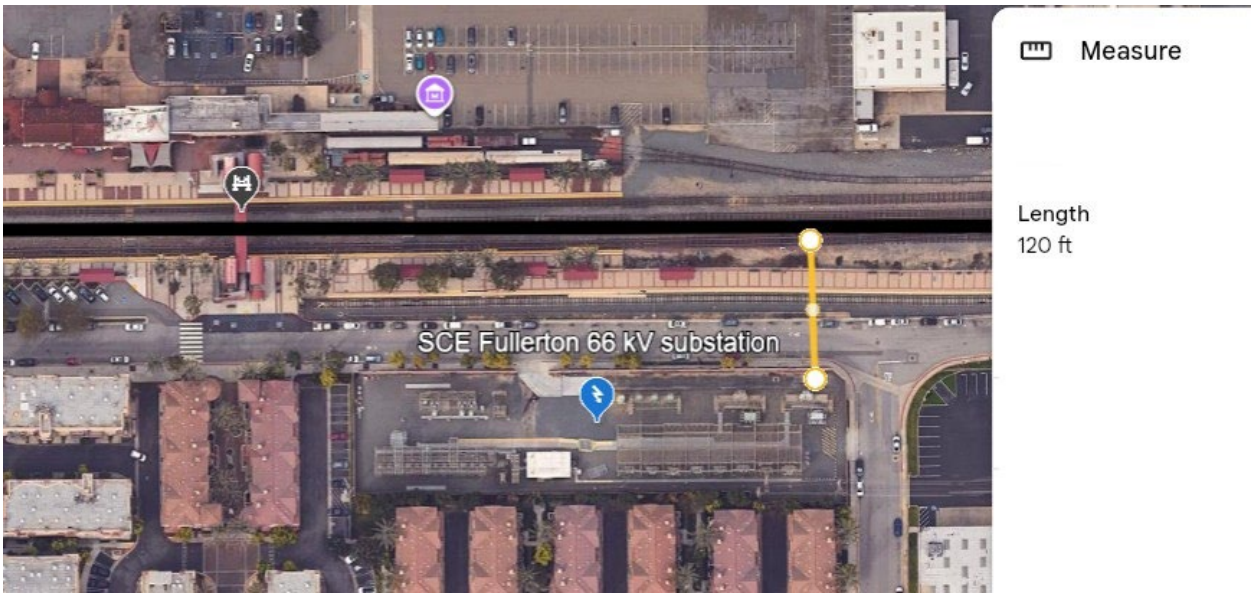
substation are isolated from each other in order to avoid a fault condition. In addition, switching stations provide operating flexibility during equipment outages. Exact locations are to be determined.

- Paralleling station compound dimensions are typically about 40' x 80'. Paralleling stations are typically spaced between switching and traction power substations, to maintain system voltages and the auto-transformer system.

New traction power substations will connect to existing utility substations, owned by the electric utilities Southern California Edison (SCE), Anaheim Public Utilities (APU) and San Diego Gas & Electric (SDGE). There are many existing electric utility substations adjacent to the Orange, San Diego and Escondido subdivisions. The majority of substations identified in this concept paper are located next to the tracks, and others in relatively close proximity. Many also appear to be surrounded by enough free space for a new, adjacent rail traction power substation to be built. It should be noted that not all of the substations listed below will be need to directly power traction power substations, but are all possible candidates for further feasibility and design evaluation.

