Supporting Material for

Karras, G. 2020. *Decommissioning California Refineries: Climate and Health Paths in an Oil State.* Communities for a Better Environment (CBE): Huntington Park, Oakland, Richmond, and Wilmington, CA. www.CBECAL.org

Data and details of methods,
72 pages including 24 annotated tables and supporting references:

Table S1. Baseline CO_2e Emissions and Oil Industry Activity Data, 2013–2017*

Mt: Megaton; 1 million metric tons **b:** barrel (oil); 42 U.S. gallons; 0.15898 m^3
CO_2e: carbon dioxide equivalents (100-year Global Warming Potential)

Parameter	Measurement	Data	Units	Mean
California oil refining				
Capacity in use	Crude feed rate by volume	ARB[a]	b/d	1,648,270
Direct emissions	Mass emitted	ARB[b]	Mt/y	35.71
Extraction of feed				
In-state	Crude feed rate by volume	ARB[a]	b/d	559,015
Out-of-state	Crude feed rate by volume	ARB[a]	b/d	1,089,255
In-state	Mass emitted	ARB[b]	Mt/y	21.72
Out-of-state	Mass emitted	ARB[c]	Mt/y	32.32
Refined products				
Gasoline	In-state usage by volume	ARB[d]	b/d	897,899
Distillate / diesel	In-state usage by volume	ARB[d]	b/d	254,402
Jet fuel and kerosene	In-state usage by volume	ARB[d]	b/d	26,485
LPG and propane	In-state usage by volume	ARB[d]	b/d	39,480
Petroleum coke	In-state usage by volume	ARB[d]	b/d	3,734
Other refined products	In-state usage by volume	ARB[d]	b/d	21,244
Gasoline	Mass emitted by in-state use	ARB[d]	Mt/y	124.72
Distillate / diesel	Mass emitted by in-state use	ARB[d]	Mt/y	41.21
Jet fuel and kerosene	Mass emitted by in-state use	ARB[d]	Mt/y	4.00
LPG and propane	Mass emitted by in-state use	ARB[d]	Mt/y	3.52
Petroleum coke	Mass emitted by in-state use	ARB[d]	Mt/y	0.85
Other refined products	Mass emitted by in-state use	ARB[d]	Mt/y	2.19
Gasoline	California refinery production	CEC[e]	b/d	1,057,491
Distillate / diesel	California refinery production	CEC[e]	b/d	363,775
Jet fuel and kerosene	California refinery production	CEC[e]	b/d	286,728
LPG and propane	California refinery production	Estimated[f]	b/d	38,376
Petroleum coke	California refinery production	Estimated[f]	b/d	100,099
Gasoline	Mass emitted in and out of state	Calculated	Mt/y	146.89
Distillate / diesel	Mass emitted in and out of state	from the	Mt/y	58.93
Jet fuel and kerosene	Mass emitted in and out of state	data shown	Mt/y	43.27
LPG and propane	Mass emitted in and out of state	above[g]	Mt/y	3.62
Petroleum coke	Mass emitted in and out of state		Mt/y	22.89
Other refined products	Mass emitted in and out of state		Mt/y	2.19
	Total products use emissions	Sum	Mt/y	277.33
Petroleum fuel chain emissions baseline		Sum	Mt/y	367.52
All other (non-petroleum) statewide emissions baseline		ARB[d,h]	Mt/y	203.45
Statewide total emissions baseline including petroleum fuel chain		Sum	Mt/y	570.53

* Based on the most recent five-year period when complete data were reported as of February 2020. Figures may not add due to rounding.

Table continued next page

Table S1. Baseline CO_2e Emissions and Oil Industry Activity Data, 2013–2017,* *continued*

Mt: Megaton; 1 million metric tons **b:** barrel (oil); 42 U.S. gallons; 0.15898 m^3
CO_2e: carbon dioxide equivalents (100-year Global Warming Potential)

