

SR-710 Study

Alternatives Analysis Report

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## Appendix E

LRT Preliminary Operating Plans

Technical Memorandum





## TECHNICAL MEMORANDUM

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# SR 710 Study – LRT Preliminary Operating Plans

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At a June 2010 meeting, the Los Angeles County Metropolitan Transportation Authority (Metro) in coordination with the California Department of Transportation (Caltrans), moved to broaden the search for multimodal solutions for the State Route 710 (SR 710) study area and move forward with the environmental review phase.

More recently, Metro has initiated the SR 710 Alternatives Analysis (AA) process to evaluate alternatives for transportation improvements in the SR 710 study area. A series of project alternatives have been developed, which include a Transportation Systems Management (TSM) alternative, freeway alternatives, Bus Rapid Transit (BRT) alternatives, and Light Rail Transit (LRT) alternatives.

Four LRT alternatives have been developed, connecting between the north and east legs of the Metro Gold Line in the SR 710 corridor. This technical memorandum documents the approach used to develop preliminary operating plans and the operating and maintenance (O&M) cost methodology for each of the LRT alternatives. Preliminary operating plan and O&M cost results for the four alternatives are presented.

## Operating Assumptions and Plans

This technical memorandum documents general operating assumptions and plans for each of the SR 710 Study Area LRT alternatives based on service levels projected for Year 2035. These assumptions include: operating agency, span of service, vehicle performance, and station dwell times. The operating plans include station-to-station run time estimates and operating requirements for each build alternative.

### Operating Assumptions

Existing transit services in the SR 710 study area are operated by Metro, Alhambra Community Transit, East Los Angeles Shuttle, Foothill Transit, Montebello Bus Lines, Monterey Park Spirit Bus, Norwalk Transit System, Pasadena Area Rapid Transit System, and South Pasadena. Metro provides local and express bus service throughout the study area, and the other transit providers offer local bus service in the municipalities where the SR 710 LRT Alternatives are proposed to operate. Metro is assumed to be the operating agency for the proposed SR 710 LRT line that would connect the Metro Gold Line Eastside Extension to the Metro Gold Line in Pasadena.

**Span of Service.** The span of service for the proposed LRT alternatives would be comparable to the current respective weekday, Saturday, and Sunday and holiday schedules for the Gold Line. Table 1 summarizes the assumed span of service.



TABLE 1  
Metro LRT Span of Service

Day of Week	Time Period	Hours
Monday-Sunday	Early AM	5:00 – 6:00 a.m.
	AM Peak Period	6:00 – 9:00 a.m.
	Midday	9:00 a.m. – 3:00 p.m.
	PM Peak Period	3:00 – 6:00 p.m.
	Early Evening	6:00 – 8:00 p.m.
	Late Evening	8:00 p.m. – 2:00 a.m.

**Service Frequency.** The assumed service frequency of the proposed LRT alternatives are presented in Table 2. The assumed service frequencies are based on Metro’s Draft 2008 Long Range Transportation Plan criteria.

TABLE 2  
Metro LRT Service Frequency

Day of Week	Frequency	Hours
Weekdays	5 minutes	6:00 – 9:00 a.m., 3:00 – 6:00 p.m.
	12 minutes	9:00 a.m. – 3:00 p.m., 6:00 – 8:00 p.m.
	10 minutes	5:00 – 6:00 a.m., 8:00 p.m. – 12:00 a.m.
	20 minutes	12:00 a.m. – 2:00 a.m. Friday
Saturday, Sunday and Holidays	7.5 minutes	8:00 a.m. – 8:00 p.m.
	15 minutes	5:00 – 8:00 a.m.
	20 minutes	8:00 p.m. – 12:00 a.m. (2:00 a.m. Saturday)

**Vehicle Performance.** LRT vehicles are assumed to have a normal service maximum acceleration rate of about 2.5 miles per hour per second (mphps) between 0 and 30 miles per hour (mph), decreasing to an average acceleration rate of 1.0 mphps between 30 to 65 mph. Normal service braking is assumed to be a constant 2.5 mphps from 65 mph to 0 mph. LRT vehicles are assumed to have a maximum revenue operation speed of 65 mph. Operation speeds along the proposed alignments vary due to horizontal and vertical curves and station spacing, as well as speed limits on street-running alignment segments. Station-to-station LRT time estimates developed based on these criteria are presented below.