Existing large electric utility substations along the OCTA Orange, NCTD San Diego and NCTD Escondido Subdivisions
*** on Sprinter line (NCTD Escondido Subdivision)**

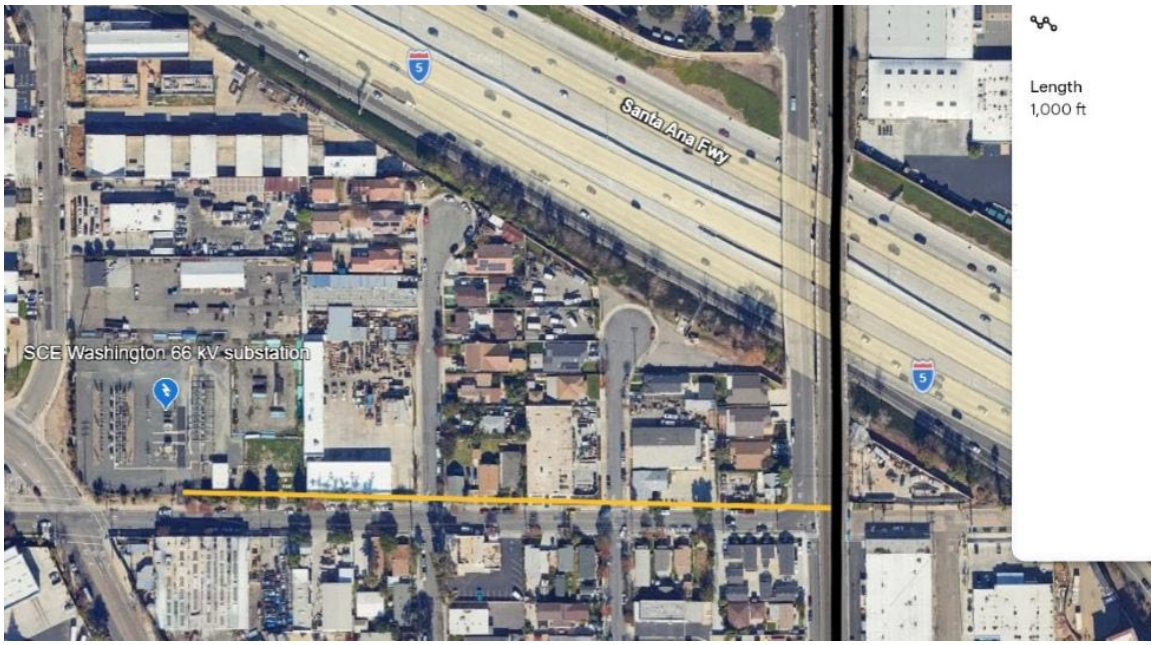
Milepost (MP, approx.)	Electric Utility	Substation	Voltage
165.1	SCE	Fullerton	66 kV
167.0	APU	Sharp	69 kV
168.6	APU	Vermont	69 kV / 220 kV
169.6	APU	Lewis	69 kV / 220 kV
175.1	SCE	Washington	66 kV
176.0	SCE	Chestnut	66 kV
183.0	SCE	Santiago	66 kV / 230 kV
193.0	SDGE	Trabuco	138 kV
196.4	SDGE	Capistrano	138 kV
210.2	SCE	San Onofre	230 kV
216.6	SDGE	Las Pulgas	69 kV
226.1	SDGE	Oceanside	69 kV
102.9*	SDGE	San Luis Rey	230 kV
108.5*	SDGE	Melrose	69 kV
119.8*	SDGE	Escondido	69 kV / 230 kV
121.5*	SDGE	Esco	69 kV
231.0	SDGE	Encina & Cannon	138 kV / 230 kV
242.7	SDGE	Del Mar	69 kV
250.8	SDGE	Eastgate & Mira Sorrento	69 kV
257.2	SDGE	Rose Canyon	69 kV
265.0	SDGE	NTCQ	69 kV
265.8	SDGE	Vine	69 kV
266.3	SDGE	Kettner	69 kV
267.7	SDGE	Station B	69 kV

