APPENDIX 3.3-A, APPENDIX D: BALLAST HAULING MEMORANDUM

Memorandum

To:	James Tung, HSR Alice Lovegrove, HSR
From:	David Ernst, ICF Anne Winslow, ICF
Date:	January 28, 2019
Re:	**San Francisco to San Jose Project Section of the California High-Speed Rail Project: Estimated Emissions from Hauling Ballast Material**

Introduction

Construction of the San Francisco to San Jose Project Section (Project Section) would require a substantial amount of railroad subballast and ballast material to serve as the foundation for the track alignment. This memorandum describes the methods used to: (1) determine two possible scenarios of material hauling that could occur during construction of the Project Section, and (2) calculate criteria pollutant and greenhouse gas (GHG) emissions associated with the material hauling activities for each project alternative. The information presented in this memo is intended to be used as an initial estimate of criteria pollutant and GHG emissions associated with truck and rail trips from material hauling that would occur within the San Francisco Bay Area Air Basin (SFBAAB). The actual distances and quantities associated with material hauling activities for the Project Section are not known at this time, but this memo reflects a reasonable estimate of these activities given currently available information.

Table 1 shows total ballast and subballast requirements for the project alternatives based on construction data provided by the project engineering team (Scholz 2018).

Table 1. Material Quantities by Alternative (cubic yards)

Material Type	Alternative A	Alternative B
Ballast	387,000	432,000
Subballast	519,000	588,000
Total	**906,000**	**1,020,000**

Source: Scholz 2018

Quarries Evaluated

A list of all active quarries in California was obtained from the California Department of Conservation, Division of Mine Reclamation's interactive Mines Online (MOL) map (California Department of Conservation 2016). Quarries were filtered for those supplying a primary commodity that could potentially be used for ballast material (rock or sand and gravel), and those quarries that are in the air basin in which the Project Section is located. Quarries with 200 or more acres of permitted area were considered to be of sufficient size to effectively serve the demand, consistent with the analysis approach taken for the Bakersfield to Palmdale Project Section of the California High-Speed Rail Project (URS/HMM/Arup 2012).

Based on these criteria, the list of all active quarries in California was narrowed down to five quarries. It was assumed that the fewest possible quarries would be used for efficiency, and that the selection of quarries would differ through the Project Section based on proximity to transportation infrastructure. Five quarries were identified to serve the San Francisco to South San Francisco, San Bruno to San Mateo, San Mateo to Palo Alto, and Mountain View to Santa Clara Subsections.

All selected quarries were evaluated using the following criteria:

1. Distance to the Project Section in rail miles.
2. Distance from the quarry to the nearest railhead for transport (via roads).
3. Truck hauling distance (road miles) to project work sites through the SFBAAB.

Table 2 shows the results of these inquiries. Distances were measured to the centerpoint of each subsection.

Table 2. Quarry Information

Quarry Name	Project Subsection							
	San Francisco to South San Francisco		San Bruno to San Mateo		San Mateo to Palo Alto		Mountain View to Santa Clara	
	Rail Miles[1]	Road Miles[2]	Rail Miles[1]	Road Miles[2]	Rail Miles[1]	Road Miles[2]	Rail Miles[1]	Road Miles[2]
Dutra Materials	N/A	35	N/A	44	N/A	57	N/A	68
Eliot Facility	52	44	42	42	30	43	40	37
Calmat/Pleasanton	52	45	42	42	30	44	40	37
Pilarcitos Quarry	N/A	22	N/A	13	N/A	18	N/A	30
Mission Valley Sand and Gravel	N/A	49	N/A	40	N/A	33	N/A	21

N/A = quarries with no visible railhead
[1] Measured from each railhead, following the rail tracks, to the centerpoint of the alignment, using Google Earth imagery.
[2] Measured from each quarry to the centerpoint of the alignment using Google Earth directions.