See page 1 of this table for parameter measurements

Parameter	Units	2013	2014	2015	2016	2017
California oil refining [a,b]						
Capacity in use (crude feed rate)	b/d	1,611,656	1,677,623	1,659,586	1,590,441	1,702,046
Direct emissions	Mt/y	35.69	35.46	35.67	35.95	35.77
Extraction of feed [a–c]						
In-state crude feed rate supplied	b/d	592,570	609,233	580,678	524,627	487,970
Out-of-state crude feed rate supplied	b/d	1,019,087	1,068,391	1,078,909	1,065,813	1,214,076
In-state extraction emissions	Mt/y	21.85	23.49	22.64	20.33	20.29
Out-of-state extraction emissions	Mt/y	28.55	31.31	31.98	31.38	38.37
Refined products [d–g]						
Gasoline burned in-state	b/d	875,123	874,471	901,346	914,835	923,721
Distillate / diesel burned in-state	b/d	250,128	262,802	261,037	252,024	246,020
Jet fuel and kerosene burned in-state	b/d	24,361	24,124	25,946	28,218	29,778
LPG and propane burned in-state	b/d	41,815	38,299	36,240	41,268	39,776
Petroleum coke burned in-state	b/d	3,427	3,801	4,224	3,656	3,562
Other refined products burned in-state	b/d	13,430	25,050	24,510	24,412	18,818
In-state gasoline emissions	Mt/y	121.79	121.55	125.12	127.20	127.96
In-state distillate / diesel emissions	Mt/y	40.52	42.53	42.23	40.91	39.86
In-state jet fuel and kerosene emissions	Mt/y	3.67	3.64	3.91	4.27	4.49
In-state LPG and propane emissions	Mt/y	3.73	3.42	3.23	3.68	3.55
In-state petroleum coke emissions	Mt/y	0.87	0.87	0.89	0.85	0.77
In-state other refined prod. emissions	Mt/y	1.78	2.28	2.36	2.43	2.09
Calif. refinery gasoline production	b/d	1,003,842	1,043,326	1,014,112	1,107,902	1,118,271
Calif. refinery distillate/diesel production	b/d	356,277	374,422	348,096	372,454	367,625
Calif. refinery jet fuel & kerosene prod.	b/d	274,299	290,762	286,088	283,393	299,099
Calif. refinery LPG & propane production	b/d	39,160	43,657	34,371	37,367	37,327
Calif. refinery petroleum coke production	b/d	103,087	99,442	96,860	98,963	102,142
Gasoline end use emission total	Mt/y	139.70	145.02	140.78	154.04	154.92
Distillate / diesel end use emission total	Mt/y	57.71	60.60	56.31	60.46	59.57
Jet fuel & kerosene end use em. total	Mt/y	41.37	43.86	43.15	42.86	45.11
LPG & propane end use emission total	Mt/y	3.73	3.89	3.23	3.68	3.55
Petroleum coke end use emission total	Mt/y	26.09	22.67	20.47	23.05	22.15
Other refined products end use em. total	Mt/y	1.78	2.28	2.36	2.43	2.09
Refined products end use emission total	Mt/y	270.39	278.31	266.30	286.52	287.38
Petroleum fuel chain emissions baseline	Mt/y	356.48	368.57	356.59	374.18	381.81
All other (non-petroleum) emissions [g,h]	Mt/y	217.79	211.42	205.31	193.43	189.31
Statewide total	Mt/y	574.27	579.99	561.90	567.60	571.12

* Based on the most recent five-year period when complete data were reported. Figures may not add due to rounding.

a. Refining and extraction volume data, and data for the carbon intensity of extracting out-of-state crude fed to California refineries relative to that of in-state extraction (76%), were taken from California Air Resources Board (ARB) Low Carbon Fuel Standard documentation reports (*RS1*). <u>See</u> Table S2.

Table S1. Baseline CO_2e Emissions and Oil Industry Activity Data, 2013–2017 *continued*

b. Refining and in-state extraction emissions data were taken from third party-verified Mandatory Reporting Regulation (MRR) reports by the ARB (*RS2*). See Table S3.

c. Emissions from out-of-state extraction of California refinery crude feeds were estimated based on the relative volumes and emission intensities of in-state and out-of-state extraction (*RS1, RS2;* tables S2, S3) and were calculated as 1,058,780 b/d • (22.08 Mt/y ÷ 577,136 b/d) • 0.76 = 30.78 Mt/y.

d. Data for in-state use of refined products outside refining and extraction plant gates, in-state emissions from refined products outside those plant gates, and all other (non-petroleum) emissions were taken from ARB Greenhouse Gas Inventory reports (*RS3–RS5*) as detailed in Table S4. For jet fuel the reported in-state usage excludes usage for cross-border and military jet travel as well as direct exports (see also e).

e. California refinery production data for gasoline, distillate/diesel, and jet fuel and kerosene were taken from California Energy Commission (CEC) Fuels Watch reports (*RS6*). See Table S5. Total refinery production volume exceeds total oil feed volume because of volume gain. Carbon subtraction and hydrogen addition processes break ("crack") the carbon-carbon bonds of hydrocarbons in the crude and add hydrogen to them—thus creating a lighter mix of hydrocarbons and expanding its volume. In the industry's jargon, this thermal cracking, catalytic cracking and hydrocracking "fluffs the crude barrel." For jet fuel and kerosene, the large difference between in-state production and use reflects both direct exports and "exports" via cross-border and military jet travel, and emissions from the total, including in-state and export usage, was accounted for in fuel chain emissions (see calculation described in note g).