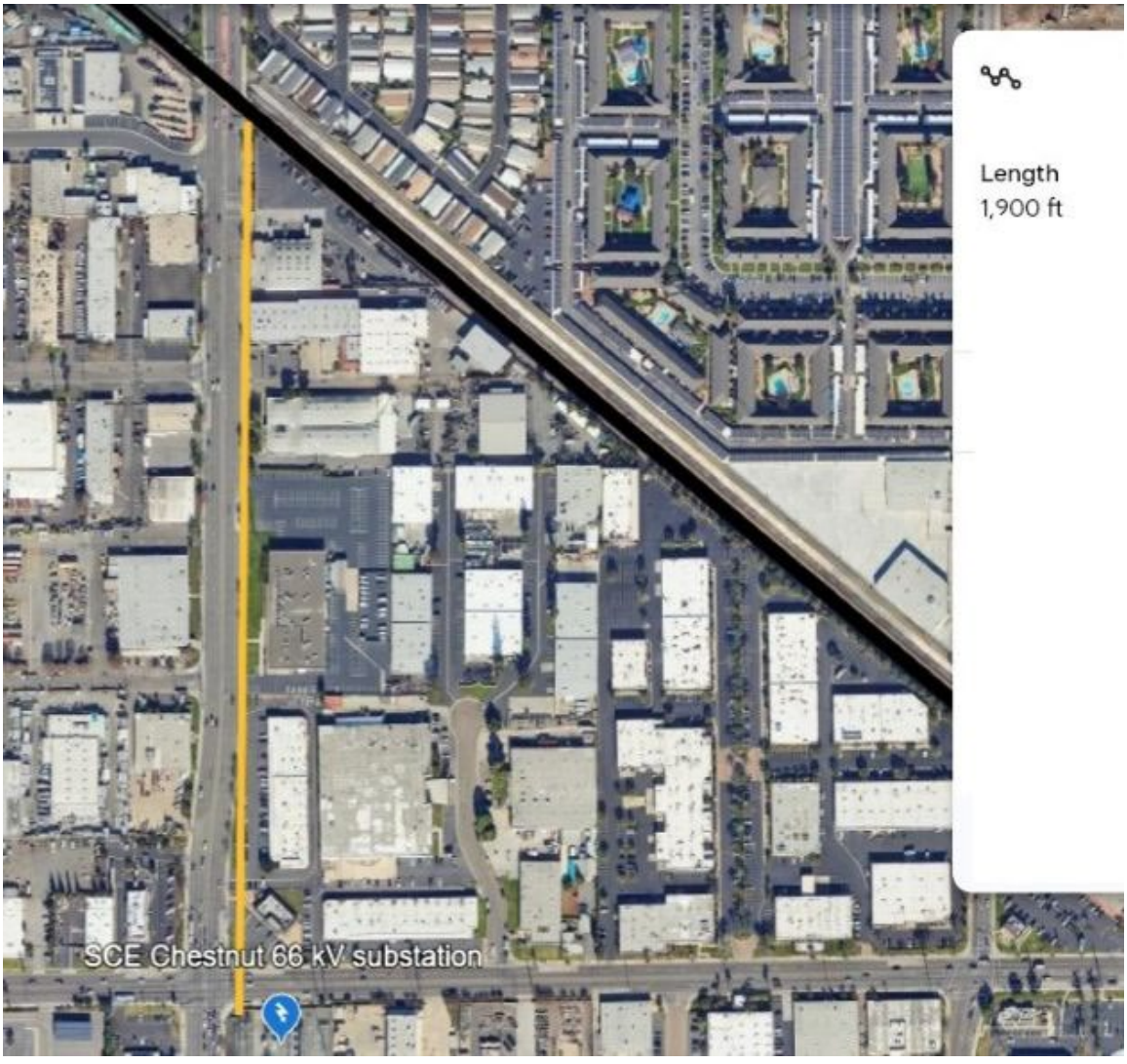

Measure
Length
120 ft
SCE Fullerton 66 kV substation

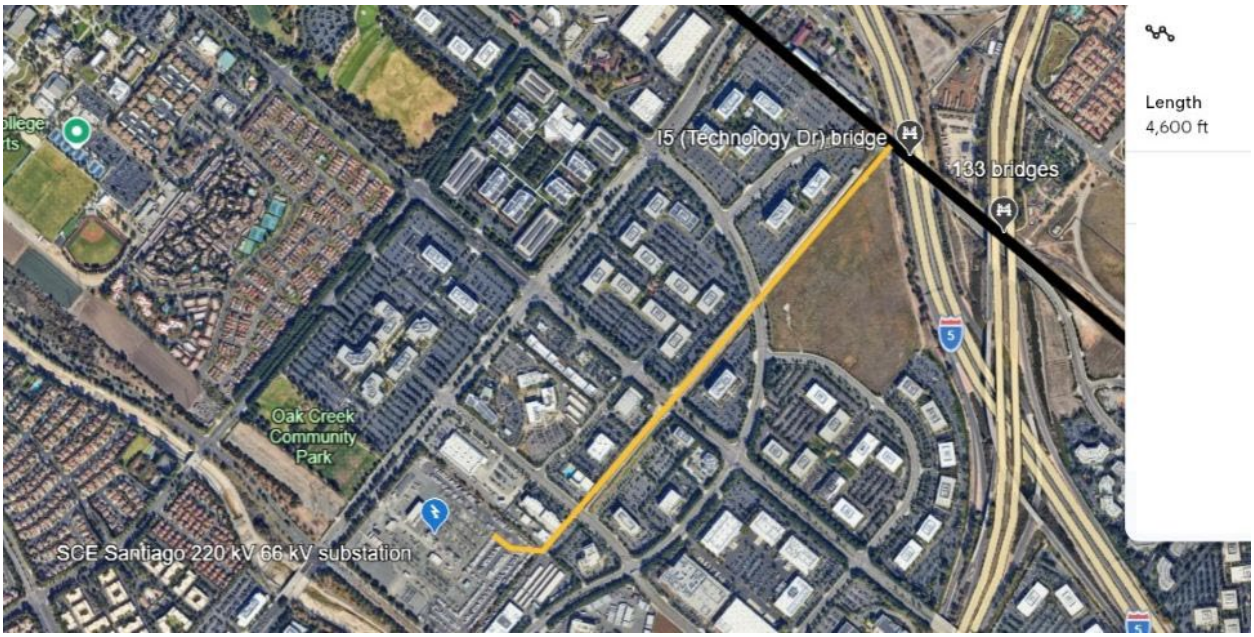

arian
naheim
APU Sharp 69 kV substation
Length
150 ft