Methodology for Developing Ballast Hauling Scenarios

The actual hauling scenarios that would take place during construction are not known at this time. Accordingly, the following two potential total hauling scenarios for ballast and subballast material for the two project alternatives were developed for the quarries listed in Table 2.

- **Scenario 1**—All ballast and subballast materials from quarries would be hauled by truck. This scenario represents the maximum emissions scenario for truck hauling.
- **Scenario 2**—All ballast and subballast materials from quarries without rail or where rail would be infeasible would be hauled by truck. All ballast and subballast materials from quarries with rail would be hauled by rail. Rail was considered infeasible if there was determined to be no direct route of train tracks from the quarry to the project alignment. This scenario represents the maximum emissions scenario for rail hauling.

These scenarios were developed to provide a reasonable range of potential criteria pollutant and GHG emissions that might be generated by material hauling activities. The scenarios characterize a range of supply from the different quarries, representing the maximum amount of haul activity for truck transport to a maximum amount of haul activity for rail transport. Each of the selected quarries in each subsection was assumed to supply an equal amount of ballast (e.g., for the San Francisco to South San Francisco Subsection, each of the five quarries was assumed to supply one-fifth of the total amount of ballast and subballast material required for the subsection).

Table 3 shows the amount of ballast and subballast hauled by truck and rail under Scenarios 1 and 2 for each project alternative.

Table 3. Amount of Ballast and Subballast Material Hauled from Each Quarry for Scenarios 1 and 2 (cubic yards per year)

Quarry Name	Alternative A		Alternative B	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Dutra Materials				
Rail	0	0	0	0
Truck	181,200	181,200	204,000	204,000
Eliot Facility				
Rail	0	181,200	0	204,000
Truck	181,200	0	204,000	0
Calmat/Pleasanton				
Rail	0	181,200	0	204,000
Truck	181,200	0	204,000	0
Pilarcitos Quarry				
Rail	0	0	0	0
Truck	181,200	181,200	204,000	204,000
Mission Valley Sand and Gravel				
Rail	0	0	0	0
Truck	181,200	181,200	204,000	204,000

Considerations for the Criteria Pollutant and Greenhouse Gas Emissions Analysis

The material quantities shown in Table 3 were used to determine the pollutant emissions that would be generated within the SFBAAB from hauling activities for each construction phase that requires ballast and subballast material hauling. The criteria pollutants evaluated were carbon monoxide (CO), nitrogen oxide (NO_X), particulate matter with a diameter of 10 micrometers or less (PM_{10}), particulate matter with a diameter of 2.5 micrometers or less ($PM_{2.5}$), reactive organic gases (ROG), and sulfur dioxide (SO_2). Analysts also evaluated carbon dioxide equivalents (CO_2e)—the contributions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Emissions were calculated by multiplying the mileage associated with each scenario by criteria pollutant and GHG emission factors for rail and truck hauling.

The distances between each quarry and the centerpoint of the alignment were estimated for rail hauling using Google Earth imagery. The distances between each quarry and the centerpoint of the alignments were estimated for truck hauling using Google Earth directions.

Total hauling distances associated with each scenario were calculated by multiplying the number of truck trips needed by the hauling trip distances associated with each scenario. The number of truck trips needed was determined by dividing the material quantities for each scenario by an assumed capacity of 20 cubic yards per truck. The emission factor used for trains is in units of grams per ton-mile (Table 4), which was converted to grams per cubic yard-mile using a conversion factor of 1.3 cubic yards per ton of ballast/subballast materials (Gravelshop 2019).

Table 4 shows the emission factors used in the analysis. Rail emission factors are based on *Emission Factors for Locomotives* (USEPA 2009). Haul truck emission factors are from EMFAC2017 (CARB 2018), based on the regional fleet of heavy-heavy duty trucks. The analysis presents emissions after implementation of AQ-IAMF#5: Reduce Criteria Exhaust Emissions from On-Road Construction Equipment, which requires a model year fleet-wide average of 2010 or newer engines for all material hauling vehicles. Emission factors for the analysis assumed implementation of AQ-IAMF#5.