f. LPG, propane, and petroleum coke production were not available from CEC Fuels Watch Reports (*RS6*). Values were estimated based on U.S. Energy Information Administration data for West Coast refinery production (*RS7*) and *Oil & Gas Journal* data for the production capacity of California refineries relative to that of the entire West Coast (*RS8*). See Table 6. The LPG & propane estimate is within 3% of reported in-state LPG & propane usage shown in the table, consistent with little or no export of these fuels, while the pet coke estimate suggests some 96% of pet coke was exported, consistent with other West Coast export data that document major exports of this extremely dirty-burning refining byproduct.

g. Total emissions from usage of products refined in California were estimated based on total California refinery production and in-state emission intensity (emission/usage) data for each refined product. For example, refined product emissions from gasoline that was produced in California from 2013–2017 were calculated as: 1,057,491 b/d • (124.72 Mt/y ÷ 897,899 b/d) = 146.89 Mt/y. This method conservatively assumed that the fuel-specific emission intensities of out-of-state fuels combustion are equivalent to, and do not exceed, those of in-state fuels combustion.

LPG and propane emissions calculated by this method, however, suggest overly conservative production estimates for this fuel: estimated production (note f) exceeded reported in-state usage (note d) in 2014 but was less than reported usage in other years. For LPG and propane in those other years total end-use emissions were estimated based on the reported usage data. This adjustment did not appear significant as it changed the mean petroleum fuel chain and total emissions estimated by only 0.03–0.05 percent.

h. In 2016 a multi-year drought broke, hydroelectric power generation surged dramatically (*RS9*), and reduced emissions from fossil-fueled power generation led a reduction in non-petroleum emissions (*RS2;* Table S4), changing the statewide emissions profile. It was judged appropriate to include the emissions variability described by these data, which appears to be related to climate variability, in the baseline. The baseline for comparing emission trajectories along plausible future pathways was estimated as the five-year average of 2013–2017 data. This method accounts for the mix of wet and dry years expected over time in the future better than comparing a single-year baseline to such future conditions. See also note k to Table S4 for more detail on this point.

Table S2. Annual California Refinery Crude Feed Extraction Data, 2013–2017 [a]

	Volume and carbon intensity* of crude feeds extracted	
	In-state oilfields	Out-of-state imports**
Crude oil volume (b/year)		
2013	216,287,874	371,966,596
2014	222,369,959	389,962,538
2015	211,947,382	393,801,666
2016	192,013,608	390,087,627
2017	178,109,048	443,137,684
mean	204,145,574	397,791,222
Carbon intensity (CI; g CO_2e/MJ)*		
2013	13.05	10.39
2014	13.31	9.97
2015	14.46	10.77
2016	14.73	10.87
mean	13.89	10.50
Percentage of in-state CI	100 %	76 %

b: barrel (oil); 42 U.S. gallons; 0.15898 cubic meters **g:** gram **MJ:** Megajoule, 1 million Joules

* Carbon intensity as reported for the Low Carbon Fuel Standard[a] is shown for crude oil extraction only.

** Imported from other states and nations; other nations account for 80 percent of imports.[a]

a. Data were taken from California Air Resources Board *Crude Average CI Value* data documentation reports for the ARB's Low Carbon Fuel Standard (*RS1).* Values shown in the table for volume averages and volume-weighted carbon intensity (extraction only) averages by extraction location were calculated from these data. The total volume of crude oil refined in California from 2013–2017 reported by the Air Resources Board (shown) is within 1 percent of that reported by the California Energy Commission for the same period (not shown; *RS6*). As of 6 September 2019, complete ARB crude CI data were not reported for 2017.

Table S3. Annual In-state Refining and Extraction CO_2e Data, 2013–2017

Annual CO_2e emitted in metric tons

	In-state oil extraction[a]	In-state oil refining[a–c]
2013	21,847,075	35,690,313
2014	23,488,708	35,463,334
2015	22,643,712	35,673,211
2016	20,326,263	35,946,578
2017	20,291,122	35,771,270
mean	21,719,376	35,708,941

a. Data were taken from the Annual Summary of Greenhouse Gas Emissions Data Reported to the California Air Resources Board in public reports under its Mandatory Reporting Rule (*RS2*). These data are verified by independent third parties through the agency's emission certification system (*RS2*).

b. In-state refining emissions from facilities in or adjacent to refineries that supplied hydrogen, sulfur handling, heat and power, or sulfur and petroleum coke processing for and are integral to refining operations but were owned by third parties were included in the statewide refining emissions totals. These plants were the Air Liquide hydrogen plants in El Segundo and Rodeo, the Air Products hydrogen plants in Carson, Martinez, and Wilmington, Martinez Cogen in Martinez, Chemtrade West in Richmond, the Tesoro Coker Calciner in Wilmington and the Phillips 66 Carbon Plant in Rodeo/Hercules.

