Appendix 22A
Air Quality Analysis ~~Assumptions~~Methodology

This appendix discusses the approach and methodology used to assess construction and operational emissions associated with the water conveyance facility. The analysis evaluates maximum daily and yearly emissions to comply with CEQA and NEPA guidelines in the Plan Area (the area covered by the BDCP). Emissions analyzed include criteria pollutants and GHGs (CO_2, CH_4, N_2O, ~~and~~ SF_6, and HFCs).

22A.1 Construction

Construction of the water conveyance facilities would generate emissions of ROG, NO_X, CO, PM10, PM2.5, SO_2 and GHGs (CO_2, CH_4, N_2O, ~~and~~ SF_6, and HFCs) that would result in short-term impacts on ambient air quality in the Plan area. Emissions would originate from mobile and stationary ~~construction~~ heavy-duty equipment exhaust, marine vessel exhaust, tunneling locomotive exhaust, employee and haul truck vehicle exhaust, helicopter exhaust, site grading and earth movement, paving, ~~dust from earthmoving and clearing the land,~~ electricity use, and concrete batching. Construction-related emissions vary substantially depending on the level of activity, length of the construction period, specific construction operations, types of equipment, number of personnel, wind and precipitation conditions, and soil moisture content.

DWR and 5RMK Inc. (5RMK) developed construction phasing and scheduling assumptions as part of an economic analysis ("cost estimate") in 2014 for the modified pipeline alignment (MPTO). The cost estimate provides detailed information on equipment and vehicle activity (e.g., operating hours per day), as well as the start date and number of working days for each phase. Construction features analyzed in the cost estimate include the intakes, intermediate and Clifton Court forebays, and tunnel reaches. Schedule and construction activity assumptions for features not evaluated in the cost estimate, including geotechnical explorations, utility development, and tunnel segment hauling, were provided separately by DWR. The construction assumptions developed by 5RMK and DWR were used to estimate emissions, as described further below in Sections 22A.1 through 22A.9.

A similar cost estimate was developed by DWR and 5RMK in 2010 for the pipeline tunnel option (PTO) and east canal. The assumptions and methodology used in the 2010 cost estimate have been superseded by the approach utilized to develop the MPTO cost estimate. Accordingly, emissions associated with the PTO and east canal were analyzed using a combination of the 2010 and 2014 cost estimate assumptions, where appropriate, as well as activity scaling factors, as described further below. Emissions generated by the west canal and separate corridors options (SCO) were analyzed using a similar approach, since cost estimates unique to these alignments were not available at the time of analysis.

Table 22A-1 summarizes the cost estimate files that inform the emissions analysis for each feature, as well as whether any scaling factors were utilized to adjust or update the underlying cost estimate assumptions. The scaling factors were derived based on similarities in construction design among the alternatives. For example, Alternative 4 would construct three intakes, whereas Alternatives 1A, 2A, and 6A would construct five, resulting in a scaling factor of 1.67.

Table 22A-1. Cost Estimate Assumptions and Scaling Approach for the Air Quality and Greenhouse Gas Emissions Analysis

		Scaling Factor							
Feature	Assumption Source[a]	Alts 1A, 2A, 6A	Alts 1B, 2B, 6B	Alts 1C, 2C, 6B	Alt 3	Alt 4	Alt 5	Alt 7, 8	Alt 9
-Intakes	2014 MPTO cost estimate	1.67	1.67	1.67	0.67	None	0.33	None	2.80
Intermediate Forebay	2014 MPTO cost estimate	3.33	-	-	3.33	None	3.33	3.33	-
Tunnels	2014 MPTO cost estimate	0.80	0.04	0.40	0.63	None	0.62	0.70	-
Clifton Court Forebay	2014 MPTO cost estimate	0.50	0.50	0.50	0.50	None	0.50	0.50	-
Combined Pumping Plant	2014 MPTO cost estimate	-	-	-	-	None	-	-	-
Geotechnical Explorations	DWR activity estimate	-	-	-	-	None	-	-	-
Temporary Utilities 69Kv	DWR activity estimate	0.58	0.29	0.29	0.34	None	0.34	0.40	0.15
Temporary Utilities 69kV+	DWR activity estimate	-	-	-	-	None	-	-	0.15
Permeant Utilities	DWR activity estimate	3.29	1.33	2.85	1.33	None	0.68	1.98	-
Segment Hauling	DWR activity estimate	-	-	-	-	None	-	-	-
Pumping Plants	2012 MPTO cost estimate[b]	1.67	1.67	1.67	0.67	-	0.33	None	0.67
Pipelines	2010 PTO cost estimate	None	1.77	1.23	0.56	-	0.27	0.60	-
Intermediate Pumping Plant	2010 PTO cost estimate	None	0.95	None	0.44	-	0.33	None	0.00
Canals	2010 East cost estimate	-	None	0.93	-	-	-	-	0.16
Siphons/Gates/Barriers	2010 East cost estimate	-	4.07	3.82	-	-	-	-	4.40
Bridges	2014 MPTO cost estimate[c]	-	3.01-5.42[d]	0.00-5.57[d]	-	-	-	-	3.00
Dredging	2014 MPTO cost estimate[e]	-	-	-	-	-	-	-	1.70

Notes

- Feature does not exist

None No scaling factor needed; the activity estimates in the assumption file were used without modification.

[a] Representing the underlying source for the activity assumptions (e.g., operating hours, vehicle trips). The assumptions source is also used to define the scaling factor for each alternative. For example, the 2014 MPTO cost estimate is based on the construction of three intakes for Alternative 4. Alternatives 1A, 2A, and 6A would construction five intakes, resulting in a scaling factor of 1.67.

[b] An initial draft of the MPTO cost estimate was prepared in 2012, but was superseded by the 2014 estimate. Since the pumping plants were eliminated from the construction design in 2014, the 2014 estimate did not include pumping plants. Accordingly, the 2012 MPTO cost estimate represents the best available data for construction of the pumping plants.

[c] Construction of a single bridge was excerpted from the 2014 MPTO cost estimate to define the additional bridges needed for the SCO and east and west canals. Please note that construction of bridges at specific features (e.g., intakes) under the MPTO and PTO are incorporated into that features activity assumptions (i.e., there is no standalone bridge "feature" for these alignments).

[d] Separate scaling factors were identified for each anticipated bridge contract, as defined below:

East Canal: Contract 1 = 3.01; Contract 2 = 4.00; Contract 3 = 5.42; Contract 4 = 4.95; Contract 5 = 3.61

West Canal: Contract 1 = 3.09; Contract 2 = 1.82; Contract 3 = 5.57; Contract 4 = 5.46; Contract 5 = 0.00

[e] The dredging only activity at the Clifton Court Forebay was excerpted from the 2014 MPTO cost estimate to define dredging activities under the SCO. Please note that dredging activities at the Clifton Court Forebay under the MPTO are incorporated in the activity assumptions for the Clifton Court Forebay feature (i.e., there is no standalone dredging "feature" for the MPTO).

All equipment operating assumptions from the 2010 and 2014 cost estimates are summarized in Appendix 22B, *Air Quality Assumptions.* This appendix also provides the construction schedule (Table 22B-1), emission factors, and model outputs, as applicable. Please refer to Sections 22A.1.1 through 22A.1.9 for a detailed overview of the equations and approach used to quantify emissions from each source (e.g., heavy-duty equipment).

22A.1.1 Schedule and PhasingHeavy Duty Equipment

22A.1.1.1 Alternatives 1A, 2A, 6A (Pipeline/Tunnel Alignment) and Alternatives 1B, 2B, and 6B (East Alignment)

DWR provided data on construction phasing separately as part of an economic analysis ("cost estimate") and construction schedule. The cost estimate includes detailed information on construction activity (e.g., equipment type, hours of operation) by phase, but lacks information on when each phase will specifically occur. The construction schedule outlines the start date for each phase, but does not contain any activity information. The distribution of construction activity in the construction sequence was therefore determined by matching information in the cost estimate with a corresponding schedule entry. For example, the clearing and grubbing phase for Intake 1 was matched with "River Intake 1: Clearing & Grubbing / Demolition" in the constructions schedule, which is anticipated to begin in March 2017 (pipeline/tunnel alignment). In instances where more than one cost estimate phase was matched with the same construction schedule phase, the start dates of sequential phases were staggered based on professional judgment. All scheduling assumptions were verified through email communication with DWR.

While the construction schedule provides construction duration data, the cost estimate provides the most refined representation of the actual construction activities associated with the project. The duration of each construction phase was therefore based on the cost estimate and not the construction schedule. In instances where the cost estimate did not list phase duration, the construction schedule, rather than the cost estimate, was used to define the phase length. Because the construction schedule includes periods of inactivity in the overall phase duration, emissions estimates for these phases are likely conservative in that they overestimate actual emissions. The methodology for determining the phase length was based on guidance provided by DWR.

The cost estimate includes several duplicative entries, as well as phases solely associated with the procurement of materials or equipment that would result in no construction activities. Construction activity that has been duplicated in two identical phases is accounted for twice in the cost estimate, whereas no construction activity (e.g., operation of heavy-duty equipment or vehicles) would occur during phases associated with procurement. Consequently, duplicative and non-activity phases were excluded from the air quality and GHG analysis to avoid double counting.

Several phases in the cost estimate do not have corresponding activity assumptions and are either listed as "zero cost" or "lump sum." Based on guidance provided by DWR, construction activity associated with "zero cost" phases was assumed to be incorporated elsewhere in the construction schedule (i.e., a "duplicative" entry). Because emissions associated with "zero cost" phases are captured elsewhere in the schedule, they were excluded from the air quality and GHG analysis.

"Lump sum" phases can be categorized by their anticipated activity (e.g., "procurement", "grading", "dewatering"). Phases associated solely associated with procurement were excluded from the

~~analysis as no emissions-generating activities would occur (see above). For "lump sum" phases with actual construction activity (e.g., "dewatering"), scheduling assumptions were developed by ICF International and DWR based on professional experience.~~

~~Construction phasing assumptions for Alternatives 1A, 2A, and 6A (pipeline/tunnel alignment) and Alternatives 1B, 2B, and 6B (east alignment) are presented in Tables 22B-1 and 22B-2, respectively, in Appendix 22B, *Air Quality Assumptions*. The tables list the total working days and construction start date (month, year).~~

~~Alternative 9 (Through Delta/Separate Corridors Alignment)~~

~~DWR provided data on construction phasing and scheduling as part of an activity analysis and construction schedule. The activity analysis identifies equipment required for construction of the water conveyance facilitates associated with Alternative 9 by major construction phase (e.g., DCC Fish Screen), but lacks information on when each phase will occur. The construction schedule outlines the start date for each phase, but does not contain any activity information. The distribution of each phase in the construction sequence was determined using the methodology described above for the pipeline/tunnel alignment and east alignment. Phase duration was not provided in the activity analysis and was therefore based solely on the construction schedule.~~

~~Construction phasing assumptions for Alternative 9 (through Delta/separate corridors alignment) are presented in Table 22B-3 in Appendix 22B, Air Quality Assumptions. The table lists the total working days and construction start date (month, year).~~

~~Emissions Calculations~~

~~Heavy-Duty Offroad Equipment~~

~~The~~ Emission factors obtained from the CalEEMod ~~emissions model~~Users Guide and ARB's OFFROAD2007 model were ~~was~~ used to calculate exhaust emissions from heavy-duty construction equipment without ~~project~~ environmental commitments. ~~DWR provided equipment assumptions for each construction phase as part of the cost estimates (pipeline/tunnel alignment and east alignment) and activity analyses (through Delta/separate corridors alignment).Equipment assumptions for the modified pipeline/tunnel alignment were provided for construction of the tunnels, Clifton Court Forebay, utilities, siphons, and canals (see Section 22A.1.1.4).~~ Equipment descriptions provided by DWR and 5RMK as part of the cost estimate were frequently model specific (e.g., CAT 963), and were not grouped into generic operating types (e.g., bulldozer). To estimate emissions using CalEEMod emission factors, which are given for generic equipment, individual equipment provided by ~~DWR~~ the cost estimate was assigned a generic type based on the model description, industry resources, and professional experience.