**Station Dwell Times and End-of-Line Layovers.** The average station dwell times (i.e., time to allow passengers to board and alight the transit vehicle) for the LRT alternatives are assumed to be 20 seconds at all of the proposed stations, not including the end-of-line station.

End-of-line layovers provide sufficient time for drivers to take breaks as required by union agreement, as well as allow for schedule recovery (i.e., a late train can “catch up” to its schedule). Layovers of 5.5 minutes are assumed at each end-of-line station. Metro currently uses “drop-back” operators at most terminal stations for rail operations.

**Average Intersection Delay.** A limited level of signal priority for LRT operations on at-grade alignments is assumed. Average intersection delay for existing minor signalized intersections (i.e. major collectors and minor arterials) is assumed to be 10 seconds, while a 30-second delay is assumed at major arterial intersections. Non-signalized intersections, driveways and other crossings will be signal or gate-controlled and no delay will be incurred.

## Operating Plans

Operating plans were developed for the following alternatives:

- LRT-4A: East LA Civic Center to Fillmore Stations via Fremont and Fair Oaks Ave. tunnel
- LRT-4B: East LA Civic Center to Fillmore Stations via Palm Ave. and Fair Oaks Ave. tunnel
- LRT-4D: Atlantic to Fillmore Stations via Palm Ave. and Raymond and Fair Oaks Ave. tunnel
- LRT-6: Atlantic to Fillmore Stations via Atlantic Blvd. and Fair Oaks Ave.

The LRT-4 Alternatives would each have seven stations, and the LRT-6 alternative would have nine stations. All stations are planned to include park-and-ride facilities except the Cal State LA station (LRT-4 alternatives) and the northern terminus at Fillmore Gold Line Station (all alternatives).

Figures illustrating the LRT alternatives are attached at the end of this memorandum. A detailed description of each alternative, along with tables of one-way run time estimates, is provided below.

**LRT-4A: East LA Civic Center to Fillmore Gold Line Station via Fremont and Fair Oaks Ave. Tunnels.** Alternative LRT-4A would originate at an aerial station on Mednik Avenue adjacent to the existing East LA Civic Center Station. From there, the line would be routed north along Mednik Avenue on an elevated structure, turn west on Floral Drive, then turn north across Corporate Center Drive and enter the Interstate 710 right-of-way. A station would be provided near the intersection of Floral Drive and Mednik Avenue. After entering the I-710 right-of-way, the alignment would be routed north, with a station at Cal State LA providing a transfer location to and from El Monte Busway and Metrolink service. Continuing north of Cal State LA, the alignment would enter a tunnel between Valley Boulevard and Mission Road. The tunnel alignment would be routed northeast to Fremont Avenue, with a station near the Los Angeles County office building in Alhambra. The alignment would then be routed north under Fremont Avenue, shifting slightly east to Fair Oaks Avenue, remaining in tunnel. Stations would be placed near the intersections of Fair Oaks Avenue/Huntington Drive and Fair Oaks Avenue/Mission Street. The alignment would continue in a tunnel under SR-110 reaching a terminus station near the existing Fillmore Station.

TABLE 3  
Alternative LRT-4A Station-to-Station Run Times

Station	Speed (mph)	Distance (miles)		Run Time (min:sec)	Delay Time	Dwell Time	Total Time
		Increment	Total				
East LA Civic Center (Mednik Ave / Civic Center Way)	25 – 45	0.72	0.00	01:31	00:00	00:20	00:20
Floral Dr / Mednik Ave	25 – 55	1.46	0.72	02:20	00:00	00:20	02:11
Cal State LA	45 – 55	1.86	2.18	02:39	00:00	00:20	04:51
Alhambra (Fremont / Concord Aves)	45 – 55	1.35	4.04	01:57	00:00	00:20	07:50
Huntington Dr (Fair Oaks Ave / Spruce St)	55	0.79	5.39	01:17	00:00	00:20	10:07
South Pasadena (Fair Oaks Ave / Mission St)	35 – 55	1.29	6.18	01:56	00:00	00:20	11:44
Fillmore St / Fair Oaks Ave			7.47			00:00	13:40
<b>Total</b>			<b>7.47</b>	<b>11:40</b>	<b>00:00</b>	<b>02:00</b>	<b>13:40</b>
Average speed, station spacing	32.8	1.25					

Note: Run times are based on one-way travel.