c. A major explosion that led to an unusually protracted outage at the PBF (then ExxonMobil) Torrance refinery from February 2015 to May 2016 (*RS10, RS11*) resulted in anomalous production and emission profiles for this refinery in these years. The Air Resources Board data (*RS2*) confirmed that Torrance refinery emissions were anomalously low in both years and only half of 2013 emissions in 2015. The anomalous Torrance 2015 and 2016 emission reports were replaced with the average of its 2013, 2014, and 2017 emissions in the total refinery emissions for these years (shown). Correcting for this anomaly changed reported statewide refinery emissions in 2015 and 2016 by 4.1% and 1.4%, respectively, and changed the statewide mean estimate for refinery emissions from 2013–2017 by approximately 1.1%.

Table S4. In-state Refined Products Use, Emission, and Emission Balance Details

Mt: Megaton; 1 million metric tons **b:** barrel (oil); 42 U.S. gallons; 0.15898 m^3

In-state refined products emissions including all cogeneration (a)

Mt/y	IPCC#	2013	2014	2015	2016	2017
Gasoline	1A1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Gasoline	1A2	1.7529E+00	1.2113E+00	1.3493E+00	6.0034E-01	6.3023E-01
Gasoline	1A3	1.1945E+02	1.1975E+02	1.2356E+02	1.2650E+02	1.2723E+02
Gasoline	1A4	5.7995E-01	5.8456E-01	2.0754E-01	9.2341E-02	9.6939E-02
Gasoline	1B2	2.7172E-03	2.7509E-03	2.7858E-03	2.8201E-03	9.2002E-03
Distillate-diesel	1A1	1.8824E-01	1.4269E-01	2.6967E-02	4.5837E-02	3.6072E-02
Distillate-diesel	1A2	8.5152E-01	7.5021E-01	7.9902E-01	6.3566E-01	6.9577E-01
Distillate-diesel	1A3	3.5528E+01	3.6784E+01	3.6156E+01	3.5506E+01	3.5542E+01
Distillate-diesel	1A4	3.9492E+00	4.8547E+00	5.2441E+00	4.7211E+00	3.5901E+00
Jet fuel and kerosene	1A1	3.3625E-03	4.7663E-03	1.4051E-03	6.0574E-03	2.1099E-03
Jet fuel and kerosene	1A2	5.3987E-04	6.9165E-03	1.3038E-03	3.6671E-04	2.4447E-04
Jet fuel and kerosene	1A3	3.6471E+00	3.5977E+00	3.8878E+00	4.2189E+00	4.4624E+00
Jet fuel and kerosene	1A4	2.3062E-02	2.9367E-02	2.2501E-02	4.2579E-02	2.6199E-02
LPG and propane	1A1	1.1347E-02	5.8998E-03	1.8716E-02	3.8084E-02	7.4955E-03
LPG and propane	1A2	1.4057E+00	1.3561E+00	1.2295E+00	1.4480E+00	1.4019E+00
LPG and propane	1A3	3.1666E-01	3.4085E-01	2.4757E-01	6.8658E-02	3.7872E-02
LPG and propane	1A4	2.0014E+00	1.7145E+00	1.7526E+00	2.1614E+00	2.1052E+00
Petroleum coke	1A1	3.5019E-01	4.4012E-01	1.8547E-01	2.4958E-01	3.0566E-01
Petroleum coke	1A2	8.4013E-01	8.4358E-01	8.1234E-01	8.5140E-01	7.7248E-01
Petroleum coke	1A3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Petroleum coke	1A4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Other petroleum products	1A1	2.7315E+00	3.9571E+00	3.6457E+00	3.0000E+00	3.0821E+00
Other petroleum products	1A2	1.8735E-01	2.1443E-01	2.4101E-01	2.4933E-01	2.3470E-01
Other petroleum products	1A3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Other petroleum products	1A4	0.0000E+00	2.8258E-04	3.0518E-04	4.7473E-04	0.0000E+00
Other petroleum products	1B2	5.9448E-03	6.0940E-03	6.2540E-03	6.4248E-03	1.1301E-02
Other petroleum products	2D1	1.5214E+00	1.5872E+00	1.7282E+00	1.9248E+00	1.6367E+00
Other petroleum products	4D	5.1262E-05	5.3545E-05	5.6035E-05	5.8526E-05	1.0956E-03

Emissions from cogeneration used in refining and extraction (b)