Table~~s~~ 22B-~~5~~ 2~~through 22B-8~~ in Appendix 22B, *Air Quality Assumptions,* summarize~~s~~s the heavy-duty equipment assumed in the emissions modeling ~~for Alternatives 1A, 2A, and 6A (pipeline/tunnel alignment); Alternative 4 (modified pipeline/tunnel alignment); Alternatives 1B, 2B, and 6B (east alignment); and Alternative 9 (through Delta/separate corridors alignment), respectively~~. Key assumptions include:

- Equipment load factors were based on latest Carl Moyer Program Guidelines[1] (California Air Resources Board 2011:236-237).
- Diesel ~~E~~equipment ~~summarized in Appendix 22B, *Air Quality Assumptions,* was assumed to be diesel powered~~were evaluated based on emission factors from the CalEEMod Users Guide, whereas~~.~~ gasoline powered equipment were evaluated based on emission factors from the OFFROAD2007 model.
- ~~Equipment summarized in Appendix 22B, *Air Quality Assumptions,* would operate 8 hours per day.~~
- Accessory equipment (e.g., trailers, clamshell bucket) with no engines or emissions-generating components were excluded from the analysis.
- Tunnel boring machines, tunnel fans, tunnel lights, certain air compressors, and pumps were assumed to be electric and were included in the electricity analysis (see ~~section~~ Section 22.1.~~3.6~~8).

Criteria pollutant, CO_2, ~~and~~ CH_4, and N_2O (gasoline equipment only) emissions for each phase were calculated using the information summarized ~~in~~ Table 22B-2 ~~Tables 22B-5 through 22B-8~~ and Equation 22A-1.

Equation 22A -1 $$E_{phase} = \Sigma(Activity \times EF_i \times LF_i \times HP_i) \times Conv$$

Where:

E_{phase} = Total exhaust emissions for the phase, pounds per day

Activity = Equipment activity, hours per day (Table 22B-2)

EF = Engine emissions factor, grams/horsepower-hour (~~CalEEMod~~CalEEMod and OFFROAD)

LF = Engine load factor, unitless (Table 22B-2~~Carl Moyer Program~~)

HP = Engine horsepower, unitless (Table~~s~~ 22B-~~4~~ 2~~through 22B-6~~)

Conv = Conversion from grams to pounds, 0.002205

i = Equipment type ~~(Tables 22B-4 through 22B-6)~~

CalEEMod does not include emission factors for N_2O for off-road diesel equipment. Emissions of N_2O generated by each diesel-powered equipment piece were determined by scaling the CO_2 emissions quantified by Equation 22A-1 by the ratio of N_2O/CO_2 (0.00002~~6~~5) emissions expected per gallon of diesel fuel according to the ~~California Climate Action Registry~~Climate Registry ~~(CCAR)~~ (~~California Climate Action Registry 2009~~2015).

22A.1.2 Marine Vessels (Workboats, Passenger Boats, Tugboats)

Marine vessels used during construction include workboats, passenger boats, and tugboats. Workboats would be needed to support in-water construction of the intakes, Clifton Court Forebay, combined pumping plant, and portions of tunnel reach 6. A passenger speedboat would be required

[1] The Carl Moyer Program provides funding to encourage the voluntary purchase of cleaner-than-required engines. Load factors provided in the guidelines account for the most recent engine technologies and regulations.

to transport personnel to exploration sites during the geotechnical investigations (MPTO only). Finally, tugboats would be used to transport a portion of the tunnel segments to Bouldin Island and the Clifton Court Forebay (MPTO only). Tunnel segments were assumed to originate from three offsite casting yards, as described further in Section 22A.1.9.

~~Exhaust~~ Criteria pollutant emissions from marine vessels without project commitments were quantified using ~~emission factors developed by ICF International (2009:3-8) and~~ activity data provided by ~~DWR~~5RMK and DWR and the ARB's (2012) *Emissions Estimation Methodology for Commercial Harbor Craft Operating in California* (Harbor Craft Methodology). The methodology is based on a zero hour emission rate for the engine model year in the absence of any malfunction or tampering of engine components that can change emissions, plus a deterioration rate. The deterioration rate reflects the fact that base emissions of engines change as the equipment is used due to wear of various engine parts or reduced efficiency of emission control devices.[2] GHG emissions were estimated using the DWR activity data and emission factors obtained from the EPA (2009).

~~Similar to the heavy-duty equipment, generic vessel types were not provided. To estimate emissions using emission factors developed by ICF International (2009:3-8), individual vessels provided by DWR were assigned a generic type based on the model description, industry resources, and professional experience.~~

Table~~s~~ 22B-~~5~~ 3 ~~through 22B-8~~ in Appendix 22B, *Air Quality Assumptions*, summarize~~s~~ the ~~marine~~ marine vessels ~~vessels~~ assumed in the emissions modeling ~~for Alternatives 1A, 2A, and 6A (pipeline/tunnel alignment); Alternative 4 (modified pipeline/tunnel alignment);Alternatives 1B, 2B, and 6B (east alignment); Alternative 9 (through Delta/separate corridors alignment), respectively~~. Engine emission factors are summarized in Table 22B-4. Key assumptions include:

- ~~Vessels summarized in Appendix 22B, *Air Quality Assumptions*, were assumed to be Tier 0 Category 1 workboats.~~
- ~~Vessel horsepower and load factors are based on information provided by ICF International (2009:3-8).~~
- ~~Vessels summarized in Appendix 22B, *Air Quality Assumptions*, were assumed to operate 8 hours per day.~~
- Barges ~~are~~ were assumed to be either pushed or pulled by tug~~-~~boats and workboats; no emissions are generated by the barge.
- All vessels were assumed to utilize model year 2000 or older engines.

Criteria pollutant, CO_2, and CH_4 emissions for each phase were calculated using the information summarized in Tables 22B-3 and 22B-4~~Tables 22B-5 through 22B-8 and Equation 22A-2~~. N_2O emissions were calculated by scaling the CO_2 emissions quantified by the N_2O/CO_2 ratio identified in S~~s~~ection 22.1.3.1.

Equation 22A -2 $$E_{phase} = \Sigma(Activity_i \text{ X } EF_i \text{ X } LF_i \text{ X } [HP_i \text{ X } Conv_1]) \text{ X } Conv_2$$

Where:

[2] ARB's deterioration factors, useful life, and zero-hour emission factors were used for all pollutants except SO_X. SO_X emissions were quantified based on brake-specific fuel consumption and a sulfur fuel content of 15 ppm, which is the sulfur content limit for California harbor craft, in accordance with California Diesel Fuel Regulations.

E_{phase} = Total exhaust emissions for the phase, pounds per day

Activity = ~~Vessel~~ Boat activity, hours per day (Table 22B-3)

EF = Engine emissions factor, grams/~~kWh~~ hp-hr (~~ICF International 2009:3~~ Table 22B-4~~8~~)

LF = Engine load factor, ~~unitless~~ (Table 22B-3) ~~(ICF International 2009)~~

HP = Engine horsepower~~kW~~, ~~unitless~~ (Table 22B-3) ~~(Tables 22B-4 through 22B-6)~~

~~$Conv_1$ = Conversion from horsepower to kilowatts, 0.75~~

Conv~~$_2$~~ = Conversion from grams to pounds, 0. 002205

22A.1.3 Locomotives

Small, mining-type locomotives would be used to convey excavated material and personnel in rail cars through the tunnel alignments. The ARB's (2010) off-road diesel engine standards were used to quantify regulated criteria pollutant emissions (ROG, NO_X, CO, and PM). The SO_X emission factor was calculated assuming a 15 parts per million (ppm) sulfur content, consistent with ARB and EPA requirements. ~~Emissions from these diesel-powered locomotives without project commitments were quantified using EPA Tier 0 off-road diesel emission standards (ICF International 2009:4-13-4-17).~~ Locomotive engine ~~rating, based on engineering specifications (25-ton), were~~rating, based on engineering specifications (25-ton), was assumed to be 150 horsepower (Tier 1).

Table~~s~~ 22B-~~5~~ 5 ~~through 22B-7~~ in Appendix 22B, *Air Quality Assumptions,* identifi~~es~~y the ~~number days in which locomotives would operate during each tunneling phase~~locomotive operating information assumed in the emissions modeling ~~for Alternatives 1A, 2A, and 6A (pipeline/tunnel alignment); Alternative 4 (modified pipeline/tunnel alignment); and Alternatives 1B, 2B, and 6B (east alignment), respectively (no locomotives would be required for construction of Alternative 9)~~. Engine emission factors are summarized in Table 22B-6. Criteria pollutant~~,~~ and CO_2~~, and CH_4~~ emissions for each phase requiring locomotives were calculated using Equation 22A-3. CH_4 and N_2O emissions were ~~calculated~~ estimated by scaling the CO_2 emissions quantified ~~by the~~by the ratio of CH_4/CO_2 (0.000057) and N_2O/CO_2 (0.000025)~~identified in section 22.1.3.1~~.

Equation 22A -3 $$E_{phase} = \Sigma(\text{Activity} \times EF \times HP \times LF) \times Conv$$

Where:

E_{phas} = Total exhaust emissions for the phase, pounds per day

Activity = Engine activity, hours per day (Table 22B-5)

EF = Engine emissions factor, grams/horsepower-hour (~~ICF International 2009~~Table 22B-6)

HP = Engine horsepower, 150

LF = Engine load factor, 0.80

Conv = Conversion from grams to pounds, 0. 002205

22A.1.4 On-Road Vehicles

22A.1.4.1 Engine Exhaust

On-road vehicles include vehicles used for material and equipment~~s~~ hauling, tunnel segment hauling, employee commuting, onsite crew and material movement, and as-needed supply and equipment pick-up. ~~and general crew movement, as well as vehicles used for employee commuting to the project site.~~ Emissions from ~~materials hauling and general crew movement~~on-road vehicles without project commitments were estimated using the ~~EMFAC2011~~ EMFAC2014 emissions model and activity data provided by DWR and 5RMK. Similar to heavy-duty equipment~~ and marine vessels~~, generic vehicle types were not provided. To estimate emissions using EMFAC emission factors, individual vehicles provided by DWR and 5RMK was assigned a generic type based on the model description, industry resources, and professional experience. ~~Emissions from employee commuting were estimated using EMFAC2011 and the total number of personnel required to complete construction of each phase, which was provided by DWR.~~

Tables~~s~~ 22B-~~5~~ 7 through 22B-10~~through 22B-8 i~~ in Appendix 22B, *Air Quality Assumptions,* summarizes ~~the number of employees and~~ vehicle data~~s~~ assumed in the emissions modeling. ~~for Alternatives 1A, 2A, and 6A (pipeline/tunnel alignment); Alternative 4 (modified pipeline/tunnel alignment); Alternatives 1B, 2B, and 6B (east alignment); and Alternative 9 (through Delta/separate corridors alignment), respectively.~~ Key assumptions include:

- Criteria pollutant, CO_2, and CH_4 emission factors for diesel ~~V~~trucks~~ehicles~~ used for material and equipment~~s~~ hauling are based on weighted average vehicle speeds for EMFAC's T7 Tractor vehicle category. Equipment and materials delivered to the project site will likely originate in the Bay Area, Sacramento, or Stockton. As a reasonable, yet conservative assumption, it was assumed all equipment and material would be delivered from the Port of San Francisco (greatest distance from the project area).

- Criteria pollutant, CO_2, and CH_4 emission factors for diesel trucks used for tunnel segment hauling (MPTO only) are based on weighted average vehicle speeds for EMFAC's T7 Single vehicle category. Tunnel segments were assumed to originate from three offsite casting yards, two of which would be located in the Bay Area and one would be located in Stockton. Trip distances (miles) from each casting yard were quantified using GoogleEarth.

- Criteria pollutant and CO_2 emission factors for employee commute vehicles are based on weighted average vehicle speeds for EMFAC's LDA/LDT vehicle categories. One-way trip lengths were provided by DWR based on a geospatial analysis of labor densities in the Plan area. Each employee would make 2 trips to the project site per day.

- Criteria pollutant and CO_2 emission factors for onsite crew and material movement are based on EMFAC's LDT, T6 Utility, T6 Heavy, T6TS, and T7 Tractor categories for vehicles traveling at 5 miles per hour. Daily mileage assumptions were developed based on data from 5RMK and DWR, as shown in Appendix 22B, *Air Quality Assumptions*.