**LRT-4B: East LA Civic Center to Fillmore Gold Line Station via Palm Ave. and Fair Oaks Ave. Tunnel.** Alternative LRT-4B would deviate from LRT-4A north of the Cal State LA station. Instead of immediately entering a tunnel, LRT-4B would continue on an elevated structure above Mission Road, turning north on Palm Avenue. The alignment would descend to grade on Palm Avenue, with an at-grade station near the intersection of Palm Avenue/Orange Street to serve the area around the county office building. LRT-4B would then enter a tunnel south of Main Street and continue along an alignment similar to that of LRT-4A.

TABLE 4  
Alternative LRT-4B Station-to-Station Run Times

Station	Speed (mph)	Distance (miles)		Run Time (min:sec)	Delay Time	Dwell Time	Total Time
		Increment	Total				
East LA Civic Center (Mednik Ave / Civic Center Way)	25 – 45	0.72	0.00	01:31	00:00	00:20	00:20
Floral Dr / Mednik Ave	25 – 55	1.46	0.72	02:20	00:00	00:20	02:11
Cal State LA	25 – 55	2.19	2.18	03:27	00:00	00:20	04:51
Alhambra (Palm Ave / Orange St)	30 – 55	1.44	4.37	02:28	00:10	00:20	08:38
Huntington Dr (Fair Oaks Ave / Spruce St)	55	0.79	5.81	01:17	00:00	00:20	11:36
South Pasadena (Fair Oaks Ave / Mission St)	35 – 55	1.29	6.60	01:56	00:00	00:20	13:13
Fillmore St / Fair Oaks Ave			7.89			00:00	15:09
<b>Total</b>			<b>7.89</b>	<b>12:59</b>	<b>00:10</b>	<b>02:00</b>	<b>15:09</b>
Average speed, station spacing	31.3	1.32					

Note: Run times are based on one-way travel.

**LRT-4D: Atlantic to Fillmore Gold Line Station via Palm Ave. and Raymond and Fair Oaks Ave. Tunnels.**

Alternative LRT-4D would originate at an underground station beneath Beverly Boulevard, near the existing Gold Line Atlantic Station. LRT-4D would continue north underground, transitioning to an elevated structure along First Street. The elevated portion would then turn onto Mednik Avenue and follow the same alignment as LRT-4B to Palm Avenue. North of the Palm Avenue station, LRT-4D would enter a tunnel under the Southern California Edison right-of-way adjacent to Raymond Avenue, following that right-of-way to Huntington Drive. LRT-4D would continue underground beneath Huntington Drive to Fair Oaks Avenue, then follow generally the same alignment as LRT-4A and LRT-4B to the Fillmore Station.

TABLE 5  
Alternative LRT-4D Station-to-Station Run Times

Station	Speed (mph)	Distance (miles)		Run Time (min:sec)	Delay Time	Dwell Time	Total Time
		Increment	Total				
Atlantic Blvd / Beverly Blvd	25 – 45	1.34	0.00	02:34	00:00	00:20	00:20
Floral Dr / Mednik Ave	25 – 55	1.46	1.34	02:20	00:00	00:20	03:14
Cal State LA	25 – 55	2.19	2.80	03:28	00:00	00:20	05:54
Alhambra (Palm Ave / Orange St)	25 – 55	1.72	4.99	03:22	00:10	00:20	09:42
Huntington Dr (Fair Oaks Ave / Laurel St)	55	0.69	6.71	01:11	00:00	00:20	13:34
South Pasadena (Fair Oaks Ave / Mission St)	15 – 55	1.23	7.40	02:07	00:00	00:20	15:05
Fillmore St / Fair Oaks Ave			8.63			00:00	17:12
<b>Total</b>			<b>8.63</b>	<b>15:02</b>	<b>00:10</b>	<b>02:00</b>	<b>17:12</b>
Average speed, station spacing	30.1	1.44					

*Note: Run times are based on one-way travel.*

**LRT-6: Atlantic to Fillmore Gold Line Station via Atlantic Blvd. and Fair Oaks Ave.** Alternative LRT-6 would originate at an aerial station on Atlantic Boulevard near Pomona Boulevard. The alignment would be routed north along Atlantic Boulevard on an elevated structure across State Route 60, with another elevated station at Cesar Chavez Boulevard. LRT-6 would then descend to grade and continue north on Atlantic Boulevard, with stations at Monterey Park Hospital and Garvey Avenue. The alignment cross Interstate 10 on an aerial configuration, returning to grade for stations at Valley Boulevard, Main Street, and Pine Street (Huntington Drive). LRT-6 would turn west on Huntington Drive and then north along Fair Oaks Avenue, remaining at-grade with a station near Mission Street. After crossing State Route 110, LRT-6 would again ascend on an aerial structure, turning onto Fillmore Street, with a new, elevated station above the existing Fillmore Station.