Table 4. Rail and Truck Emission Factors

Emission Source	Emission Factors						
	ROG	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	CO_2
Rail[1]							
2022	0.01	0.21	0.06	<0.01	<0.01	<0.01	21
2023	0.01	0.20	0.06	<0.01	<0.01	<0.01	21
2024	0.01	0.19	0.06	<0.01	<0.01	<0.01	21
2025	0.01	0.18	0.06	<0.01	<0.01	<0.01	21
Trucks							
With AQ-IAMF#5[2]							
2022	0.04	3.08	0.42	0.10	0.04	0.02	1,749
2023	0.03	2.98	0.40	0.10	0.04	0.02	1,715
2024	0.03	3.02	0.41	0.10	0.04	0.02	1,694
2025	0.03	3.06	0.41	0.10	0.04	0.02	1,673

Sources: CARB 2018; USEPA 2009
CO = carbon monoxide
CO_2 = carbon dioxide
NO_X = nitrogen oxide
$PM_{2.5}$ = particulate matter smaller than or equal to 2.5 microns in diameter
PM_{10} = particulate matter smaller than or equal to 10 microns in diameter
ROG = reactive organic gases
SO_2 = sulfur dioxide
USEPA = U.S. Environmental Protection Agency
Emission factors are presented for 2022, 2023, 2024, and 2025, which are the years in which ballast hauling would occur.
[1] Emission units are grams per ton-mile. Based on a conversion factor of 479 ton-miles/gallon from the Association of American Railroads and grams/gallon emission factors from the USEPA's *Emission Factors for Locomotives* (USEPA 2009; American Association of Railroads 2019).
[2] Emission units are grams per mile. Based on EMFAC2017 regional fleet for heavy-heavy duty model year 2010 or newer engines.

For this analysis, the significance of the criteria pollutant emissions associated with hauling activities is determined by comparing the emissions to the emissions thresholds relevant to the SFBAAB. The applicable air district in the SFBAAB is the Bay Area Air Quality Management District (BAAQMD). The federal and state air quality attainment status of the air basin—which determines the General Conformity *de minimis* thresholds that apply to the Project Section—is shown in Table 5. The General Conformity *de minimis* thresholds that are applicable to the Project Section are shown in Table 6, and the applicable air district California Environmental Quality Act (CEQA) thresholds are shown in Table 7. BAAQMD has not adopted a GHG emission threshold for construction-related emissions.

Table 5. Federal and State Attainment Status of the SFBAAB

Pollutant	Federal	State
Ozone (O_3)	N (marginal)	N
Particulate matter (PM_{10})	A/U	N
Particulate matter ($PM_{2.5}$)	N (moderate)	N
Carbon monoxide (CO)	A/U	A
Nitrogen dioxide (NO_2)	A/U	A
Sulfur dioxide (SO_2)	A/U	A

Sources: CARB 2017; USEPA 2018
A/U = attainment/unclassified
N = nonattainment

Table 6. General Conformity *de minimis* Thresholds for the Resource Study Area

	Emissions Threshold (Tons per Year)					
Air Basin	ROG	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2[1]
San Francisco Bay Area Air Basin	100	100	N/A	N/A	100	100

Source: 40 Code of Federal Regulations Part 93.153
CO = carbon monoxide
N/A = not applicable: SFBAAB is in attainment for CO and PM_{10}
NO_X = nitrogen oxide
$PM_{2.5}$ = particulate matter smaller than or equal to 2.5 microns in diameter
PM_{10} = particulate matter smaller than or equal to 10 microns in diameter
ROG = reactive organic gases
RSA = resource study area
SO_2 = sulfur dioxide
[1] Although the RSA is in attainment for SO_2, because SO_2 is a precursor for $PM_{2.5}$, the $PM_{2.5}$ General Conformity *de minimis* thresholds are used.