- Criteria pollutant and CO_2 emission factors for as-needed supply and equipment pick-up are based on weighted average vehicle speeds for EMFAC's LDA/LDT/T7 Tractor vehicle categories. All vehicle trips would be made to hardware or other local supply stores. An average one-way trip distance of 10 miles was assumed, based on information provided by DWR and 5RMK.

- ~~and general crew movement would each make a maximum of 8 trips per day. This value represents a conservative estimate of vehicle activity and is based on consultation with Fehr & Peers, the project traffic engineer.~~
- ~~Vehicle trips used for materials hauling and general crew movement would be 9.5 miles in all air districts, based on Plan area CalEEMod default trips lengths for “commercial work” trips.~~
- ~~Each employee would make 2 trips to the project site per day.~~
- ~~Passenger vehicles were assumed to be used for employee commute trips. Based on CalEEMod defaults for the Plan area, 82% of passenger vehicles were assumed to be light-duty automobiles (LDA) and 18% were assumed to be light-duty trucks (LDT).~~
- ~~Employee vehicle trips would be 10.8 miles in the YSAQMD, SMAQMD, and SJVAPCD, based on Plan area CalEEMod default trips lengths for “home based work” trips.~~
- ~~Employee vehicle trips would be 12.4 miles in the BAAQMD, based on Plan area CalEEMod default trips lengths for “home based work” trips.~~
- All ~~V~~vehicle emission factors from EMFAC2014 ~~were based on~~were generated for the ~~EMFAC2011 for the air district~~ counties in which activity would occur, as determined by GIS (see Section 22A.1.6~~2~~).

Criteria pollutant, ~~and~~ CO_2, and CH_4 (diesel vehicles only) emissions for each phase were calculated using the information summarized in Appendix 22B, *Air Quality Assumptions*,~~Tables 22B-5 through 22B-8~~ and Equation 22A-4.

Equation 22A -4 $$E_{phase} = \Sigma(EF \times \text{~~Trips X Trip Distance~~Miles}) \times Conv$$

Where:

E_{phase} = Total exhaust emissions for the phase, pounds per day

EF = Engine emissions factor, grams/mile (~~EMFAC2011~~EMFAC2014)

~~Trips = Vehicle trips per day~~

~~Trip Distance~~Miles = ~~Default t~~Trip ~~length, miles (CalEEMod)~~distance (Tables 22B-7 through 22B-10)

Conv = Conversion from grams to pounds, 0.0002205

~~EMFAC2011 does not include emission factors for CH_4 or N_2O. Emissions of CH_4 and N_2O from diesel-powered vehicles were determined by scaling the CO_2 emissions quantified by Equation 22A-4 by the ratio of CH_4/CO_2 and N_2O/CO_2 (0.000026) emissions expected per gallon of diesel fuel according to the CCAR (California Climate Action Registry 2009).~~ Emissions of CH_4, ~~and~~ N_2O, and HFCs ~~emissions~~ from gasoline-powered vehicles were determined by dividing the CO_2 emissions quantified by Equation 22A-4 by 0.95. This statistic is based on EPA’s ~~recommendation~~ assessment that CH_4, N_2O, and ~~other GHG~~HFC emissions account for ~~approximately~~ 1% to 5% of on-road emissions (U.S. Environmental Protection Agency ~~2011~~2014a).

22A.1.4.2 Road Dust

Fugitive re-entrained road dust emissions are based on the EPA’s (2006a; 2011) *Compilation of Air Pollutant Emission Factors* (AP-42) methodology, Sections 13.2.1 and 13.2.2. Offsite vehicles, including employee commuting cars and equipment and material delivery trucks, were evaluated based on Section 13.2.1 for paved roads. Onsite vehicles required for general crew and material movement were evaluated based on Section 13.2.2 for unpaved roads. Precipitation data to support the emission factor calculations were obtained from the Western Regional Climate Center (2014). Daily miles traveled for all vehicles were obtained from Equation 22A-4 (see above).

22A.1.422A.1.5Helicopters

Helicopters would be used during line stringing activities for the 115-230 kV transmission lines. Based on guidance provided by DWR, two light-duty helicopters were assumed to operate four hours a day to install new poles and lines (see Table 22B-11 in, Appendix 22B, *Air Quality* Assumptions). Helicopter emissions were estimated using emission factors from the Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS), version 5.1.4expected fuel consumption for a MD 500 D/E (U.S. Department of Interior National Business Center 2006) and emission factors derived from the California Public Utilities Commission (2006 and 2007) and the U.S. Department of Energy (2008).. EDMS estimates emission factors for standard landing-takeoff cycles (LTO).[3] EDMS does not calculate emission factors for cruising flight or for operations above 3,000 feet altitude.

Since line stringing activities would include operations beyond the standard LTO cycle, the EDMS emission factors were supplemented to account for cruising operations. Key assumptions include:

- Helicopters would fly from base to the jobsite in a cruise mode. The helicopter's cruise speed was assumed to be approximately 138 mph (MD Helicopters 2014). Fuel flow in cruise mode was estimated based on the ratio of cruise to takeoff power levels (MD Helicopters 2014). This ratio is consistent with earlier data from EPA (1985) that have often been used in EIR/EIS analyses of helicopter flight.
- The flight from base to the jobsite was assumed to take 15 minutes, corresponding in a cruise speed and nominal distance from base to jobsite of up to 35 miles. The return flight from the jobsite to base was assumed to be the same as the flight from base to the jobsite.
- Helicopters would fly at low speeds during line stringing and would hover for a significant portion of time. Based on FAA (2012), it was assumed that during line stringing the helicopter would operate at an average of approximately 85% power, and hence approximately 85% of maximum fuel flow rate.

Criteria pollutant and CO_2 emissions were calculated using the information summarized in Appendix 22B, *Air Quality Assumptions*, and Equation 22A-5.

[3] The LTO cycle consists of the following phases: startup and taxi-Out, takeoff, climb out to the atmospheric mixing height (nominally 3,000 feet altitude), descent from 3,000 feet, landing, and taxi.

Equation 22A -5 $E_{phase} = \Sigma(EF \times Hours) \times Conv$

Where:

E_{phase} = Total exhaust emissions for the phase, pounds per day

EF = Helicopter emissions factor, grams/hour (Table 22B-12)

Hours = Helicopter operating hours, hours/day (Table 22B-11)

Conv = Conversion from grams to pounds, 0.0002205

EDMS does not estimate CH_4 and N_2O emissions. CH_4 and N_2O emissions were estimated using data from EPA (2013).

~~Table 22A-6 summaries the fuel consumption data and emission factors used in the analysis.~~

~~**Table 22A-6. Helicopter Fuel Consumption (gallon/hour) and Emission Factors (pounds/hour)**~~

~~Helicopter~~	~~Fuel Use~~	~~ROG~~	~~NO_X~~	~~CO~~	~~PM10[a]~~	~~SO_2~~	~~CO_2[b]~~
~~MD 500 D/E~~	~~28~~	~~0.66~~	~~1.75~~	~~2.07~~	~~0.10~~	~~0.14~~	~~18.36~~

~~Notes~~

~~[a] Emission factors for PM2.5 are currently unavailable. Consequently, PM2.5 emissions were assumed to equal PM10 emissions. Because PM2.5 represents a fraction of PM10, this approach represents a conservative assessment of PM2.5 emissions from electricity consumption.~~

~~[b] Emission factor in pounds per gallon of fuel consumed. Emissions of CH_4 and N_2O were determined by scaling the CO_2 emissions by the CCAR ratios discussed in Section 22.1.3.4.~~

~~22A.1.5~~

22A.1.6 Fugitive Dust from ~~Land Disturbance~~Earth Movement

Fugitive dust emissions ~~(without project commitments)~~ from earth movement (i.e., site grading, bulldozing, and truck loading) ~~land disturbance~~were quantified using emission factors from EPA's (1998) AP-42 and CalEEMod. Emission factors for site grading and bulldozing were calculated from Section 11.9, *Western Surface Coal Mining*, of AP-42. This approach is consistent with the CalEEMod Users Guide and the resulting emission factors match CalEEMod outputs on a pound per acre and pound per hour basis. Although the CalEEMod Users Guide indicates that Section 13.2.4, *Aggregate Handling and Storage Piles*, of AP-42 is used to quantify emissions from Truck Loading, ICF could not independently derive matching emission factors through CalEEMod model runs. Since the CalEEMod results were slightly higher than the AP-42 calculations, truck loading emissions were quantified based on a pound per cubic yard emission factor obtained from the model output.

The 5RMK cost estimate provided the total acreage, borrow, excavated, and dredged material for each construction phase. The estimate also identified the maximum acreage and material that would be disturbed in any one day. Table 22B-13 in Appendix 22B, *Air Quality Assumptions*, summarizes the total and maximum daily earth movement quantities assumed in the modeling. Bulldozing equipment hours were also obtained from the cost estimate (see~~As shown in the construction schedules for the proposed action (see Appendix 22B, *Air Quality Assumptions*), construction of the water conveyance features would require multiple phases with the potential to disturb land. The duration of phases with land disturbance activity for each water conveyance feature were summed to obtain the total number of days in which fugitive dust could be generated. PM10 and PM2.5 emissions estimated for the water conveyance features were divided by the total number of activity~~

days to determine average PM10 and PM2.5 emissions per day. For example, under Alternative 1A, land disturbance associated with Intake 1 would generate 203 pounds of PM10 and occur over a period of 381 days. Average daily PM10 emissions would equate to 0.53 pounds per day (203/381). Table 22B-9 212 in Appendix 22B, *Air Quality Assumptions*), summarize the construction phases assumed in the emissions calculations for Alternatives 1A, 2A, and 6A (pipeline/tunnel alignment); Alternative 4 (modified pipeline/tunnel alignment); Alternatives 1B, 2B, and 6B (east alignment); and Alternative 9 (through Delta/separate corridors alignment), respectively. Fugitive dust emission factors from AP-42 and CalEEMod are provided in Table 22B-14. Total acres disturbed for each major water conveyance feature are also provided.

22A.1.7 Fugitive ROG from Paving

Fugitive ROG emissions generated during paving activities were calculated using an emissions factor of 2.62 pounds of ROG per acre, as reported in the CalEEMod Users Guide appendix. Table 22B-15 in Appendix 22B, *Air Quality Assumptions*, summarizes the total and maximum daily paving acreages assumed in the modeling.

22A.1.722A.1.8Electricity Usage

Construction of the water conveyance facility will require the use of electricity for lighting, tunnel ventilation, boring, and certain types of equipment. Annual electric demand for all alternatives was provided by DWR and 5RMK and is summarized in Table 22B-136 in Appendix 22B, *Air Quality Assumptions*Table 22A-7. Generation of this electricity will result in criteria pollutant and GHG emissions at regional power plants.

The EPA (2014b2)[4] and University of California, Davis (Delucchi 2006 1996:110) have developed emission factors for the current generation of electricity within California (see Table 22B-1415). Table 22A-8 summarizes the criteria pollutant and GHG emission factors used in the unmitigated analysis. Emissions associated with the generation of electricity were estimated by multiplying the expected annual electricity usage (Table 22A22B-7137) by the published emission factors show in Table 22A-8. As discussed in Section 22A.1.2, adopted and proposed statewide legislation will increase future energy efficiency and the proportion of renewable energy supplied to the electrical grid. Electricity emissions were therefore also estimated using adjusted factors that account for implementation of the Renewables Portfolio Standard (RPS), as discussed below.

[4] Power will be supplied to BDCP by multiple utilities. The quantity of power supplied by each utility is currently unknown. Consequently, average statewide emission factors, as opposed to utility-specific factors, were used to quantify emissions associated with electricity consumption.