TABLE 6  
Alternative LRT-6 Station-to-Station Run Times

Station	Speed (mph)	Distance (miles)		Run Time (min:sec)	Delay Time	Dwell Time	Total Time
		Increment	Total				
Pomona Blvd / Atlantic Blvd	45	0.42	0.00	00:53	00:00	00:20	00:20
Cesar Chavez Blvd / Atlantic Blvd	25 – 35	0.92	0.42	02:32	00:30	00:20	01:33
Monterey Park Hospital (Sevilla St / Atlantic Blvd)	25 – 35	1.03	1.34	03:11	01:10	00:20	04:55
Garvey Ave / Atlantic Blvd	55	0.95	2.37	01:28	00:00	00:20	09:36
Valley Blvd / Atlantic Blvd	25 – 35	0.94	3.32	02:44	01:20	00:20	11:24
Alhambra (Main St / Atlantic Blvd)	25 – 35	0.87	4.26	02:30	01:00	00:20	15:48
Pine St / Atlantic Blvd	25 – 40	1.82	5.13	05:30	02:40	00:20	19:38
South Pasadena (Fair Oaks Ave / Mission St)	15 – 45	1.36	6.95	03:45	02:20	00:20	28:08
Fillmore St / Fair Oaks Ave			8.31			00:00	34:13
<b>Total</b>			<b>8.31</b>	<b>22:33</b>	<b>09:00</b>	<b>02:40</b>	<b>34:13</b>
Average speed, station spacing	14.6	1.04					

Note: Run times are based on one-way travel.

## LRT Maintenance Yards

The proposed LRT alternatives would each require a maintenance yard for cleaning, maintaining, and storing light rail vehicles (LRVs). The maintenance yard would include a car wash, paint shop, and other support facilities, and would also have enough storage tracks to accommodate all of the LRVs required to operate the light rail line. Two potential sites have been identified for the maintenance yard, only one of which would be required:

- Valley Boulevard Site—This site is located at the end of SR 710 between Valley Boulevard and the Union Pacific Alhambra Subdivision rail line, in the City of Los Angeles. This site could be used for LRT-4, but not for LRT-6.
- Glenarm Street Site—This site is located between Glenarm Street and Fillmore Street on the south and north and between Fair Oaks Avenue and Raymond Avenue on the west and east, in the City of Pasadena. This site could be used for LRT-4 or for LRT-6. Only a portion of it may be required for LRT-4.

## Operating Requirements

Operating requirements were developed for each of the alternatives based on the assumptions outlined above. Each train in service is assumed to consist of three LRVs, and fleet calculations include ready trains to support “drop back” operations and 20 percent spare capacity. Annual operation and maintenance costs are calculated based on the Fiscal Year 2012 cost per revenue service hour presented in Metro’s Fiscal Year 2013 Proposed Budget. This unit cost of \$374.48 is applied for each hour each LRV would be operated in revenue service during a one-year period, and includes transportation costs, maintenance costs, other operating costs, and support department costs.

**LRT-4A.** Operating requirements for Alternative LRT-4A are presented in Table 7. A fleet of 36 LRVs would be required, and annual operation and maintenance costs would amount to \$35,984,000.

TABLE 7  
Alternative LRT-4A Operating Requirements

Day	Headway			Peak LRVs	Annual Revenue			Lay over	Cycle Time	Trains		
	Peak	Base	Eve		Car-Miles	Car-Hrs	Train-Hrs			Peak	Base	Eve
Weekdays	5.0	10.0	15.0	24	1,752,200	74,970	24,990	5.5	38.3	8	4	3
Weekends and Holidays	10.0	15.0	20.0		493,600	21,120	7,040			4	3	2
<b>Estimated Totals:</b>				<b>24</b>	<b>2,245,800</b>	<b>96,090</b>	<b>32,030</b>			<b>8</b>	<b>4</b>	<b>3</b>
Ready Cars:				6								
Peak Revenue Total:				30								
Maintenance Spares:				6								
Total Fleet:				<b>36</b>								
Annual Operation and Maintenance Costs:												<b>\$35,984,000</b>

**LRT-4B.** Operating requirements for Alternative LRT-4B are presented in Table 8. A fleet of 40 LRVs would be required, and annual operation and maintenance costs would amount to \$42,076,000.