Table 7. BAAQMD Mass Emission Construction CEQA Thresholds

ROG: 54 lb/day
NO_X: 54 lb/day
PM_{10}: 82 lb/day (exhaust only)
$PM_{2.5}$: 54 lb/day (exhaust only)

Source: BAAQMD 2017
BAAQMD = Bay Area Air Quality Management District
lb = pounds
NO_X = nitrogen oxide
$PM_{2.5}$ = particulate matter smaller than or equal to 2.5 microns in diameter
PM_{10} = particulate matter smaller than or equal to 10 microns in diameter
ROG = reactive organic gases

Annual Hauling Activity Emissions

Maximum annual criteria pollutant and GHG emissions associated with hauling the ballast and subballast material within the SFBAAB are shown in Table 8 for the two potential hauling scenarios. Ballast and subballast hauling would occur in 2022, 2023, 2024, and 2025, with maximum emissions occurring in 2025. In Table 8, the maximum annual emissions are compared to the General Conformity *de minimis* thresholds and annual CEQA thresholds applicable to the resource study area, respectively (see Tables 6 and 7).

As shown in Table 8, ballast and subballast hauling under both project alternatives would not exceed the General Conformity *de minimis* NO_X threshold but would exceed BAAQMD's annual NO_X threshold. Ballast and subballast hauling emissions have been incorporated into the larger Project Section construction analysis presented in the *San Francisco to San Jose Project Section Air Quality and Greenhouse Gases Technical Report* (Air Quality and Greenhouse Gases Technical Report) (Authority 2019) (see Chapter 7, Air Quality Effects Analysis). Emissions greater than BAAQMD CEQA thresholds would be offset to below air district threshold levels through implementation of AQ-MM#1: Offset Project Construction Emissions in the SFBAAB.

Daily Hauling Activity Emissions

Daily maximum criteria pollutant emissions associated with hauling the ballast and subballast material in the BAAQMD are shown in Table 9 for the two potential hauling scenarios. Emission estimates were developed based on the hauling schedule, as provided by the project engineers (Scholz 2018). As shown in Table 9, ballast and subballast hauling emissions would exceed the BAAQMD's daily NO_x threshold.

Ballast and subballast hauling emissions have been incorporated into the larger Project Section construction analysis presented in the Air Quality and Greenhouse Gases Technical Report (see Chapter 7). Emissions greater than BAAQMD CEQA thresholds would be offset to below air district threshold levels through implementation of AQ-MM#1.

Greenhouse Gas Emissions

Total GHG emissions (in terms of CO_2e over the 4-year hauling period) associated with hauling the ballast and subballast material within the SFBAAB are shown in Table 9. The table indicates total combined hauling emissions in the SFBAAB would range from 3,977 to 6,910 metric tons CO_2e, depending on the project alternative and hauling scenario. Amortized GHG emissions over a 25-year period range from 159 to 276 metric tons CO_2e per year.

Ballast and subballast hauling emissions have been incorporated into the larger Project Section construction analysis presented in the Air Quality and Greenhouse Gases Technical Report (see Chapter 8, Global Climate Change Effects Analysis). The short-term increase in construction-related emissions would be more than compensated for by long-term emissions reductions achieved during project operations. Material hauling activities to construct the Project Section would also be consistent with Assembly Bill (AB) 32 reduction goals, as the California High-Speed Rail System is included in the AB 32 scoping plan as Measure #T-9.