Table 22A-7. Annual Electric Demand for Construction (megawatt-hours [MWh])

Alternative	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8[a]	Year 9[a]
Alternative 1A, 2A, 6A	20,442	32,058	56,446	220,100	324,230	376,487	236,181	81,058	81,058
Alternative 4	73,692	196,604	345,322	449,466	480,470	483,411	363,354	129,168	27,600
Alternative 7, 8	13,628	21,372	45,760	209,414	313,544	365,801	230,648	78,386	78,386
Alternative 3	10,221	16,029	40,417	204,071	308,201	360,458	227,882	77,050	77,050
Alternative 5	6,814	10,686	23,818	112,424	170,294	196,937	123,770	42,574	42,574
Alternative 1C, 2C, 6C	21,642	33,858	45,314	121,262	168,602	196,436	119,944	42,151	42,151
Alternative 1B, 2B, 6B	22,042	41,205	66,314	83,391	70,391	62,072	26,160	17,598	17,598
Alternative 9[b]	11,021	20,603	33,157	41,696	35,196	31,036	13,080	-	-

- No construction

[a] Based on guidance provided by DWR, electrical demand assumed to be one-quarter the demand for year 5.

[b] Based on guidance provided by DWR, electrical demand assumed to be half the demand of alternatives 1B, 2B, 6B (east alignment).

Table 22A-8. Criteria Pollutant and GHG Emission Factors (2009) for Electricity Generation

Pollutant	Value	Unit	Source
CO_2	298.772	MT/GWh	EPA 2012
CH_4	0.013	MT/GWh	EPA 2012
N_2O	0.003	MT/GWh	EPA 2012
SF_6	0.0001	MT/GWh	ARB 2010; CEC 2012[a]
NMHC[b]	0.0014	g/kWh	Delucchi 1996
CO	0.0134	g/kWh	Delucchi 1996
NOx	0.2321	g/kWh	Delucchi 1996
PM10[c]	0.0155	g/kWh	Delucchi 1996
SO_2	0.4267	g/kWh	Delucchi 1996

MT/GWh = metric tons gigawatt-hourg/kWh = grams per kilowatt-hour

NMHC = non-methane hydrocarbons

[a] Neither the EPA nor the University of California, Davis have a published emission factor for SF_6. Statewide SF_6 emissions in 2008 were therefore used to identify an emission factor per megawatt-hour by dividing total SF_6 emissions by the total electricity generation in California (California Air Resources Board 2010; California Energy Commission 2012)

[b] Emission factor used to quantify ROG (because ROG only represents a fraction of NMHC, this assumption is conservative).

[c] Emission factor used to quantify PM2.5 (because PM2.5 only represents a fraction of PM10, this assumption is conservative).

22A.1.8

Adopted and proposed statewide legislation will increase future energy efficiency and the proportion of renewable energy supplied to the electrical grid. Actual emissions from construction of the water conveyance facilities will therefore likely be less than those estimated using emission factors presented in Table 22A-8. This analysis thus provides a worst-case scenario of criteria pollutants and GHG emissions associated with electricity use.

22A.1.9 Concrete Batching

22A.1.9.1 Particulate Matter

Concrete required to construct the water conveyance facility will be manufactured at batch plants that store, convey, and discharge water, cement, fine aggregate, and coarse aggregate. PM10 and PM2.5 may be emitted through the transfer of aggregate, truck loading, mixer loading, vehicle traffic, and wind erosion. The amount of PM10 and PM2.5 generated during concrete batching depends primarily on the surface moisture content of surface materials, and the extent of fugitive emission controls.

PM10 and PM2.5 emissions from onsite concrete batching were estimated using emission factors provided the EPA's (2006b) ~~Compilation of Air Pollutant Emission Factors (~~AP-42~~)~~ ~~(U.S. Environmental Protection Agency 2006:11.12-11; Sacramento Metropolitan Air Quality Management District 2011)~~ and concrete data provided by DWR. The total volume of concrete required to construct the major water conveyance features (e.g., Intake, pumping plants) is summarized in Table ~~22A~~22B-~~8~~14~~8~~. Daily PM10 and PM2.5 emissions from onsite concrete batching were calculated by multiplying the anticipated volume of concrete produced at each batch plant by the AP-42 dust emission factors (see Table 22B-~~15~~19). A process rate of 1,100 cubic yards per day was batch plants, based on information from the cost estimate. Annual emissions were quantified based on the daily production rates and the total volume of concrete required to construct the project features.

PM10 and PM2.5 emissions from the thee offsite batch plants were quantified based the volume of concrete associated with the tunnel segments and facility specific permit limits for PM10, as provided by BAAQMD and SJVAPCD through public records requests.

22A.1.9.2 Carbon Dioxide

Cement manufacturing produces CO_2 through fuel combustion and calcination. Emissions generated by on-site fuel combustion account for approximately 40% of total emissions generated by a batching facility, whereas calcination accounts for the reaming 60%. Calcination involves heating raw materials to over 2,500 ˚F, which liberates CO_2 and other trace materials (Portland Cement Association 2011).

Emissions generated by concrete batching were calculated based on the anticipated volume of concrete at various compression strengths. Based on data provided by DWR, structural components would require compression strength between 3,000 and 4,000 pounds per square inch (psi), whereas the tunnel segments would require strength between 6,000 and 8,000 psi. CO_2 emission factors for these strength ratios were obtained from Nisbet, Marceau, and VanGeem (2002) and the Slag Cement Association (2013) (see Table 22B-19).

1

Type	Alternatives 1A, 2A, 6A	Alternative 4	Alternatives 7, 8	Alternative 3	Alternative 5	Alternatives 1C, 2C, 6C	Alternatives 1B, 2B, 6B	Alternative 9
Intakes	147,500	88,500	88,500	59,000	29,500	147,500	147,500	-
Pumping Plants	442,035	265,221	265,221	176,814	88,407	442,035	442,035	-
Pipelines	161,608	79,526	161,608	161,608	161,608	187,500	107,000	-
Canals	0	52,711	0	0	0	251,915	282,422	-
Siphons	0	229,233	0	0	0	768,538	644,846	-
Control Structures/Forebay	239,961	147,008	239,961	239,961	239,961	110,008	110,008	-
Tunnels	3,741,459	4,046,481	3,741,459	3,425,200	1,119,249	1,681,659	477,120	-
Bridges	0	0	0	0	0	54,341	51,291	-
Intermediate PP	171,143	2,857[d]	171,143	171,143	171,143	169,043	195,373	-
Total	4,903,706	4,911,537	4,667,892	4,233,726	1,809,868	3,812,539	2,457,595	1,400,502

- Component assumption unavailable

[a] Assumes the construction of three intakes/pumping plants

[b] Assumes the construction of two intakes/pumping plants

[c] Assumes the construction of one intakes/pumping plants

[d] Inlet control structure

2

3

Studies have calculated the CO_2 absorption rates of hardened concrete. These studies assume a 70 year service life and a 30-year demolition and recycling period for concrete materials. Given these assumptions, up to 57% of the CO_2 emitted during the cement manufacturing calcination may be re-absorbed by concrete over the 100 year life cycle (equivalent to about 7% of total batching emissions) (Haselbach 2009). While reabsorption may occur throughout the project lifetime, GHG impacts from concrete batching were conservatively evaluated assuming no reabsorption would occur.

22A.1.10 State Mandates to Reduce GHG Emissions

Actions undertaken by the state will contribute to project-level GHG reductions. For example, the state requires electric utility companies to increase their procurement of renewable resources by 2020. Renewable resources, such as wind and solar power, produce the same amount of energy as coal and other traditional sources, but do not emit any GHGs. By generating a greater amount of energy through renewable resources, electricity provided to the project will be cleaner and less GHG intensive than if the state hadn't required the renewable standard.

The analysis assumes implementation of Pavley, LCFS, and RPS. Pavley will improve the efficiency of automobiles and light duty trucks, whereas LCFS will reduce the carbon intensity of diesel and gasoline transportation fuels. To account for GHG reductions achieved by Pavley~~ and LCFS~~, emissions generated by construction equipment and vehicles were calculated using adjusted emission factors from EMFAC201~~1~~4.[5]

The RPS will increase the proportion of renewable energy supplied to the electrical grid. The emission factors summarized in Table 22B-~~14~~17 are based on the statewide renewable energy mix in 2010 (14%). Implementation of the RPS will increase the proportion of renewable energy within the state to 33% by 2020. To account for emissions reductions achieved by increases in renewable energy, annual electricity emission factors were calculated assuming a linear increase in statewide renewables between 2010 and 2020. Because RPS requirements end in 2020, the percentage of renewable energy after 2020 was assumed to remain constant at 33%.

Electricity emissions with implementation of RPS were estimated by multiplying the expected annual electricity usage (Table 22B-~~13~~17) by the emission factors show in Table 22B-~~17~~20. Note that implementation of the RPS will affect criteria pollutants, in addition to GHG emissions.

22A.1.11 ~~Project~~ Environmental Commitments to Reduce Criteria Pollutants, GHGs, and DPM

The lead agency has identified several ~~project~~ environmental commitments to reduce construction-related criteria pollutants and GHG emissions, as described in Appendix 3B, *Environmental Commitments.* Emissions were quantified with implementation of the environmental commitments by making the following adjustments to the emissions analysis described in Sections 22A.1.1 through 22A.1.9:

1. **Heavy-Duty Equipment**: CalEEMod and OFFROAD emission factors for heavy-duty equipment greater than 50 horsepower were replaced with model year 2013 emission factors obtained

[5] EMFAC2014 does not include emissions reductions achieved by LCFS.

from the Sacramento Metropolitan Air Quality Management District's (SMAQMD) Construction Mitigation Calculator. The 2013 model year emission factors for each equipment piece are built from the zero-hour emissions rates, annual deterioration rates, and assumptions about engine operating hours.

2. **Marine Vessels**: Model year 2000 marine vessel engines were replaced with model year 2010 emission factors (Tier 3 compliance for new engines) obtained from the ARB (2012), as shown in Table 22B-4.

3. **On-Road Haul Trucks**: Fleet average emission factors for heavy-duty diesel trucks were replaced with average emission factors for model year 2010 or newer vehicles obtained from EMFAC2014.

4. **Locomotives**: Tier 1 emission factors for locomotives were replaced with Tier 4 emission factors obtained from the ARB (2010), as shown in Table 22B-6.

5. **Earth Movement and Road Dust**: Uncontrolled emission factors for onsite soil disturbance and re-entrained road dust were reduced by 61% and 55%, respectively, pursuant to the Western Governors' Association Fugitive Dust Handbook (Countess Environmental 2006).

~~1.~~6. **Concrete Batching**: Uncontrolled emission factors for batching processes and active piles were reduced by 70% and 80%, respectively, pursuant to the SMAQMD's (2011) Concrete Batching Operations Policy Manual.~~Based on guidance provided by DWR, annual electric demand identified in Table 22B-13 would be sufficient to support new electrification commitments. Emissions associated with the electrification of project equipment were therefore assumed to be accounted for in the electricity analysis (see Section 22.1.3.7).~~

~~Diesel particulate filters were assumed to result in an 85% reduction in PM10 and PM2.5 exhaust (California Air Resources Board 2012). Emissions generated by use of Tier 4 locomotive engines were calculated using EPA Tier 4 off-road diesel emission standards in place of Tier 0 emissions standards (see section 22.1.3.3). Emissions from use of CNG were calculated by multiplying emissions generated by diesel equipment (see section 22.1.3.1) by the percent reduction achieved by switching from diesel to CNG (see Table 22A-10). Note that for some pollutants, CNG results in an emissions increase, relative to diesel fuel.~~

~~**Table 22A-10. Change in Emissions Due to Fuel Switch from Diesel to CNG**~~

Equipment	ROG	NO_X	CO	PM	SO_2	CO_2e
Forklift	-16%	+17%	+696%	-45%	0%	+21%
Heavy Truck	-8%	+3%	+485%	-44%	0%	+19%
Source: California Air Pollution Control Officers Association 2010						

~~**Table 22A-11. Annual Criteria Pollutant and GHG Emission Factors with Implementation of RPS[a]**~~

	%	CO_2	CH_4	N_2O	NMHC[b]	CO	NO_X	PM10[c]	SO_X
Year	Renewable	*MT/MWh*	*MT/MWh*	*MT/MWh*	*g/kWh*	*g/kWh*	*g/kWh*	*g/kWh*	*g/kWh*
2014	0.21	0.266790	0.000012	0.000002	0.0012	0.0118	0.2042	0.0136	0.3755
2015	0.23	0.260237	0.000011	0.000002	0.0012	0.0115	0.1992	0.0133	0.3663
2016	0.25	0.253685	0.000011	0.000002	0.0012	0.0112	0.1942	0.0130	0.3570
2017	0.27	0.247132	0.000011	0.000002	0.0011	0.0109	0.1892	0.0126	0.3478
2018	0.29	0.240580	0.000011	0.000002	0.0011	0.0106	0.1842	0.0123	0.3386
2019	0.31	0.234027	0.000010	0.000002	0.0011	0.0103	0.1792	0.0120	0.3294
2020+	0.33	0.227474	0.000010	0.000002	0.0011	0.0101	0.1741	0.0116	0.3201

[a] No change in SF_6 emission factor (see Table 22A-6)

[b] Emission factor used to quantify ROG (because ROG only represents a fraction of NMHC, this assumption is conservative

[c] Emission factor used to quantify PM2.5 (because PM2.5 only represents a fraction of PM10, this assumption is conservative).