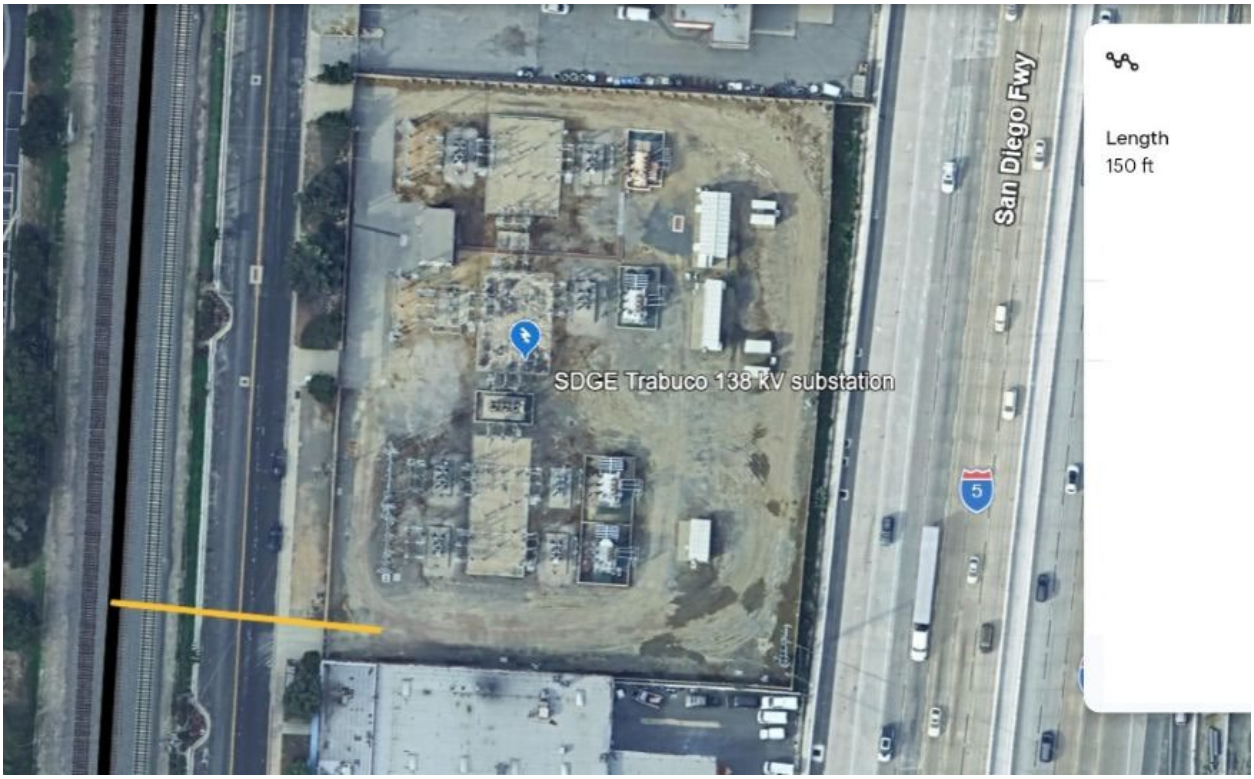

Length
50 ft
APU Vermont 220 kV 69 kV substation
Anaheim Public Utilities


Length
700 ft
APU Lewis 220 kV 69 kV substation
The Rinks - KHS ICE


Santa Ana Fwy
SCE Washington 66 kV substation
Length
1,000 ft


Length
1,900 ft
SCE Chestnut 66 kV substation


Length
4,600 ft
15 (Technology Dr) bridge
133 bridges
Oak Creek Community Park
SCE Santiago 220 kV 66 kV substation