Mt/y	Cogen for:	2013	2014	2015	2016	2017
Distillate-diesel	Extraction	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Distillate-diesel	Refining	3.9681E-04	3.3592E-04	3.4494E-04	8.5427E-04	2.8315E-04
LPG and propane	Extraction	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
LPG and propane	Refining	6.1403E-03	1.8761E-03	1.6232E-02	3.5551E-02	4.8268E-03
Petroleum coke	Extraction	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Petroleum coke	Refining	3.2292E-01	4.1700E-01	1.0497E-01	2.4958E-01	3.0566E-01
Other (associated gas)	Extraction	6.5735E-01	1.5697E+00	1.3135E+00	9.8119E-01	1.1148E+00
Other (associated gas)	Refining	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Other (refinery gas)	Extraction	2.0965E-03	2.1737E-03	3.0181E-04	8.3791E-04	1.4767E-03
Other (refinery gas)	Refining	2.0035E+00	1.9169E+00	1.9496E+00	1.7677E+00	1.7628E+00
Natural gas	Extraction	3.1679E+00	2.4350E+00	2.5263E+00	2.4127E+00	2.4486E+00
Natural gas	Refining	2.5566E+00	2.6946E+00	2.0207E+00	1.7755E+00	1.9223E+00

continued next page

Table S4. In-state Refined Products Use, Emission, and Emission Balance Details *continued*

Mt: Megaton; 1 million metric tons **b:** barrel (oil); 42 U.S. gallons; 0.15898 m^3

In-state refined products emissions excluding cogeneration used in refining and extraction (c)

Mt/y	2013	2014	2015	2016	2017
Gasoline	121.790	121.546	125.124	127.200	127.964
Distillate-diesel	40.517	42.531	42.226	40.907	39.864
Jet fuel and kerosene	3.674	3.639	3.913	4.268	4.491
LPG and propane	3.729	3.415	3.232	3.681	3.548
Petroleum coke	0.867	0.867	0.893	0.851	0.772
Other petroleum products	1.783	2.276	2.358	2.431	2.087

In-state refined products usage (d)

b/d (e)	2013	2014	2015	2016	2017
Gasoline	875,123	874,471	901,346	914,835	923,721
Distillate-diesel	250,128	262,802	261,037	252,024	246,020
Jet fuel and kerosene (f)	24,361	24,124	25,946	28,218	29,778
LPG and propane (e)	41,815	38,299	36,240	41,268	39,776
Petroleum coke (e)	3,427	3,801	4,224	3,656	3,562
Other petroleum products (e)	13,430	25,050	24,510	24,412	18,818

In-state balance of emissions (g)

Mt/y	2013	2014	2015	2016	2017
Total in-state emissions (g–k)	447.69	444.65	441.37	429.04	424.10
– in-state refining emissions (h)	35.69	35.46	35.67	35.95	35.77
– in-state extraction emissions (i)	21.85	23.49	22.64	20.33	20.29
– in-state refined product emissions (j)	172.36	174.27	177.75	179.34	178.73
All other (non-petroleum) emissions (k)	217.79	211.42	205.31	193.43	189.31

---

a. In-state refined products emissions by IPCC category, including all cogeneration and excluding all other refining and extraction emissions, were taken from the California Air Resources Board (ARB) *Greenhouse Gas Inventory by IPCC Category* (*RS3*). Emissions from out-of-state as well as in-state generation of electricity used in the state (IPCC# 1A1) were included. Emissions from fuels burned in California refining and extraction facilities were excluded to avoid double counting (see notes b, g–i).

b. Emissions from cogeneration used in refining and extraction in California were taken from the ARB *Disaggregation of Industrial Cogeneration Categories* documentation for its GHG Inventory (*RS4*). These emissions were not included in the estimate for refined products emissions (see note c).

c. In-state refined products emissions excluding cogeneration were derived by subtracting emissions associated with cogeneration used in refining and extraction (note b) from the total in-state emissions (note a) for each product. This was done to avoid double counting (see notes g–i).

d. In-state refined products usage data were taken from the ARB *Fuel Activity for California's Greenhouse Gas Inventory by Sector & Activity* (*RS5*). Refined products burned in California refining and extraction facilities were excluded to avoid overestimating end-use fuel volumes, and thus under-estimating end-use fuel combustion carbon intensities (see note g in Table S1).

e. Barrels of gaseous and solid fuels based on 0.0278 gallons/standard cubic foot of propane and 210 gallons per short ton of petroleum coke.

f. Jet fuel usage and emissions shown exclude those from cross-border and military air travel. See Table S1 for totals.