TABLE 8  
Alternative LRT-4B Operating Requirements

Day	Headway			Peak LRVs	Annual Revenue			Lay over	Cycle Time	Trains		
	Peak	Base	Eve		Car-Miles	Car-Hrs	Train-Hrs			Peak	Base	Eve
Weekdays	5.0	10.0	15.0	27	1,955,400	85,300	28,430	5.5	41.3	9	5	3
Weekends and Holidays	10.0	15.0	20.0		620,400	27,060	9,020			5	3	3
<b>Estimated Totals:</b>				<b>27</b>	<b>2,575,800</b>	<b>112,360</b>	<b>37,450</b>			<b>9</b>	<b>5</b>	<b>3</b>
Ready Cars:				6								
Peak Revenue Total:				33								
Maintenance Spares:				7								
Total Fleet:				<b>40</b>								
Annual Operation and Maintenance Costs:												<b>\$42,076,000</b>



**LRT-4D.** Operating requirements for Alternative LRT-4D are presented in Table 9. A fleet of 43 LRVs would be required, and annual operation and maintenance costs would amount to \$46,171,000.

TABLE 9  
Alternative LRT-4D Operating Requirements

Day	Headway			Peak LRVs	Annual Revenue			Lay over	Cycle Time	Trains		
	Peak	Base	Eve		Car-Miles	Car-Hrs	Train-Hrs			Peak	Base	Eve
Weekdays	5.0	10.0	15.0	30	2,172,500	95,240	31,750	5.5	45.4	10	5	4
Weekends and Holidays	10.0	15.0	20.0		639,800	28,050	9,350			5	4	3
<b>Estimated Totals:</b>				<b>30</b>	<b>2,812,300</b>	<b>123,290</b>	<b>41,100</b>			<b>10</b>	<b>5</b>	<b>4</b>
Ready Cars:				6								
Peak Revenue Total:				36								
Maintenance Spares:				7								
Total Fleet:				<b>43</b>								
Annual Operation and Maintenance Costs:					<b>\$46,171,000</b>							

**LRT-6.** Operating requirements for Alternative LRT-6 are presented in Table 10. A fleet of 65 LRVs would be required, and annual operation and maintenance costs would amount to \$71,968,000.

TABLE 10  
Alternative LRT-6 Operating Requirements

Day	Headway			Peak LRVs	Annual Revenue			Lay over	Cycle Time	Trains		
	Peak	Base	Eve		Car-Miles	Car-Hrs	Train-Hrs			Peak	Base	Eve
Weekdays	5.0	10.0	15.0	48	1,881,600	149,940	49,980	5.5	79.4	16	8	6
Weekends and Holidays	10.0	15.0	20.0		530,100	42,240	14,080			8	6	4
<b>Estimated Totals:</b>				<b>48</b>	<b>2,411,700</b>	<b>192,180</b>	<b>64,060</b>			<b>16</b>	<b>8</b>	<b>6</b>
Ready Cars:				6								
Peak Revenue Total:				54								
Maintenance Spares:				11								
Total Fleet:				<b>65</b>								
Annual Operation and Maintenance Costs:					<b>\$71,968,000</b>							