Length
150 ft
San Diego Fwy
SDGE Trabuco 138 kV substation


Length
300 ft
SDGE Capistrano 138 kV substation
Hines Trails


Length
300 ft
SCE San Onofre 230 kV substation
San Diego Fwy
5
5

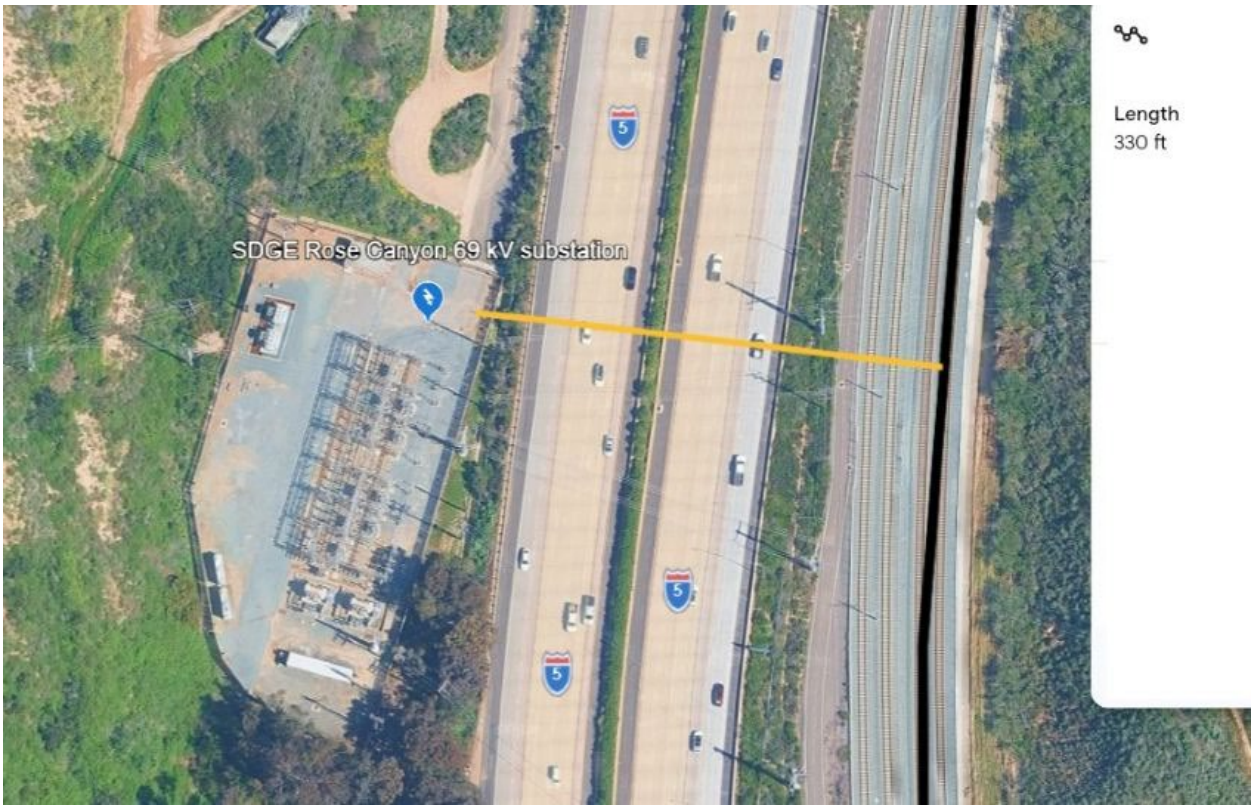

SDGE Las Pulgas 69 kV substation
Length
0.41 mi


SDGE Oceanside 69 kV substation
California Surf Museum
Historic boards, iconic surfers & more
Length
520 ft


SDGE Encina 230 kV 138 kV substation
SDGE Cannon 138 kV substation
Cannon Substation
Length
200 ft


Via De La Ville bridge
SDGE Del Mar 69 kV substation
Del Mar Dog Bch
Del Mar Racing
5
5
Length
0.83 mi


SDGE Mira Sorrento 69 kV substation
Length
900 ft
805
I805 (N) bridge
SDGE Eastgate 69 kV substation


SDGE Rose Canyon 69 kV substation
Length
330 ft


SDGE NTCQ 69 kV substation
Witherby St
SE Autobody / Collision Center
Length
80 ft