22A.1.12 Mitigation to Reduce GHG Emissions

Mitigation Measure AQ-21 requires developing and implementing a GHG mitigation program to completely offset (i.e., to net zero) construction-related GHG emissions through implementing emissions-reduction projects. The mitigation measure outlines 13 GHG-reduction strategies that will be used in formulating the GHG mitigation program. Potential GHG reductions associated with the strategies were evaluated to ensure the mitigation could offset GHG emissions from the BDCP alternatives to net zero.

A brief overview of the method and assumptions for each strategy is provided below. The reduction analysis was developed for informational purposes only and in many cases, only a high-level estimate was generated for offset validation. BDCP proponents will develop a mechanism for quantifying, funding, implementing, and verifying emissions reductions associated with the selected strategies and facility-specific technologies. BDCP proponents will also conduct annual reporting to verify and document that selected strategies achieve sufficient emissions reductions to offset construction-related emissions to net zero.

Strategy-1: Renewable Energy Purchase Agreement: Potential GHG reductions were not explicitly quantified; according to the National Renewable Energy Laboratory (2012), California's technical potential for utility-scale photovoltaics exceeds 246,000 gigawatt-hours, which far exceeds the construction energy demands for CM1 (2,132 gigawatt-hours over the entire construction period for Alternative 4). Assuming renewable energy would offset 50% of the construction electric demands yields an emissions reduction of approximately 231,000 metric tons CO_2e for Alternative 4.

Strategy-2: Engine Electrification: GHG reductions achieved by this strategy would depend on the number and type of equipment pieces ultimately electrified. While some electric engines are commercially available, it is currently unknown which specific equipment in the construction inventory may be electrified. Conservatively assuming only 1 to 5% of the equipment fleet would be electrified yields emissions reductions of approximately 8,000 to 41,000 metric tons CO_2e for Alternative 4.

Strategy-3: Low Carbon Concrete: According to Donovan and Pyle (n.d.), cement with supplementary cementitious materials (SCM) has a 29% lower total carbon footprint. As a high-level estimate, it was assumed that CM1 components would be constructed out of concrete with up to 70% replacement of cement with SCM. Potential GHG reductions were therefore quantified by multiplying estimated CO_2 emissions from concrete batching by 70% and then by 29%, resulting in an emissions reduction of approximately 500,000 metric tons CO_2 for Alternative 4.

Strategy-4: Renewable Diesel and/or Bio-diesel: According to the Department of Energy (DOE) (2008), B20 (20% biodiesel/ 80% petroleum diesel) can reduce CO_2 emissions by 15%. It was conservatively assumed that 50% of diesel-powered equipment would utilize B20 during construction. Potential GHG reductions were therefore quantified by multiplying estimated CO_2 emissions from diesel-powered equipment by 50% and then by 15%, resulting in an emissions reduction of approximately 60,000 metric tons CO_2 for Alternative 4.

Strategy-5: Residential Energy Efficiency Improvements: DOE's (2014) Home Energy Saver (HES) estimates that the retrofits outlined in Mitigation Measure AQ-21 would reduce CO_2 emissions by 5,152 pounds per package per year. There are 1.4 million homes (2008 est.) within the socioeconomic Study area (i.e., Delta Study area). As a high-level estimate, it was conservatively assumed that 50,000 of these homes would be retrofit. Potential GHG reductions were therefore quantified by multiplying 50,000 retrofits by 5,152 pounds of CO_2 per retrofit per year, resulting in an emissions reduction of approximately 116,000 metric tons CO_2e per year. Total lifetime GHG reductions could reach 2.1 million metric tons CO_2e, assuming a retrofit lifetime of 18 years (California Energy Commission 2009).

Strategy-6: Commercial Energy Efficiency Improvements: According to the Energy Information Admiration (2008), average commercial floorspace in the Pacific Region is approximately 28,000 square feet per building. As a high-level estimate, it was conservatively assumed that 10,000 commercial buildings in the Plan Area would be retrofitted to achieve a 15% reduction in building wide energy use. Electricity and natural gas reductions achieved by the retrofits were quantified assuming 15 kilowatt-hours and 0.28 therms are consumed per square foot, respectively (California Energy Commission 2006). The electricity and natural gas reductions were translated to GHG savings based on the emission factors presented in Table 22B-20, resulting in an emissions reduction of approximately 198,000 metric tons CO_2e per year. Total lifetime GHG reductions could reach 2.4 million metric tons CO_2e, assuming a retrofit lifetime of 18 years (California Energy Commission 2009).

Strategy-7: Residential Rooftop Solar: National Renewable Energy Laboratory (NERL) System Advisor Model (SAM) was used to calculate the energy potential of a typical residential solar installation in the Sacramento Valley.[6] As a high-level estimate, it was conservatively assumed that 50,000 of homes would receive solar PV. Energy reductions were therefore quantified by

[6] See *Final GHG Reduction Measure Analysis for the Sacramento Municipal Utility District* (ICF International 2011).

multiplying 50,000 systems by the estimated solar output per system (4,617 kWh). The resulting electricity reductions were translated to GHG savings based on the emission factors presented in Table 22B-20, resulting in an emissions reduction of approximately 49,000 metric tons CO_2e per year. Total lifetime GHG reductions could reach 1.2 million metric tons CO_2e assuming a PV lifetime of 25 years (U.S. Department of Energy 2013).

Strategy-8: Commercial Rooftop Solar: NERL's SAM was used to calculate the energy potential of a typical commercial solar installation in the Sacramento Valley. As a high-level estimate, it was conservatively assumed that 2,500 of commercial buildings would receive solar PV. Energy reductions were therefore quantified by multiplying 2,500 systems by the estimated solar output per system (304,152 kWh). The resulting electricity reductions were translated to GHG savings based on the emission factors presented in Table 22B-20, resulting in an emissions reduction of approximately 164,000 metric tons CO_2e per year. Total lifetime GHG reductions could reach 4.1 million metric tons CO_2e assuming a PV lifetime of 25 years (U.S. Department of Energy 2013).

Strategy-9: Purchase Carbon Offsets: Potential GHG reductions were not explicitly quantified; according to the Legislative Analyst's Office (2012), it is estimated that between 2012 and 2020, 2.5 billion allowances will be made available within the state, which far exceeds estimated construction emissions for all alternatives.

Strategy-10: Development of Biomass Waste Digestion and Conversion Facilities: Based on information provided by the CEC (Mariscal 2012), the technical potential for biomass feedstock production within 200 miles of the CM1 is approximately 122 MW per year. Potential electricity production (MWh) associated with this potential was calculate based on the energy generating potential (MWh/MW/year) of dairy farms (U.S Environmental Potential 2014b). The resulting electricity reductions were translated to GHG savings based on the emission factors presented in Table 22B-20. As a high-level estimate, it was conservatively assumed that only 10% of the technical potential would be captured, resulting in an emissions reduction of approximately 20,000 metric tons CO_2e per year. Total lifetime GHG reductions could reach 200,000 metric tons CO_2e assuming a digester lifetime of 10 years (Biogas Energy Inc. 2008).

Strategy-11: Agriculture Waste Conversion Development: Based on information provided by the CEC (Mariscal 2012), the technical potential for digestible biomass production within 200 miles of the CM1 is approximately 13 million bone-dry tons (BDT) per year. Potential electricity production (kWh) associated with this potential was calculate based on the energy generating potential (kWh/pound) of woody biomass (U.S. Forest Service et al. 2008). The resulting electricity reductions were translated to GHG savings based on the emission factors presented in Table 22B-20. As a high-level estimate, it was conservatively assumed that only 5% of the technical potential would be captured, resulting in an emissions reduction of approximately 196,000 metric tons CO_2e per year. Total lifetime GHG reductions could reach 3.9 million metric tons CO_2e assuming a system lifetime of 20 years (United States Environmental Protection Agency 2008).

Strategy-12: Temporarily Increase Renewable Energy Purchases for Operations: Potential GHG reductions were not explicitly quantified; this strategy would purchase renewable electricity in excess of the quantity needed to meet DWR's GHG emissions reduction goals.

Strategy-13: Tidal Wetland Inundation: Given the variability associated with land use change and GHG flux, maximum emissions reductions associated with this strategy were not quantified.

22A.1.12 Emissions Scaling

Alternatives 3, 5, 7, and 8 (Pipeline/Tunnel Alignment)

Assumptions for off-road equipment, marine vessels, locomotives, and on-road vehicles for the pipeline/tunnel alignment correspond to construction of the water conveyance facilities associated with Alternatives 1A, 2A, and 6A (15,000 cfs option).[7] Criteria pollutant and GHG emissions associated with these sources were calculated for Alternatives 3, 5, 7, and 8 by scaling emissions estimates for Alternatives 1A, 2A, and 6A. For example, Alternatives 1A, 6A, and 2A will construct five intakes during intake construction, whereas Alternative 3 will construct only two. For each construction component, the ratio of identified project features between Alternatives 1A, 6A, and 2A and the other alternatives was calculated (e.g., two intakes to five intakes).

Table 22A-12 summarizes the scaling factors for the Alternatives 3, 5, 7, and 8 by major construction component.

22A.1.12.1 Alternative 4 (Modified Pipeline/Tunnel Alignment)

Assumptions for off-road equipment, marine vessels, locomotives, and on-road vehicles for the intakes, pumping plants, forebays, control structures, and pipelines under Alternative 4 correspond to construction activities associated with Alternatives 1A, 2A, and 6A (15,000 cfs option). Criteria pollutant and GHG emissions associated with these components were calculated for Alternative 4 by scaling emissions estimates for Alternatives 1A, 2A, and 6A. Table 22A-12 summarizes the scaling factors for the Alternative 4 by construction component.

22A.1.12.2 Alternatives 1C, 2C, and 6C (West Alignment)

Assumptions for off-road equipment, marine vessels, locomotives, on-road vehicles, and land disturbance for the west alignment were unavailable. Criteria pollutant and GHG emissions for the alternatives using this conveyance were calculated by scaling emissions estimates for the east alignment conveyance and tunnel conveyance, due to similarities between the alternatives. The scaling analysis was based on project features unique to each construction component, which were identified for all the west alignment alternatives. For each construction component, the ratio of identified project features between the east alignment or pipeline/tunnel alignment and the west alignment alternatives was calculated.

Table 22A-13 summarizes the scaling factors for the west alignment alternatives by major construction component.

[7] Note that emissions associated with Alternative 1A and 2A are identical except for the Head of Old River Barrier, which occurs under Alternative 2A. Emissions associated with the Head of Old River Barrier were added to the emission estimates for Alternative 1A to evaluate Alternative 2A.