Table S4. In-state Refined Products Use, Emission, and Emission Balance Details *continued*

g. In-state balance of emissions data compare total in-state emissions with in-state refinery fuel chain emissions by subtracting refining, in-state extraction, and in-state refined products emissions to quantify non-petroleum (all other) emissions. Total in-state (included) emissions data for 2013–2017 were taken from the ARB *Greenhouse Gas Inventory by IPCC Category* (*RS3*). These totals were compared with in-state refinery fuel chain emissions because, though they include emissions from out-of-state generation of electricity used in the state, these totals exclude out-of-state emissions from oil refined in California.

h. Refining emissions were taken from the *Annual Summary of Greenhouse Gas Emissions Data Reported to the California Air Resources Board* (*RS2*) under its Mandatory Reporting Regulation (MRR). See also Table S3.

i. In-state extraction emissions were taken from the MRR (*RS2*). See also Table S3.

j. In-state refined products emissions were calculated as the sum of in-state products emissions for individual products that are shown in the same table above (note c). These emissions were based on ARB Inventory data (*RS3–RS5;* notes a–c).

k. Potentially significant emission variability coincided with the breaking of a multi-year drought. Hydroelectric power production surged in 2016–2017, doubling from 2013–2015 (*RS9*). As in-state hydropower supply increased by an average of 17,900 Gigawatt-hours/year over that in 2013–2015 (*RS9*), reduced emissions from fossil-fueled electricity generation led to a decline in total non-petroleum emissions of ≈20.1 Mt/y in 2016-17 from the average during 2013–2015 (*see* data in this table). The drought delayed at least some emission cuts from low-carbon electricity measures before 2016.

Non-petroleum emissions fell from ≈218 Mt in 2013 to ≈189 Mt in 2017 (this table). Electricity sector emissions, including those associated with imports, can account for all of this non-petroleum emissions decline. Total electricity sector emissions not associated with oil extraction or refining (*RS3–RS5;* not shown in table) fell by 32%, from ≈91 Mt in 2013 to ≈62 Mt in 2017. Meanwhile, more oil was imported and refined here, and more fuels refined here were burned in and out of state (*see* Table S1). Petroleum fuel chain emissions rose by 7% from ≈356 Mt in 2013 to ≈382 Mt in 2017 (*Id.*). The subtotal for other emissions outside the oil and electricity sectors changed little from 2013–2017 (*Id.*). From 2013–2017 overall, total emissions fell by only ≈3 Mt/y or 0.55% as electricity sector emissions fell from 16 to 11% of the total, oil sector emissions rose from 62 to 67% of the total, and other (non-petroleum, non-electricity) emissions remained at 22% of total emissions (*Id.*).

This shift in the emissions profile represents only a small percentage change in total emissions (0.55%), but was discernable, and was traceable to changes across emission sectors.

Based on these observations, it was judged appropriate to include the variability in the California emissions profile that is described by these data and appears to be related in part to climate variability in the baseline for future potential emission assessment. *See* also note h in Table S1.

Table S5. California Refinery Production by Key Product and Year, 2013–2017

Product leaving the refinery gate in b/year

	2013	2014	2015	2016	2017
Gasoline[a]	366,402,200	380,814,100	370,151,000	405,492,000	408,169,000
Distillate-diesel[a]	130,041,000	136,664,000	127,055,000	136,318,000	134,183,000
Jet fuel and kerosene[a]	100,119,000	106,128,000	104,422,000	103,722,000	109,171,000
LPG and propane[b]	14,293,230	15,934,920	12,545,400	13,676,400	13,624,200
Petroleum coke[b]	37,626,720	36,296,300	35,353,740	36,220,620	37,281,860

b: barrel (oil); 42 U.S. gallons; 0.15898 m^3

a. Gasoline, distillate-diesel, and jet fuel and kerosene data were taken from California Energy Commission *Weekly Fuels Watch* reports (*RS6*).

b. LPG, propane and petroleum coke production was not available from California Energy Commission *Weekly Fuels Watch* reports (*RS6*). Values were estimated based on U.S. Energy Information Administration data for West Coast refinery production and *Oil & Gas Journal* data for the production capacity of California refineries relative to that of the entire West Coast. See Table S6.

Table S6. Estimate Calculation Data for In-state LPG and Pet Coke Production

Product leaving the refinery gate in b/year

	2013	2014	2015	2016	2017
LPG and Propane					
West Coast production[a]	16,429,000	18,316,000	14,420,000	15,720,000	15,660,000
California capacity ratio[b]			0.87		
California production[c]	14,293,230	15,934,920	12,545,400	13,676,400	13,624,200
Petroleum Coke					
West Coast production[a]	43,752,000	42,205,000	41,109,000	42,117,000	43,351,000
California capacity ratio[b]			0.86		
California production[c]	37,626,720	36,296,300	35,353,740	36,220,620	37,281,860

b: barrel (oil); 42 U.S. gallons; 0.15898 m^3

a. West Coast (PADD 5) production of LPG & propane (propane and normal butane) and petroleum coke ("marketable" pet coke) data were taken from the U.S. Energy Information Administration (EIA; *RS7*).