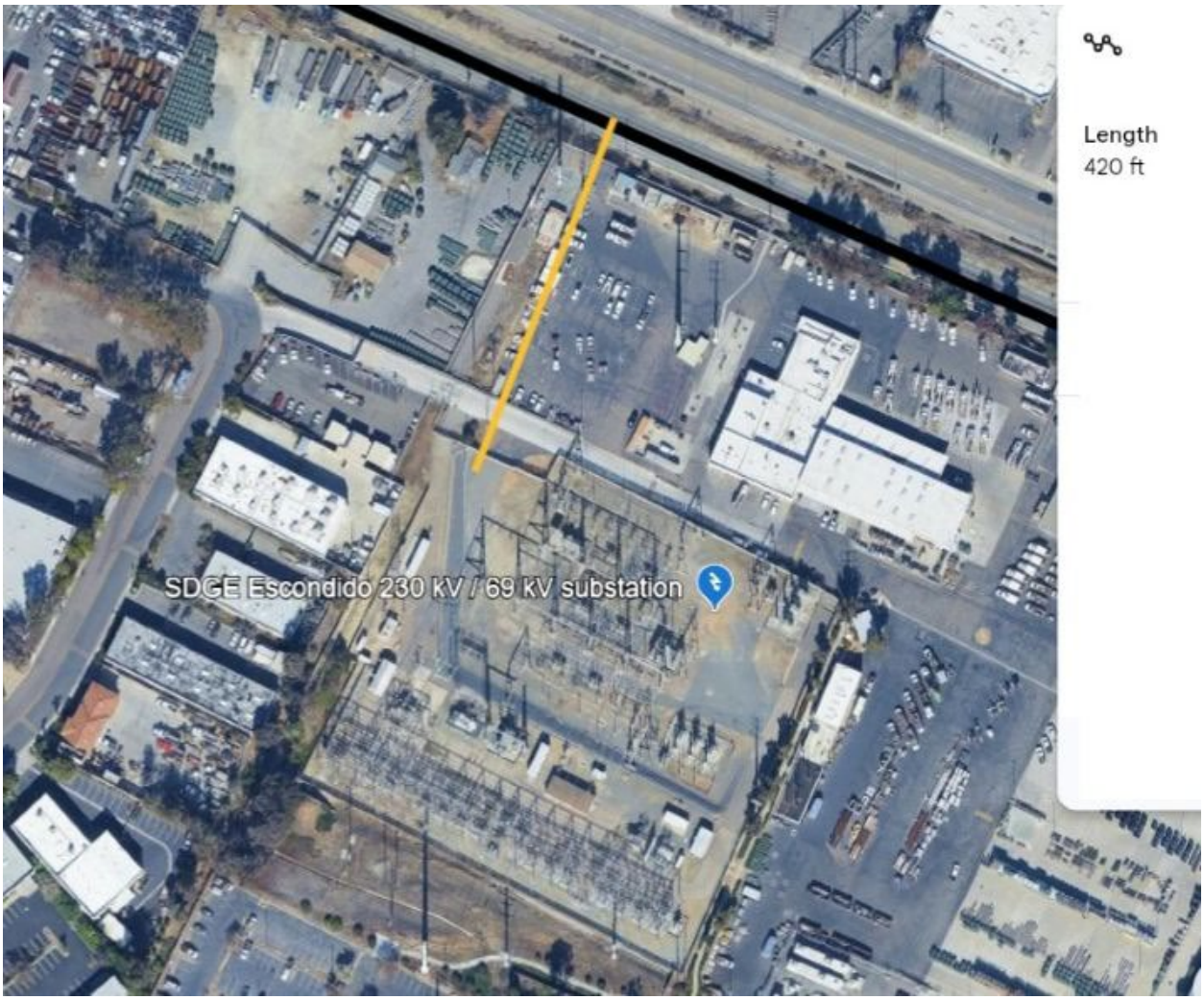

2456
Vine St
Vine St
Kettner Blvd
Kettner Blvd
SDGE Vine 69 kV substation
Length
90 ft
3548
Hertz
Vehicle


W Palm St
SDGE Kettner 69 kV substation
Length
160 ft
W Palm St
Kettner Blvd
Kiku Room
1220
1242
California St
Olive sub
Caliber Collision


701
SDGE Station B 69 kV substation
780
Kettner Blvd
701
West F St
Length
30 ft


SDGE San Luis Rey 230 kV substation
Length
0.8 mi


Length
150 ft
SDGE Melrose 69 kV substation


Length
420 ft
SDGE Escondido 230 kV / 69 kV substation


Length
120 ft
200
SDGE Esco 69 kV substation

Bridges

There are over 55 road bridges over the LOSSAN mainline track between Anaheim and San Diego, and 5 pedestrian overpasses. On the NCTD Escondido Subdivision between Oceanside and Escondido, the are 5 road overpasses. Heights shown in brackets are from Federal Highway Administration's LTBP InfoBridge minimum vertical under clearance in the public database[6].

* on Sprinter line (NCTD Escondido Subdivision)
**these clearances over railroad track were not clear from LTBP InfoBridge data, however MTS San Diego Trolley 600VDC OCS runs parallel to LOSSAN track under the same bridges.