## Alternatives Comparison

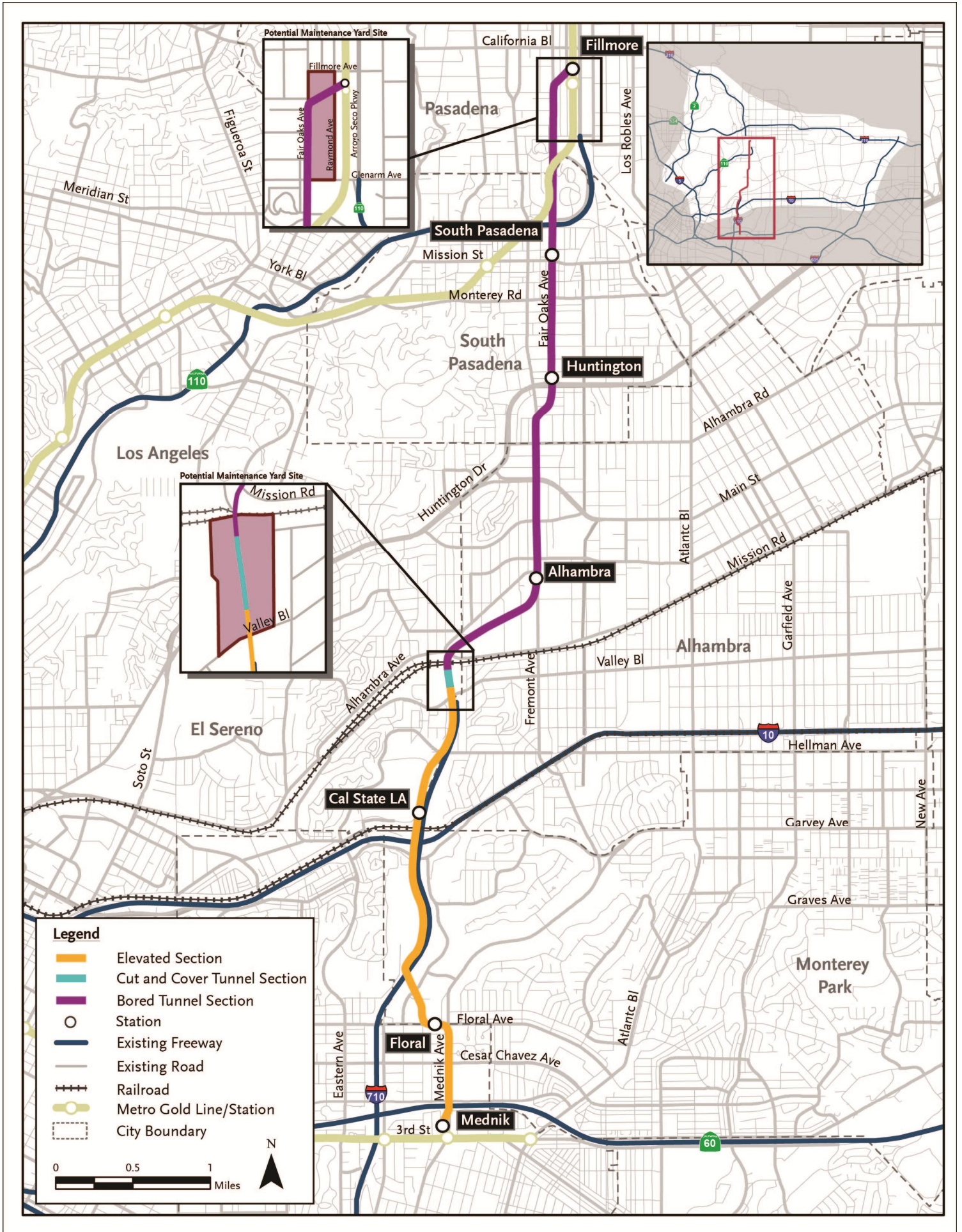
Table 11 provides a comparison table of the key operating plan and operating requirements of the alternatives. LRT-4A has the shortest run time, and accordingly the highest speed. LRT-4D has the greatest station spacing, but being the longest alternative, it has the slowest speed of the LRT-4 alternatives. LRT-6 is an outlier, with the shortest station spacing and about half the speed of the LRT-4 alternatives, due to its extensive use of street-running alignment. The alternatives require fewer vehicles and lower operating cost with increasing average speed.

TABLE 11  
**Operating Plan and Operating Requirements Comparison**

<b>Alternative</b>	<b>Length (mi)</b>	<b>Avg. Station Spacing (mi)</b>	<b>Run Time (min:sec)</b>	<b>Avg. Speed (mph)</b>	<b>Total Fleet (LRVs)</b>	<b>Annual O&amp;M Cost</b>
<b>LRT-4A:</b> East LA Civic Center to Fillmore via Fremont and Fair Oaks Ave. Tunnels	7.47	1.25	13:40	32.8	36	\$35,984,000
<b>LRT-4B:</b> East LA Civic Center to Fillmore via Palm Ave. and Fair Oaks Ave. Tunnel	7.89	1.32	15:09	31.3	40	\$42,076,000
<b>LRT-4D:</b> Atlantic to Fillmore via Palm Ave. and Raymond and Fair Oaks Ave. Tunnels	8.63	1.44	17:12	30.1	43	\$46,171,000
<b>LRT-6:</b> Atlantic to Fillmore via Atlantic Blvd. and Fair Oaks Ave.	8.31	1.04	34:13	14.6	65	\$71,968,000