b. California production was estimated as the ratio of California to West Coast refining capacity relevant to each product based on *Oil & Gas Journal* 2018 Worldwide Refining Survey data (Table S22; *RS8*). For LPG and propane a California/West Coast refining capacity ratio of 0.87 was calculated based on the sum of capacities for coking, catalytic cracking, hydrocracking and heavy oil hydrotreating. (*See* capacity data in Table S22.) For petroleum coke a California/West Coast refining capacity ratio of 0.86 was calculated based on coking capacities. (Id.) *See* also note c for pet coke.

c. The estimated values for LPG and propane production from 2013–2016 are within 3% of reported in-state LPG and propane usage during this period, as shown in Table S1. This is consistent with little or no export of these fuels. (*Id.*) The estimated values for petroleum coke suggest some 96% of petroleum coke was exported, consistent with other West Coast export data that document major exports of this extremely dirty-burning refining byproduct. (*Id.*)

Table S7. Petroleum Fuel Chain CO_2e co-pollutant emissions data.

**Selected criteria pollutants associated with toxicity effects and, like CO_2, generated by energy consumption ("combustion emissions").*

***t/y:** tonnes/year* ***t/Mt CO_2e:** tonnes/million tonnes CO_2e.*

	$PM_{2.5}$	PM_{10}	NO_x	SO_x
In-state mass emitted (t/y)[a]				
Oil refining	2,108	2,229	7,937	4,552
Oil extraction	759	767	4,903	463
Refined products use	14,997	16,556	482,872	8,780
GHG-weighted (t/Mt CO_2e)[b]				
Oil refining	59.0	62.4	222	127.5
Oil extraction	33.6	33.9	217	20.5
Refined products use	84.7	93.5	2,728	49.6
Refinery fuel chain	75.9	83.1	2,107	58.6
Refinery fuel chain baseline (t/y)[c]	27,900	30,500	773,000	21,500
In-state emissions from all sources[a]	123,000	465,000	572,000	25,500

(a) In-state mass emissions of fine particulate aerosol ($PM_{2.5}$), respirable particulates (PM_{10}), oxides of sulfur (SOx) and oxides of nitrogen (NOx). These data were taken from emissions reported for 2015 by the ARB in its 2017 State Implementation Plan Inventory (*SR13*). The oil refining and extraction estimates shown in the table account for all in-state refining and extraction emissions, including those that were classified as cogeneration emissions in *SR13,* based on the portions of 2013–2015 cogeneration CO_2e emissions (*SR3–SR5*) associated with refining (9.73%) and extraction (10.02%). The in-state emissions from all sources shown exclude emissions from refined products that were exported and burned outside the state and from extraction of imported crude that occurred outside the state.

(b) Statewide CO_2e co-pollutant emissions in 2015 (note a) were compared with in-state CO_2e emitted in 2015 to estimate GHG-weighted co-pollutant emissions. This estimate was based on in-state co-pollutant mass emitted (this table) and in-state CO_2e emitted in 2015 by refining (35.7 Mt/y), extraction (22.6 Mt/y) and refined products (177 Mt/y) from the ARB data given in tables S3 and S4.

(c) From baseline t/Mt CO_2e estimates (this table) and the total refinery fuel chain baseline CO_2e emitted (367 Mt/y) based on the data summarized in Table S1. These baseline refinery fuel chain values estimate total emissions from oil refined in California. Refinery fuel chain emissions can exceed in-state values due to emissions from out-of-state extraction of crude refined in California and exported refined products that were produced in the state (e.g., *compare* baseline refinery fuel chain emissions with emissions from all sources in the state for NOx).

These estimates do not include emissions caused by secondary impacts, such as wildfire smoke associated with droughts linked to climate impacts of petroleum combustion emissions. The petroleum fuel chain and all-source emission estimates shown are rounded to three significant digits.

Table S8. CO_2e Co-pollutant $PM_{2.5}$ Toxicity Risk Factor Estimate Calculation Data

Population-level risk of premature deaths from all causes associated with chronic exposure to fine particulate aerosol ($PM_{2.5}$): estimate for risk associated with refinery fuel chain emissions;[a] estimated as risk/tonne $PM_{2.5}$ emitted.