City	Bridge	Minimum Vertical Underclearance, ft.
Anaheim	SR91	23.3'
	SR57	23.2'
Orange	SR22	25'
Santa Ana	SR55	22.6'
Tustin	Tustin Ranch Rd	27.8'
	Jamboree Rd	23.1'
Irvine	Yale Ave	24.6'
	Golf course pedestrian	?
	I5 (Technology Dr)	20.5'
	SR133	38.8'
	Irvine Station pedestrian	?
	Alton Pkwy	23.4'
Lake Forest	El Toro Rd	23.4'
Mission Viejo	Los Alisos Blvd	24.8'
	Alicia Pkwy	22.8'
	La Paz Rd	25.1'
	I5	23.2'
	El Paseo	25'
	Oso Pkwy	25'
Laguna Niguel	Crown Valley Pkwy	23.7'
	Paseo de Colinas	24.7'
	SR73	~24'
San Juan Capistrano	Stonehill Dr	24'
Dana Point	Pacific Coast Highway	23.1'
	Capo beach pedestrian	?
San Clemente	Esplanade pedestrian	?
Camp Pendleton	Old Pacific Hyw bridge	?
	I5 (Vista Point)	22.5'
	Camp Pendleton ? bridge	?
	Donald Cook Rd	23.2'
	Cockleburr Rd	?
	Camp Pendleton ?? bridge	?
	I5 NB	24.6'
	I5 SB	22.9'
	Wire Mountain Rd	22.9'
	Harbor Dr	22.9'
Oceanside	I5 (Oceanside Blvd)*	21'
San Marcos	N Las Flores Dr*	25.9'
	N Twin Oaks Valley Rd*	19.2'
	SR78*	19.3'
Escondido	I15 SB*	27.8'
	I15 NB*	23.6'
Carlsbad	Carlsbad Blvd	22.1'
	Palomar Airport Rd	24.5'
	Poinsettia Ln	23.2'
	Avenida Encinas	24.6'
	La Costa Ave	22.9'
Solana Beach	Cliff St pedestrian	?

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

	Lomas Santa Fe Dr	24.5’
	Dahlia Dr pedestrian	?
	Via De La Ville	23.1’
Del Mar	Camino Del Mar	?
	N Torrey Pines Rd	22.4’
San Diego	I5 (Sorrento Valley)	32.2’
	I805 (N)	32.3’
	Miramar Rd	25’
	I805 (S)	50’
	Genesee Ave	22.9’
	SR52	31’
	Blue Line	?
	Clairemont Dr**	~21’
	Sea World Dr**	~21’
	I5 I8 interchange**	?
	I5 (Old Town S.)**	?
	I5 Pacific Hwy exit**	?

Field measurements of the bridge heights above the rails would need to confirm the exact clearances. While the vast majority of the bridges on the LOSSAN mainline appear to be high enough for conventional overhead catenary wire (25 kV at 23’ above top-of-rail), above double stack of two "high cube" containers or the tallest autorack cars. On the Caltrain electrified corridor, the OCS contact wires are typically mounted at approximately 22’ to 23’ above top of rail[7]. There appear to be at least a dozen ‘tight spots’ on the LOSSAN mainline, for which the ‘minimum vertical under clearance’ is reported to be or less than 23’[8]. A similar number did not have above-rail clearance information available in the LTBP InfoBridge database. 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)[9] section. Such a dead section could be strategically located at the lowest bridges, without significant modifications to the bridge or track.

[7] https://www.sccfd.org/wp-content/uploads/documents/mutual_aid_plan/18F%20Caltrain%20OCS%20Safety%20Awareness.pdf

[8] It should be noted that two bridges on the on Sprinter line (NCTD Escondido Subdivision) were listed as having clearances of 19.2’ and 19.3’, though it should be noted that this rail corridor does not host tall autorack or double-stack container cars.

[9] 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 a grounded section of conductor bar or catenary (contact wire run in parallel) in between. A PES allows a pantograph to remain up without drawing power. A neutral section would typically be fed separately on either side to separate different electrical phases/or power fed from different traction power substations.