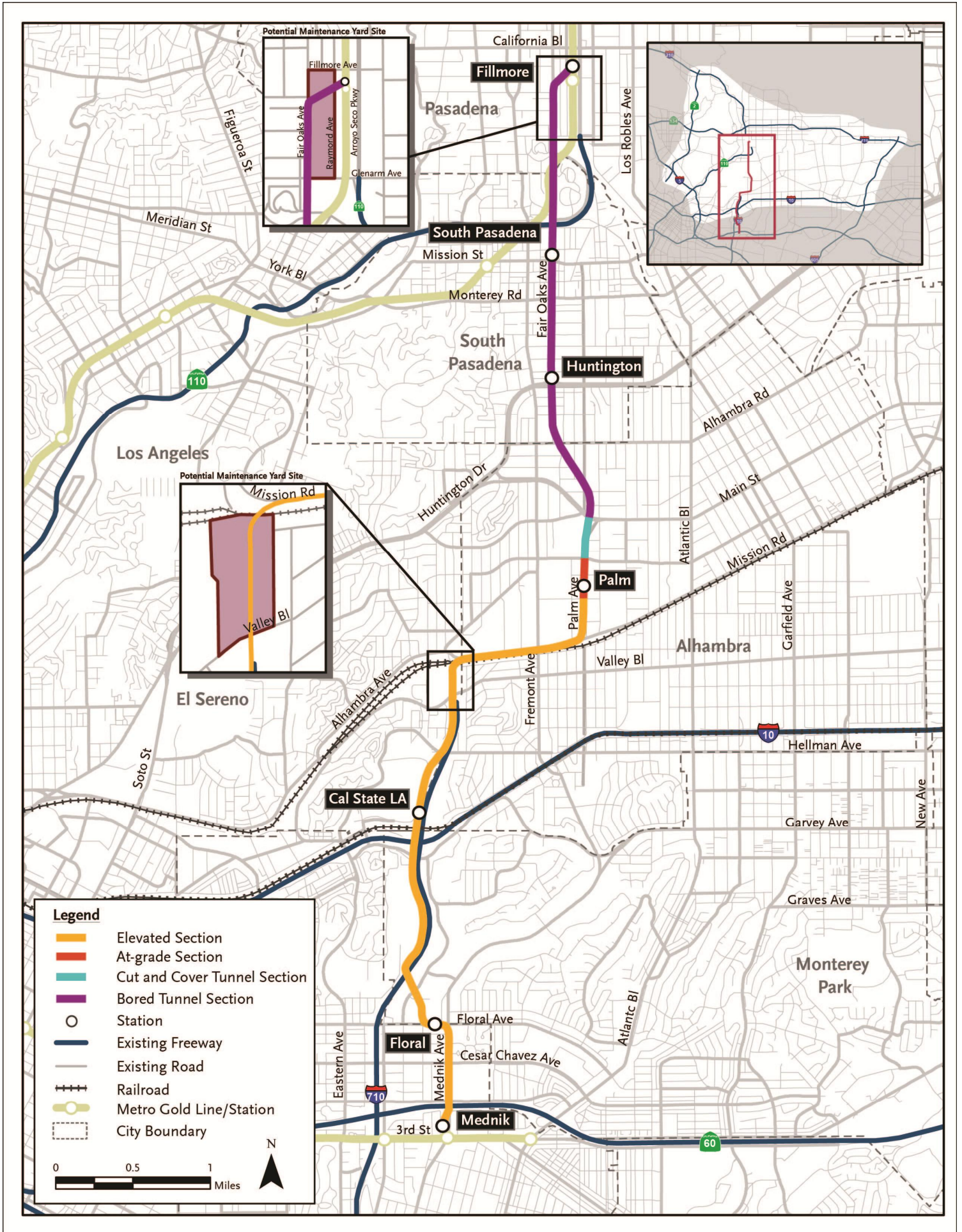
*Note: Run times are based on one-way travel.*