~~**Table 22A-12. Scaling Factors for Alternatives 3, 5, 7, and 8 (Pipeline/Tunnel Conveyance) and Alternative 4 (Modified Pipeline/Tunnel Conveyance)**~~

		Value					Ratio (to Alt 1A, 2A, 6A)			
Feature	Scaling Method	*1A, 2A, 6A*	*4*	*7,8*	*3*	*5*	*4*	*7,8*	*3*	*5*
Intakes(number)										
Intake 1	Scale by whether the feature is built	1	0	0	0	0	0	0	0	0
Intake 2	Scale by whether the feature is built	1	1	1	1	1	1	1	1	1
Intake 3	Scale by whether the feature is built	1	1	1	1	0	1	1	1	0
Intake 4	Scale by whether the feature is built	1	0	0	0	0	0	0	0	0
Intake 5	Scale by whether the feature is built	1	1	1	0	0	1	1	0	0
Pumping Plants (number)										
Pumping Plant 1	Scale by whether the feature is built	1	0	0	0	0	0	0	0	0
Pumping Plant 2	Scale by whether the feature is built	1	1	1	1	1	1	1	1	1
Pumping Plant 3	Scale by whether the feature is built	1	1	1	1	0	1	1	1	0
Pumping Plant 4	Scale by whether the feature is built	1	1	1	0	0	1	1	0	0
Pumping Plant 5	Scale by whether the feature is built	1	0	0	0	0	0	0	0	0
Intermediate Pumping Plant	Scale by whether the feature is built	1	1[a]	1	1	1	0.07[a]	1	1	1
Pipelines (Length)	Scale by length of pipeline built	8.00	0.34		2.48	1.96	0.04	0.79	0.31	0.25
Tunnels (acres)										
Reach 1	Scale by length of reach built	0.26	-[b]	0.26	0.26	0.26	-[b]	1	1	1
Reach 2	Scale by length of reach built	5.53	-[b]	5.53	5.53	5.53	-[b]	1	1	1
Reach 3	Scale by length of reach built	5.37	-[b]	5.37	5.37	2.69	-[b]	1	1	0.50
Reach 4	Scale by length of reach built	5.47	-[b]	5.47	5.47	2.74	-[b]	1	1	0.50
Reach 5	Scale by length of reach built	5.99	-[b]	5.99	5.99	3.00	-[b]	1	1	0.50
Reach 6	Scale by length of reach built	5.81	-[b]	5.81	5.81	2.91	-[b]	1	1	0.50
Reach 7	Scale by length of reach built	5.99	-[b]	5.99	5.99	3.00	-[b]	1	1	0.50
Reach 8	Scale by length of reach built	4.78	-[b]	4.78	4.78	2.39	-[b]	1	1	0.50
Forebays (number)										
Intermediate Forebay	Scale by acres of forebay built	1,892	250	1,892	1,892	1,892	0.13	1	1	1
Byron Tract Forebay	Scale by acres of forebay built	1,489	-	1,489	1,489	745	-	1	1	0.50
Control Structures(number)										
Structure 1	Scale by whether the feature is built	1	1	1	1	1	1	1	1	1
Structure 2	Scale by whether the feature is built	1	1	1	1	1	1	1	1	1
Structure 3	Scale by whether the feature is built	1	1	1	1	1	1	1	1	1
Structure 4	Scale by whether the feature is built	1	1	1	1	1	1	1	1	1

~~[a] The Intermediate Pumping Plant would be replaced by an outlet structure under Alternative 4. This assumption is reflected in the scaling factors.~~
~~[b] The component was not scaled. Emissions were calculated based on alternative-specific construction data (see Section 22A.1.1.4).~~

1 ~~**Table 22A-13. Scaling Factors for Alternatives 1C, 2C, and 6C (West Alignment)**~~

Feature	Method	Alignment Scaled	Value		Ratio (to East/PTO)
			East/PTO	West	West
Intakes(number)					
Intake 1	Scale by whether the feature is built	East	1	1	1
Intake 2	Scale by whether the feature is built	East	1	1	1
Intake 3	Scale by whether the feature is built	East	1	1	1
Intake 4	Scale by whether the feature is built	East	1	1	1
Intake 5	Scale by whether the feature is built	East	1	1	1
Pumping Plants (number)				-	
Pumping Plant 1	Scale by whether the feature is built	East	1	1	1
Pumping Plant 2	Scale by whether the feature is built	East	1	1	1
Pumping Plant 3	Scale by whether the feature is built	East	1	1	1
Pumping Plant 4	Scale by whether the feature is built	East	1	1	1
Pumping Plant 5	Scale by whether the feature is built	East	1	1	1
Intermediate Pumping Plant	Scale by whether the feature is built	East	1	1	1
Pipelines	Scale by length of pipeline built	East	3.45	7.55	2.19
Canals	Scale by acres of canal built	East	16,656	10,681	0.64
Culvert Siphons	Scale by acres of siphon built	East	1,043	1,231	1.18
Control Structures(number)				-	
Structure 1	Scale by whether the feature is built	East	1	1	1
Structure 2	Scale by whether the feature is built	East	1	1	1
Structure 3	Scale by whether the feature is built	East	1	1	1
Structure 4	Scale by whether the feature is built	East	1	0	0
Bridges	Scale by acres of bridge built	East	456	473	1.03
Tunnels	Scale by length of tunnel built	East	2.38	16.98	7.12
Forebay	Scale by acres of forebay built	East	1,625	1,484	0.91

2 Emissions by Air District and Air Basin

~~22A.1.13 Alternative 4 (Modified Pipeline/Tunnel Alignment)~~

~~The design of Alternative 4 is similar to Alternatives 1A, 2A, and 6A, but has some specific differences related to construction of the tunnels, Clifton Court Forebay, and utilities. For example, seven tunneling contracts will be required under Alternative 4, as compared to eight under Alternatives 1A, 2A, and 6A. Construction of Alternative 4 also includes new siphon and canal connections, which are not required for the pipeline/tunnel alignment. These design differences affect the number and type of construction phases, as well as the overall construction schedule. Scaling exhaust emissions from construction of these facilities by emissions estimates for Alternatives 1A, 2A, and 6A is therefore inappropriate. Accordingly, unique phasing, scheduling, and equipment assumptions for construction of the tunnels, Clifton Court Forebay, utilities, siphons, and canals were provided by DWR for Alternative 4. The construction start date (month, year) and total working days for these components are summarized in Table 22B-4 in Appendix 22B, Air Quality Assumptions.~~

~~DWR does not have a detailed schedule or equipment assumptions for construction of the intakes, pumping plants, forebays, control structures, and pipelines under Alternative 4. However, construction activities associated these features are anticipated to be similar to construction activities required for Alternative 1A, 2A, and 6A. Consequently, exhaust emissions from construction of the intakes, pumping plants, forebays, control structures, and pipelines were calculated by scaling emissions estimates for the pipeline/tunnel alignment (see section 22.1.4.2).~~

~~22A.1.14~~22A.1.13 ~~Phase Location~~

The ~~action alternatives~~project cross three air basins—SFBAAB, SVAB, and SJVAB—and falls under the jurisdiction of four air districts—YSAQMD, SMAQMD, BAAQMD, and SJVAPCD. GIS was used to identify the location of all construction activities associated with the five conveyance options. Tables ~~22A~~22B-21~~1~~ through ~~22A~~22B-25~~5~~ in Appendix 22B, *Air Quality Assumptions,* summarize the air districts and air basins crossed by each major construction component. Several features cross multiple air districts or air basins. The proportion of activity within each air district and basin was based on the number of miles or acres constructed within each air district and basin. For example, ~~5.99~~18 miles of tunnel in the modified pipeline/tunnel alignment will be constructed within Reach ~~5~~4, of which ~~0.30~~7 (~~5~~40%) will be located within the SMAQMD and ~~5.69~~11 (~~95~~60%) will be located within the SJVAPCD (see Table 22B-21).

~~**Table 22A-1. Location of Major Construction Activity by Air District and Air Basin (Pipeline/Tunnel Alignment)**~~

~~Component~~	~~Air District(s)~~	~~Air Basin(s)~~
~~Intakes~~	~~SMAQMD~~	~~SVAB~~
~~Pumping Plants~~	~~SMAQMD~~	~~SVAB~~
~~Intermediate Pumping Plant~~	~~SMAQMD~~	~~SVAB~~
~~Intermediate Forebay~~	~~SMAQMD~~	~~SVAB~~
~~Byron Tract Forebay~~	~~BAAQMD~~	~~SFBAAB~~
~~Control Structures~~	~~BAAQMD~~	~~SFBAAB~~
~~Pipeline~~	~~SMAQMD~~	~~SVAB~~
~~Head of Old River Barrier[a]~~	~~SJVAPCD~~	~~SJVAB~~
~~**Tunnel**~~		
~~Reaches 1–4~~	~~SMAQMD~~	~~SVAB~~
~~Reach 5~~	~~SMAMQD (5%)~~ ~~SJVAPCD (95%)~~	~~SVAB (5%)~~ ~~SJVAB (95%)~~
~~Reaches 6–7~~	~~SJVAPCD~~	~~SJVAB~~
~~Reach 8~~	~~SJVAPCD (55%)~~ ~~BAAQMD (45%)~~	~~SJVAB (55%)~~ ~~SFBAAB (45%)~~
~~**Transmission Lines**~~		
~~Temporary (12 kV)[b]~~	~~SMAQMD (39%)~~ ~~SJVAPCD (52%)~~ ~~BAAQMD (9%)~~	~~SVAB (39%)~~ ~~SJVAB (52%)~~ ~~SFBAAB (9%)~~
~~Temporary (69 kV)~~	~~SMAQMD (51%)~~ ~~SJVAPCD (33%)~~ ~~BAAQMD (16%)~~	~~SVAB (51%)~~ ~~SJVAB (33%)~~ ~~SFBAAB (16%)~~
~~Permanent (69 kV)~~	~~SMAQMD~~	~~SVAB~~
~~Permanent (230 kV)~~	~~SMAQMD (23%)~~ ~~SJVAPCD (44%)~~ ~~BAAQMD (33%)~~	~~SVAB (23%)~~ ~~SJVAB (44%)~~ ~~SFBAAB (33%)~~

~~[a] Barrier only included for Alternative 2A.~~
~~[b] Temporary lines will only be used during construction.~~

Table 22A-2. Location of Major Construction Activity by Air District and Air Basin (Modified Pipeline/Tunnel Alignment)

Component	Air District(s)	Air Basin(s)
Intakes	SMAQMD	SVAB
Pumping Plants	SMAQMD	SVAB
Outlet Control	SMAQMD	SVAB
Intermediate Forebay	SMAQMD	SVAB
Byron Tract/Clifton Court Forebay	BAAQMD	SFBAAB
Control Structures	BAAQMD	SFBAAB
Pipeline	SMAQMD	SVAB
Siphons	BAAQMD	SFBAAB
Canals	BAAQMD	SFBAAB
Head of Old River Barrier	SJVAPCD	SJVAB
Tunnel		
Reaches 1–3	SMAQMD	SVAB
Reach 4	SMAMQD (68%) SJVAPCD (32%)	SVAB (68%) SJVAB (32%)
Reaches 5–6	SJVAPCD	SJVAB
Reach 7	SJVAPCD (90%) BAAQMD (10%)	SJVAB (90%) SFBAAB (10%)
Transmission Lines		
Temporary (34.5 kV)[a]	SJVAPCD (100%)	SJVAB (100%)
Temporary (230 kV)	SMAQMD (11%) SJVAPCD (54%) BAAQMD (35%)	SVAB (11%) SJVAB (54%) SFBAAB (35%)
Permanent (69 kV)	SMAQMD (100%)	SVAB (100%)
Permanent (230 kV)	SMAQMD (100%)	SVAB (100%)

[a] Temporary lines will only be used during construction.