Table 8. Ballast and Subballast Hauling Emissions (maximum tons/year)

				PM_{10}			$PM_{2.5}$				
Alternative and Scenario	**ROG**	**NO_X**	**CO**	**Dust**	**Exhaust**	**Total**	**Dust**	**Exhaust**	**Total**	**SO_2**	**CO_2e (Total)[1]**
With AQ-IAMF#5											
Alternative A											
Scenario 1	<1	**10***	1	3	<1	3	1	<1	1	<1	6,647
Scenario 2	<1	**11***	3	1	<1	1	<1	<1	<1	<1	3,977
Alternative B											
Scenario 1	<1	**11***	1	3	<1	3	1	<1	1	<1	6,910
Scenario 2	<1	**11***	3	1	<1	2	<1	<1	1	<1	4,095
General Conformity Threshold for SFBAAB	100	100	-	-	-	-	-	-	100	100	-
AAQMD Yearly Construction Threshold	10	10	-	-	15	-	-	10	-	-	-
Exceedances of the General Conformity Threshold	No	No	-	-	-	-	-	-	No	No	-
Exceedances of the BAAQMD Threshold	No	**Yes**	-	-	No	-	-	No	-	-	-

Sources: Scholz 2018; USEPA 2009; CARB 2018
BAAQMD = Bay Area Air Quality Management District
CO = carbon monoxide
CO_2e = carbon dioxide equivalent
NO_X = nitrogen oxide
$PM_{2.5}$ = particulate matter smaller than or equal to 2.5 microns in diameter
PM_{10} = particulate matter smaller than or equal to 10 microns in diameter
ROG = reactive organic gases
SFBAAB = San Francisco Bay Area Air Basin
SO_2 = sulfur dioxide
Exceedances are bold with an asterisk (*).
[1] The units for CO_2e are metric tons, not short tons. Values represent total GHG over the 4-year hauling period, not maximum annual.

Table 9. Maximum Daily Ballast and Subballast Hauling Emissions within the BAAQMD (pounds/day)[1]

				PM_{10}			$PM_{2.5}$			
Scenario	**ROG**	**NO_X**	**CO**	**Exhaust**	**Dust**	**Total**	**Exhaust**	**Dust**	**Total**	**SO_2**
With AQ-IAMF#5										
Alternative A										
Scenario 1	9	**910***	122	4	276	280	4	71	75	5
Scenario 2	9	**911***	123	4	276	281	4	71	75	5
Alternative B										
Scenario 1	28	**1,053***	287	16	124	140	15	32	47	3
Scenario 2	28	**1,055***	287	16	124	140	15	32	47	3
BAAQMD daily construction threshold	54	54	-	82	-	-	54	-	-	-
Exceedances of the BAAQMD threshold	No	**Yes**	-	No	-	-	No	-	-	-

Sources: Scholz 2018; USEPA 2009; CARB 2018
BAAQMD = Bay Area Air Quality Management District
CO = carbon monoxide
CO_2e = carbon dioxide equivalent
NO_X = nitrogen oxide
$PM_{2.5}$ = particulate matter smaller than or equal to 2.5 microns in diameter
PM_{10} = particulate matter smaller than or equal to 10 microns in diameter
ROG = reactive organic gases
SO_2 = sulfur dioxide
Exceedances are bold with an asterisk (*).
[1] Table presents the highest daily emissions that would be incurred over the 4-year hauling period.

Conclusion

The material hauling scenarios discussed in this memorandum represent possible ballast and subballast material hauling activities for the Project Section. While it is currently unknown which quarries and transport methods would be used, this memorandum provides a reasonable estimation of potential hauling scenarios and the corresponding criteria pollutant and CO_2e emissions.

Ballast and subballast hauling would independently exceed the BAAQMD annual and daily CEQA thresholds for NO_x. Combined GHG emissions in the SFBAAB would range from 3,977 to 6,910 total metric tons CO_2e, or 159 to 276 metric tons CO_2e per year (over a 25-year project life).

Ballast and subballast hauling emissions have been incorporated into the larger Project Section construction analysis presented in the Air Quality and Greenhouse Gases Technical Report. Emissions greater than BAAQMD CEQA thresholds would be offset to below air district threshold levels through implementation of AQ-MM#1. GHG emissions would be more than compensated for by long-term emissions reductions achieved during operation of the Project Section.

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