# Alternative LRT-4A





# Alternative LRT-4B



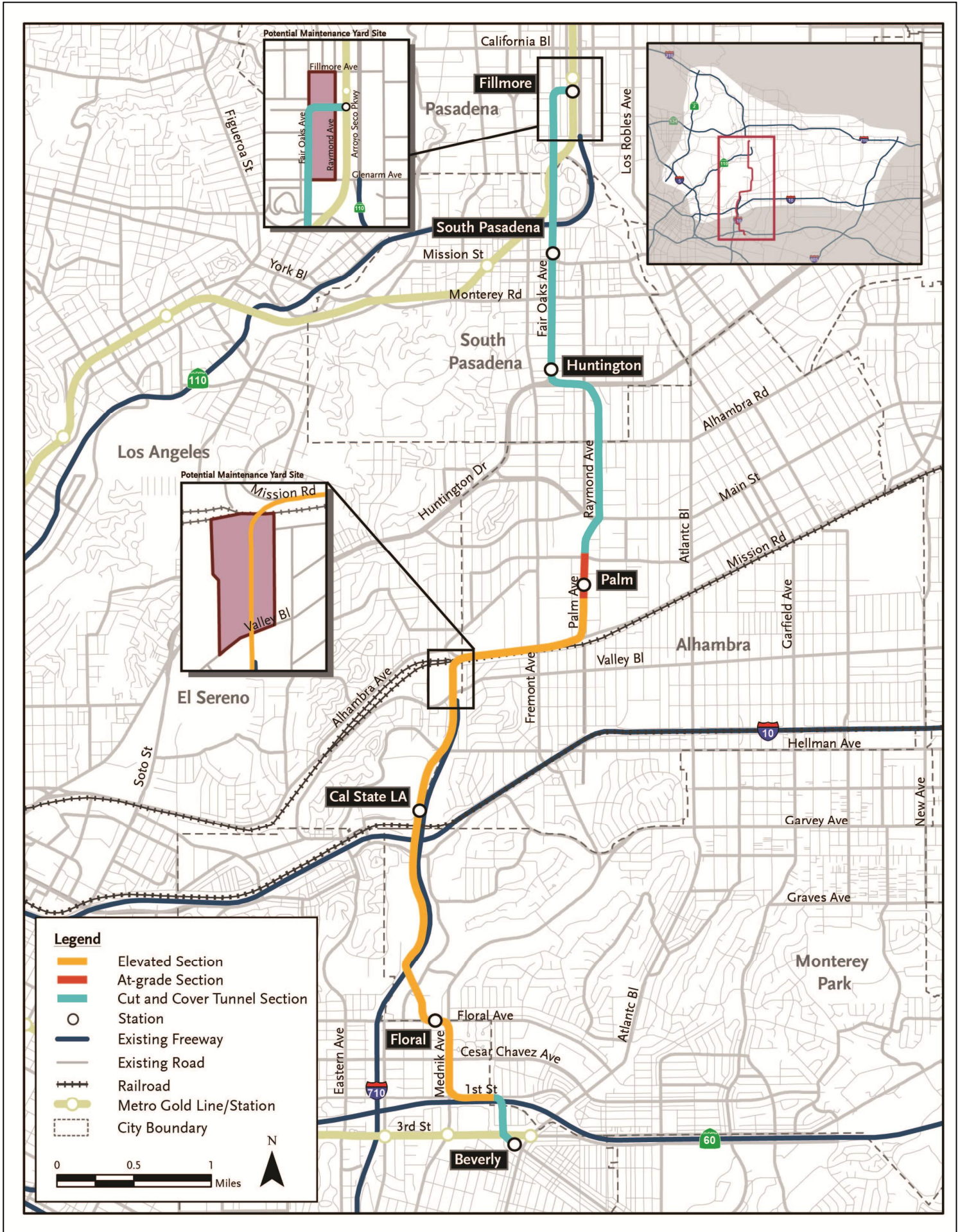
## Legend

- █ Elevated Section
- █ At-grade Section
- █ Cut and Cover Tunnel Section
- █ Bored Tunnel Section
- Station
- █ Existing Freeway
- █ Existing Road
- █ Railroad
- █ Metro Gold Line/Station
- City Boundary





# Alternative LRT-4D



## Legend

- Elevated Section
- At-grade Section
- Cut and Cover Tunnel Section
- Station
- Existing Freeway
- Existing Road
- Railroad
- Metro Gold Line/Station
- City Boundary





# Alternative LRT-6