Table 22A-3. Location of Major Construction Activity by Air District and Air Basin (East Alignment)

Component	Air District(s)	Air Basin(s)
Intakes	SMAQMD	SVAB
Pumping Plants	SMAQMD	SVAB
Intermediate Pumping Plant	SJVAPCD	SJVAB
Forebay	BAAQMD	SFBAAB
Pipeline	SMAQMD	SVAB
Canals	SMAMQD (20%) SJVAPCD (80%)	SVAB (20%) SJVAB (80%)
Siphons	SJVAPCD	SJVAB
Head of Old River Barrier[a]	SJVAPCD	SJVAB
Bridges		
Scribner	SMAQMD	SVAB
Hood-Franklin	SMAQMD	SVAB
Lambert	SMAQMD	SVAB
Dierssen	SMAQMD	SVAB
Twin Cities	SMAQMD	SVAB
West Barber	SJVAPCD	SJVAB
West Walnut Grove	SJVAPCD	SJVAB
North Blossom	SJVAPCD	SJVAB
West Woodbridge	SJVAPCD	SJVAB
SR12	SJVAPCD	SJVAB
North Guard	SJVAPCD	SJVAB
West Eight Mile	SJVAPCD	SJVAB
West McDonald	SJVAPCD	SJVAB
SR4	SJVAPCD	SJVAB
West Bacon Island	SJVAPCD	SJVAB
South Tracy	SJVAPCD	SJVAB
Cal Pack	SJVAPCD	SJVAB
Clifton Court	SJVAPCD	SJVAB
Tunnels		
Mokelumne River	SMAMQD (12%) SJVAPCD (88%)	SVAB (12%) SJVAB (88%)
Old River	SJVAPCD (38%) BAAQMD (62%)	SJVAB (38%) SFBAAB (62%)
San Joaquin River	SJVAPCD	SJVAB
Transmission Lines		
Temporary (12 kV)[b]	SMAQMD (25%) SJVAPCD (70%) BAAQMD (5%)	SVAB (25%) SJVAB (70%) SFBAAB (5%)
Temporary (69 kV)[b]	SJVAPCD (86%) BAAQMD (14%)	SJVAB (86%) SFBAAB (14%)
Permanent (69 kV)	SMAQMD (40%) SJVAPCD (60%)	SVAB (40%) SJVAB (60%)

Permanent (230 kV)	SJVAPCD (75%) BAAQMD (25%)	SJVAB (75%) SFBAAB (25%)

[a] Barrier only included for Alternative 2B.
[b] Temporary lines will only be used during construction.

Table 22A-4. Location of Major Construction Activity by Air District and Air Basin (West Alignment)

Component	Air District(s)	Air Basin(s)
Intakes	YSAQMD	SVAB
Pumping Plants	YSAQMD	SVAB
Intermediate Pumping Plant	YSAQMD	SVAB
Forebay	BAAQMD	SFBAAB
Pipeline	YSAQMD	SVAB
Head of Old River Barrier[a]	SJVAPCD	SJVAB
Canals	YSAQMD (75%) BAAQMD (25%)	SVAB (75%) SFBAAB (25%)
Siphons	SMAQMD (37%) BAAQMD (63%)	SVAB (37%) SFBAAB (63%)
Bridges	YSAQMD (49%) BAAQMD (51%)	SVAB (49%) SFBAAB (51%)
Tunnels	YSAQMD (29%) SMAQMD (16%) BAAQMD (56%)	SVAB (44%) SFBAAB (56%)
Transmission Lines		
Temporary (12 kV)[b]	SMAQMD (11%) YSAQMD (46%) BAAQMD (43%)	SVAB (57%) SFBAAB (43%)
Temporary (69 kV)[b]	SMAQMD (33%) YSAQMD (43%) BAAQMD (24%)	SVAB (76%) SFBAAB (24%)
Permanent (230 kV)	YSAQMD (93%) BAAQMD (7%)	SVAB (93%) SFBAAB (7%)

[a] Barrier only included for Alternative 2C.
[b] Temporary lines will only be used during construction.

Table 22A-5. Location of Major Construction Activity by Air District and Air Basin (Through Delta/Separate Corridors Alignment)

Phase	Air District(s)	Air Basin(s)
DCC Fish Screen Intake Facility	SMAQMD	SVAB
Georgiana Slough Fish Screen Intake Facility	SMAQMD	SVAB
San Joaquin at Old River Pumping Plant	SJVAPCD	SJVAB
Middle River Diversion Pumping Plant	SJVAPCD	SJVAB
Old River Siphon	SJVAPCD (41%) BAAQMD (59%)	SJVAB (41%) SFBAAB (59%)
West Canal Siphon	BAAQMD	SFBAAB
Coney Island Canal	SJVAPCD (58%) BAAQMD (42%)	SJVAB (58%) SFBAAB (42%)
Flood Gate at SJR at Old River	SJVAPCD	SJVAB
Tidal Gate at Middle River	SJVAPCD	SJVAB
Flood Gate at Sacramento River at Meadows Slough	SJVAPCD	SJVAB
Tidal Gate w/Boat Lock at Snodgrass Slough	SJVAPCD	SJVAB
Control Gate at Mokelumne River near Lost Slough w/Boat Lock	SJVAPCD	SJVAB
Frank's Tract	SJVAPCD (45%) BAAQMD (55%)	SJVAB (45%) SFBAAB (55%)
Three Mile Slough	SMAQMD	SVAB
Fisherman's Cut	BAAQMD	SFBAAB
Victoria Canal / North Canal	SJVAPCD	SJVAB
Connection Slough	SJVAPCD	SJVAB
Railroad Cut	SJVAPCD	SJVAB
Woodward Canal / North Victoria Canal	SJVAPCD	SJVAB
Intertie Channel from CCF to DMC Approach	BAAQMD	SFBAAB
Control Gate in DMC Approach	BAAQMD	SFBAAB
Victoria Canal Dredging	SJVAPCD	SJVAB
Middle River Dredging	SJVAPCD	SJVAB
Re-Channeling for River's End Marina Diversion	BAAQMD	SFBAAB
Levee for Victoria Canal Enlargement	SJVAPCD	SJVAB
Intertie Channel at CCF Perimeter Road Bridge	BAAQMD	SFBAAB
Intertie Channel at Herdlyn Road Bridge	BAAQMD	SFBAAB
Transmission Lines		
Temporary (12 kV)[a]	SMAQMD (36%) SJVAPCD (57%) BAAQMD (7%)	SVAB (36%) SJVAB (57%) SFBAAB (7%)

[a] Temporary lines will only be used during construction.

22A.2 Operation

22A.2.1 Maintenance Activities

22A.2.1.1 Alternatives 1A, 2A, 3, 5, 6A, 7, and 8 (Pipeline/Tunnel Conveyance), Alternative 4 (Modified Pipeline/Tunnel Conveyance), Alternatives 1B, 2B, and 6B (West Alignment), and Alternatives 1C, 2C, and 6C (East Alignment)

Operations and maintenance (O&M) include both routine activities and ~~major~~ yearly maintenance~~inspections~~. Routine activities would occur on a daily basis throughout the year, whereas ~~major~~ yearly maintenance ~~inspections~~ would occur annually or every five years.

Routine Maintenance

DWR provided labor and equipment estimates for maintenance, management, repair, and operating crews. One of each crew type is required to cover daily O&M activities at all pumping plants and intakes. Table ~~22A~~22B-~~14~~ 26 in Appendix 22B, *Air Quality Assumptions*, summarizes the number of employees, vehicles, and equipment included in each crew for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 6A, 6B, and 6C. Assumptions for all other alternatives were scaled based on the number of constructed intakes.[8]

~~**Table 22A-14. Routine O&M Assumptions for Alternatives 1A-C, 2B-C, and 6A-C**~~

~~Crew Type~~	~~Number of Employees~~	~~Vehicles (number)~~	~~Equipment (number)~~
~~Maintenance~~	~~5~~	~~Crew Truck (1)~~	~~-~~
		~~Foreman Truck (1)~~	
~~Management~~	~~3~~	~~-~~	~~-~~
~~Repair~~	~~7~~	~~Crew Truck (1)~~	~~Backhoe (1)~~
		~~Foreman Truck (1)~~	
		~~600 truckloads[a]~~	
~~Operating~~	~~9~~	~~-~~	~~-~~

~~[a] 600 truckloads would be required per intake~~

Operational emissions associated with vehicle traffic and maintenance equipment were estimated using emission factors from the EMFAC201~~1~~4 and CalEEMod models, respectively. Emissions were quantified for both the ELT (2025) and LLT (2060) periods. Key assumptions include:

- ~~Routine O&M activities for Alternatives 3, 4, 5, 7, and 8 were scaled based on the number of intakes relative to Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 6A, 6B, and 6C.~~
- Employees would make two trips to the project site per day, 250 days per year.

[8] Under Alternative 4, one of each crew type is also required for O&M activities at the combined pumping plant. Accordingly, at total of two of each crew type (one set at the intakes [scaled] and one set at the combined pumping plant) will be required.

- Employee vehicle roundtrips would be 42.2 miles, based on a geospatial analysis of employment densities and potential drive routes to the intake locations~~Employee vehicle trips would be 10.8 miles in the YSAQMD, SMAQMD, and SJVAPCD, based on Plan area CalEEMod default trips lengths for "home based work" trips~~.
- ~~Employee vehicle trips would be 12.4 miles in the BAAQMD, based on Plan area CalEEMod default trips lengths for "home based work" trips.~~
- Crew, foreman, and dump trucks would make a maximum of two trips per day~~Crew, foreman, and dump trucks would make a maximum of eight trips per day. This value represents a conservative estimate of vehicle activity and is based on consultation with Fehr & Peers, the project traffic engineers~~.
- Crew, foreman, and dump truck roundtrips would be 30 miles, based on information provided by DWR and the assumption that 1) crew vehicle movement would occur onsite among various facilities and 2) hauled debris would be deposited at local landfill sites~~Crew and foreman trucks trips would be 9.5 miles in all air district, based on Plan area CalEEMod default trips lengths for "commercial work" trips. Dump truck trips would be 20 miles in all air districts~~.
- All equipment except the welders, backhoes, and offroad trucks were conservatively assumed to operate a maximum of 8 hours per day, 250 days per year; welders, backhoes, and offroad trucks were assumed to occur 4 hours a day~~Vehicle emission factors were based on EMFAC2011 for the air district in which activity would occur, as determined by GIS (see Section 22A.1.2)~~.
- ~~The backhoe would operate a maximum of 8 hours per day, 250 days per year.~~

Yearly Maintenance

Yearly maintenance includes annual inspections, removal of sediment from sedimentation basins and drying lagoons, and half-decadal tunnel dewatering. Annual inspections include work on the fish screens, gate control structures, removal and inspection of pumps and motors, and inspection of tunnels by a remotely operated vehicle (ROV). Tunnel dewatering includes a physical inspection of the tunnel lining and shafts~~Yearly maintenance includes both annual inspections and half-decadal tunnel dewatering. Annual inspections are limited to work on the gate control structure and inspection by a remotely operated vehicle (ROV). Tunnel dewatering would include a physical inspection, as well as sediment removal~~. Table ~~22A~~22B-~~15~~ 27 in Appendix 22B, *Air Quality Assumptions,* summarizes the number of employees, vehicles, and equipment required for annual inspections and tunnel dewatering.

~~**Table 22A-15. Yearly Maintenance Assumptions for Alternatives 1A-C, 2B-C, 3, 4, 5, 6A-C, 7 and 8**~~

~~O&M Type~~	~~Number of Employees~~	~~Vehicles (number)~~	~~Equipment (number)~~
~~Annual Inspections~~	~~6~~	~~1 crew truck[a]~~	~~Crane (1)[b]~~
~~Tunnel Dewatering~~	~~18 (sediment crew) 11 (inspection crew)~~	~~1 crew truck~~	~~Crane (2)~~

~~[a] Four electric vehicles (EV) would also be required. Emissions associated with these vehicles are included in the electricity analysis (see section 22A.2.2)[b] ROV assumed to be electric~~

Operational emissions associated with vehicle traffic and maintenance equipment were estimated using emission factors from the EMFAC2011 and CalEEMod models, respectively. Emissions were quantified for both the ELT (2025) and LLT (2060) periods. Key assumptions include:

- Annual inspections would occur over a period of one month for the pipeline/tunnel and modified pipeline/tunnel alignments, two weeks for the west alignment, and one week for the east alignment. Work would occur five days per week.
- Sediment removal from the sedimentation basins and drying lagoons would occur over a period of one to two months for the pipeline/tunnel and modified pipeline/tunnel alignments[9], one month for the west alignment, and two weeks for the east alignment. Work would occur five day days per weekSediment removal would occur over a period of one to two months for the pipeline/tunnel and modified pipeline/tunnel alignments[10], one month for the west alignment, and two weeks for the east alignment. Work would occur seven day days per week.
- Tunnel dewatering inspections would occur over a period of two months for the pipeline/tunnel, modified pipeline/tunnel, and west alignments. Tunnel dewatering requires dewatering the full length of the tunnel and would take 30 days to complete, followed by sediment removal, liner cleaning, and inspection. The east alignment would not require tunnel dewatering maintenanceTunnel dewatering inspections would cover one mile of tunnel per day.
- Each employee would make two trips to the project site per day according to the inspection and dewatering schedules identified above.
- Employee vehicle roundtrip would be 70 miles, based on information provided by DWR and the assumption that specialized crews from the Bay Area or Sacramento would need to travel to the DeltaEmployee vehicle trips would be 10.8 miles in the YSAQMD, SMAQMD, and SJVAPCD, based on Plan area CalEEMod default trips lengths for "home based work" trips.
- Crew and dump trucks would make a maximum of two trips per dayEmployee vehicle trips would be 12.4 miles in the BAAQMD, based on Plan area CalEEMod default trips lengths for "home based work" trips.
- Crew and dump truck roundtrips would be 30 miles, based on information provided by DWR and the assumption that 1) crew vehicle movement would occur onsite among various facilities and 2) hauled sediments would be deposited at local landfill sitesEach crew truck would make a maximum of eight trips per day. This value represents a conservative estimate of vehicle activity and is based on consultation with Fehr & Peers, the project traffic engineers.
- All equipment except the cranes and loaders were conservatively assumed to operate a maximum of 8 hours per day; cranes, loaders, man-lifts, and water trucks were assumed to occur 4 hours a dayCrew trucks trips would be 9.5 miles in all air district, based on Plan area CalEEMod default trips lengths for "commercial work" trips.
- The cranes would operate a maximum of 8 hours per day according to the inspection and dewatering schedules identified above.

[9] Two months for alternatives with two tunnels; one month for alternatives with one tunnel

[10] Two months for alternatives with two tunnels; one month for alternatives with one tunnel

22A.2.1.2 Alternative 9 (Separate Corridors)

Specific activity assumptions for Alternative 9 are not available. However, DWR provided a cost estimate for O&M associated with Alternative 9. Total costs for routine O&M were 26% of total costs for routine O&M for Alternative 1A. Zero cost was given for yearly maintenance. Based on this information, O&M emissions associated with Alternative 9 were assumed to be 26% of emissions quantified for Alternative 1ASpecific activity assumptions for Alternative 9 are not available. However, DWR provided a cost estimate for O&M associated with Alternative 9. Total costs for routine O&M were 26% of total costs for routine O&M for all other alternatives. Zero cost was given for yearly maintenance. Based on this information, O&M emissions associated with Alternative 9 were assumed to be 26% of emissions quantified for all other alternatives.

22A.2.2 Electricity SWP and CVP PumpingUsage

Construction of the water conveyance facility would modify BDCP operations and cause the BDCP alternatives to have slightly different energy requirements within the ELT (2025) and LLT (2060) periods. Increases in annual electricity consumption for all alternatives relative to the No Action Alternative (CVP only) and existing conditions (SWP only) were calculated in Chapter 21, *Energy*, and is summarized in Table 22A22B-1628 in Appendix 22B, *Air Quality Assumptions*. Generation of this additional electricity would result in criteria pollutant and GHG emissions at regional power plants.

Table 22A-16. Additional Annual Electricity Consumption for all Alternatives, Early Late and Late Long-Term (GWh)

Alternative	State Water Project		Central Valley Project	
	Early Late	Late Long	Early Late	Late Long
Alt 1A	1,336	708	196	167
Alt 1B	1,218	593	196	167
Alt 1C	1,350	714	196	167
Alt 2A	669	227	109	103
Alt 2B	528	89	109	103
Alt 2C	667	221	109	103
Alt 3	1,034	425	180	153
Alt 4	332	-108	89	83
Alt 5	137	-400	75	57
Alt 6A	-1,019	-1,428	-115	-113
Alt 6B	-1,223	-1,605	-115	-113
Alt 6C	-1,042	-1,436	-115	-113
Alt 7	-1,334	-1,663	-122	-113
Alt 8	-2,247	-2,546	-234	-222
Alt 9	-669	-1,006	-16	-11
No Action	6,867	0	780	733

Criteria pollutant and GHG emissions generated by increased electricity consumptionSWP pumping were calculated provided by DWR and are based on actual and forecasted GHG emissions rates for the SWP system. Statewide grid average emission factors (see Table 22B-20) were utilized for SWP criteria pollutant emissions analysis as criteria pollutant emission factors specific to the SWP system were unavailable. Indirect GHG and criteria pollutants generated by increased CVP pumping were also estimated using adjusted statewide grid average emission factors for state renewable energy mandates (see Table 22A22B-920)).

22A.3 References

22A.3.1 Printed

Biogas Energy Inc. 2008. Key Elements of Biogas Energy Anaerobic Digesters. Available: <http://www.biogas-energy.com/site/BiogasEnergy.pdf>. Accessed: September 23, 2014.

California Air Resources Board. 2010. Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling: Compression-Ignition. NR-009d

———. California Air Resources Board. 2010. *California Greenhouse Gas Inventory for 2000–2008 — by Category as Defined in the Scoping Plan*. Last Revised: May 12, 2010. Available: < http://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_00-08_2010-05-12.pdf>. Accessed: February 10, 2012.

———. 2011. *The Carl Moyer Program Guidelines*. Approved April 28.

———. 2012. *Emissions Estimation Methodology for Commercial Harbor Craft Operating in California*. February.

———. 2012. *Verification Procedure – Currently Verified*. Last Revised: April 3, 2012. Available: <http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm>. Accessed: April 17, 2012.

California Air Pollution Control Officers Association. 2010. *Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures*. August. Available: <http://www.capcoa.org/wp-content/uploads/downloads/2010/09/CAPCOA-Quantification-Report-9-14-Final.pdf>. Accessed: October 9, 2010.

California Climate Action Registry. 2009. *Climate Action Registry General Reporting Protocol*. Version 3.1. January. Available: <http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf>. Accessed: April 19, 2010.

California Energy Commission. 2006. *California Commercial End-Use Survey*. Available: <http://www.energy.ca.gov/ceus>.

———.California Energy Commission. 20120092. Electricity Consumption by County. Available: <http://www.ecdms.energy.ca.gov/elecbycounty.aspx>. Accessed: February 10, 2012Database for Energy Efficient Resources (DEER). Available: <http://www.deeresources.com/index.php?option=com_content&view=category&layout=blog&id=40&Itemid=55>.

Climate Registry. 2015. *Default Emission Factors.* Last Revised: April 9, 2015. Available: <http://www.theclimateregistry.org/wp-content/uploads/2015/04/2015-TCR-Default-EF-April-2015-FINAL.pdf >. Accessed: June 18, 2015.

Countless Environmental. 2006. *WRAP Fugitive Dust Handbook*. September.

~~California Public Utilities Commission. 2006. *Southern California Edison's Antelope-Pardee 500-kV Transmission Line Project*. Available: <http://www.cpuc.ca.gov/Environment/info/aspen/antelopepardee/antelopepardee.htm>. Accessed: September 2008.~~

~~———. 2007. *Sierra Pacific Power Company Hirschdale Power Line Project: Initial Study/Mitigated Negative Declaration*. Available: <http://sppc-hirschdale.com/>. Accessed: September 2008.~~Delucchi, M. ~~1996~~2006. *Emissions of Criteria Pollutants, Toxic Air Pollutants, and Greenhouse Gases, from the Use of Alternative Transportation Modes and Fuels*. ~~Revised 2006~~Originally published in 1996. Table 24. January. University of California Davis.

Donovan, M., and Pyle, T. n.d. The Tennant Avenue Bridge.

Federal Aviation Administration (FAA). 2012. Helicopter Flying Handbook. FAA-H-8083-21A. Figure 2-32. Available: <http://www.faa.gov/regulations_policies/handbooks_manuals/aviation/helicopter_flying_handbook/>. Accessed: November 3, 2014.

Haselbach, L. 2009. Potential for Carbon Dioxide Absorption in Concrete. *Environmental Engineering* 135, 465 (2009).

~~ICF International. 2009. *Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories*. April. Prepared for U.S. Environmental Protection Agency.~~

Legislative Analyst's Office. 2012. *Evaluating the Policy Trade-Offs in ARB's Cap-and-Trade Program.* February.

Mariscal, Garry O'Neill. 2012. Potential for ag-based bioenergy production. May.

MD Helicopters. 2014. MD500E Performance Specifications. Available: <http://www.mdhelicopters.com/helicopters/pdf/500E/performance_specifications.pdf>. Accessed: October 30, 2014.

National Renewable Energy Laboratory. 2012. U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis. NREL/TP-6A20-51946. July.

Nisbet, M., Marceau, M., and VanGeem, M. 2002. *Environmental Life Cycle Inventory of Portland Cement Concrete.* Table 3-13B. PCA R&D Serial No. 2137a. July.

Portland Cement Association. 2011. *Technical Brief: Green in Practice 102—Concrete, Cement, and CO_2*. Last Revised: 2011. Available: <http://www.concretethinker.com/technicalbrief/Concrete-Cement-CO2.aspx >. Accessed: November 1, 2011.

Sacramento Metropolitan Air Quality Management District. 2011. *Concrete Batching Policy Manual*. March. ~~U.S. Department of Energy. 2008. *Voluntary Reporting of Greenhouse Gases Program - Fuel and Energy Source Codes and Emission Coefficients*. Available: <http://www.eia.doe.gov/oiaf/1605/coefficients.html>. Accessed: September 2008.~~

Slag Cement Association. 2013. Slag Cement in Concrete. *Slag Cement and the Environment*, No. 22.

U.S. Energy Information Administration. 2008. *2003 CBECS Detailed Tables*. Released September 2008. Available: <http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.htm>.

U.S. Department of Energy. 2008. Clean Cities. Fact Sheet. April.

———. 2013. A Performance Calculator for Grid-Connected PV Systems (Version 1). Available: <http://rredc.nrel.gov/solar/calculators/pvwatts/version1/>. Accessed: December 20, 2013.

———. 2014. Home Energy Saver. Available: <http://www.homeenergysaver.lbl.gov/consumer/>. Accessed: September 23, 2014.

U.S. Department of Interior National Business Center. 2006. *Aviation Management Directorate. Aircraft Rental Agreement.* Available: <http://amd.nbc.gov/akro/akflight/pdf/ex2.pdf>. Accessed: September 2008.

U.S. Environmental Protection Agency. 1985. AP-42 Compilation of Air Pollutant Emission Factors, 4th Ed. Volume II: Mobile Sources. September. Table II-A1-7. Available: <http://www.epa.gov/nscep/index.html>. Accessed: October 31, 2014.

———. 1998. *Compilation of Air Pollutant Emission Factors*. Section 11.9 Western Surface Coal Mining. Available: <http://www.epa.gov/ttn/chief/ap42/index.html>. Accessed: October 2014.

———. 2006a. *Compilation of Air Pollutant Emission Factors.* Section 13.2.2, Unpaved Roads. Available: <http://www.epa.gov/ttn/chief/ap42/index.html>. Accessed: October 2014.

———. 2006bb. *Compilation of Air Pollutant Emission Factors.* Section 11.12,: Concrete Batching. Available: <http://www.epa.gov/ttn/chief/ap42/index.html>. Accessed: October 2014June.

2006. *Compilation of Air Pollutant Emission Factors: Concrete Batching*. June.———. 2008. *Biomass Combined Heat and Power Catalog of Technologies.* Chapter 7. September.

———. 2009. *Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories.* April.

———. 2013. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012. Table A-107. <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Annex-3-Additional-Source-or-Sink-Categories.pdf>. Accessed: October 31, 2014.

———. 2011. *Compilation of Air Pollutant Emission Factors.* Section 13.2.1, Paved Roads. Available: <http://www.epa.gov/ttn/chief/ap42/ch13/bgdocs/b13s0201.pdf>. Accessed: October 2014.

———. 20144a1. *Emissions Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle*. EPA-420-F-141-0410. NovemberMay.

———. 20144b2. *Emissions & Generation Resource Integrated Database (eGRID)*. Version 1.0. Available: <http://www.epa.gov/cleanenergy/energy-resources/egrid/>< http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>. Accessed: January 2013September 23, 2014.

U.S. Forest Service, the Bureau of Land Management, the Colorado Wood Program, and Colorado Governor's Energy Office. 2008. Where Wood Works. Strategies for Heating with Woody Biomass. Available: <http://www.nrel.gov/docs/gen/fy09/42857.pdf>.

Western Regional Climate Center. 2014. *Climate Summaries*. Available: <http://www.wrcc.dri.edu/climate-summaries/>. Accessed: October 21, 2014.