	Measurement	Value
Risk/tonne $PM_{2.5}$ emitted [a,b]		
BAAQMD SIP estimate [c]	Premature deaths/tonne $PM_{2.5}$ emitted (central estimate)	0.081985
Health experts' review [d]	Premature deaths/tonne $PM_{2.5}$ emitted (central estimate)	0.060113
Use conservative value [e]	Premature deaths/tonne $PM_{2.5}$ emitted	0.060113
Copollutant emission factor [f]	Tonnes $PM_{2.5}$ emitted/million tonnes CO_2e emitted	75.9
Copollutant risk factor*	Premature deaths/million tonnes CO_2e emitted	4.563

*Calculation: premature deaths/tonne $PM_{2.5}$ • tonnes $PM_{2.5}$/million tonnes CO_2e emitted = 4.563

a. This estimate does not account for disparately vulnerable populations, less effective dispersion and greater baseline death rates in other locations (including, e.g., where exported fuels will be burned), other health effects of $PM_{2.5}$, or environmental health effects of other pollutants, and is conservative for these reasons.

b. The estimate integrates five data inputs: (1) Mass emissions (e.g., tonnes/yr). (2) Their dispersion in region-specific ambient air (i.e. 0.5 $\mu g/m^3$ per 1% change in mass emission based on modeling trued up to measurements; *RS14*). (3) Population-level exposure to that air pollution (e.g., census data). (4) A rigorously estimated risk factor based on multiple peer-reviewed epidemiology studies (i.e. a ratio of 0.01 change in death rate for each 1 $\mu g/m^3$ change in air; *RS14*), and, because this risk factor estimates the change in death rate, (5) a region-specific current baseline death rate estimate.

c. The BAAQMD SIP estimate data were taken from analysis reported by the Bay Area Air Quality Management District and is based on an estimated regional risk reduction in the San Francisco Bay Area region of 76 deaths/yr associated with a regional $PM_{2.5}$ emission reduction of 927 tonnes/yr (*RS14*).

d. The Health experts' review estimate data were taken from analysis reported to the BAAQMD in 2017 by a group of leading health experts (*RS15*). The risk estimate shown was based on an estimated regional risk reduction in the S.F. Bay Area region of 42.5 deaths/yr associated with preventing a regional $PM_{2.5}$ emission increment of 707 tonnes/yr (*RS15*).

e. Two factors primarily drive the difference between estimates. The health experts' review (*RS15*) estimated a smaller population exposed in the age range most directly linked to the chronic exposure risk factor estimate through 2050, and a lower baseline death rate, as compared with the BAAQMD SIP estimate (*RS14*). Both factors vary among regions and are also among the reasons this estimate is conservative (see note a for other reasons it is conservative).

f. The 75.9 tonnes $PM_{2.5}$ emission per million tonnes CO_2e emission factor is based on the data and analysis documented in Table S7 (see also tables S1, S3 and S4).

Approximately $9 million in health costs are incurred with each premature death associated with air pollution (e.g., $702,000,000 for averting 76 deaths annually) based on BAAQMD SIP data (*RS14*).

Table S9. Statewide Cumulative CO_2e Emission Limit Calculation Data [a]

Gt: Gigaton; 1 billion metric tons — Shading: Cumulative limit

Year	Petroleum Fuel Chain Emissions Annual (Gt/y)	Petroleum Fuel Chain Emissions Cumulative (Gt)	All Other (non-petroleum) emissions Annual (Gt/y)	All Other (non-petroleum) emissions Cumulative (Gt)	Cumulative Total (Gt)
2017 [b]	0.3675	0.3675	0.2034	0.2034	0.5710
2018	0.3598	0.7273	0.1992	0.4026	1.1299
2019	0.3459	1.0733	0.1915	0.5941	1.6674
2020	0.3326	1.4059	0.1841	0.7783	2.1841
2021	0.3198	1.7257	0.1770	0.9553	2.6810
2022	0.3075	2.0332	0.1702	1.1255	3.1587
2023	0.2977	2.2803	0.1647	1.2633	3.5426
2024	0.2842	2.6130	0.1573	1.4465	4.0595
2025	0.2733	2.8863	0.1513	1.5978	4.4841
2026	0.2628	3.1491	0.1455	1.7432	4.8923
2027	0.2526	3.4017	0.1398	1.8831	5.2848
2028	0.2429	3.6446	0.1345	2.0176	5.6622
2029	0.2335	3.8781	0.1293	2.1468	6.0250
2030 [c]	0.2245	4.1027	0.1243	2.2711	6.3738
2031	0.2141	4.3168	0.1185	2.3897	6.7064
2032	0.2026	4.5194	0.1122	2.5018	7.0212
2033	0.1918	4.7112	0.1062	2.6080	7.3192
2034	0.1816	4.8928	0.1005	2.7085	7.6013
2035	0.1718	5.0646	0.0951	2.8037	7.8683
2036	0.1627	5.2273	0.0900	2.8937	8.1210
2037	0.1540	5.3813	0.0852	2.9789	8.3602
2038	0.1457	5.5270	0.0807	3.0596	8.5866
2039	0.1379	5.6650	0.0764	3.1360	8.8009
2040	0.1306	5.7955	0.0723	3.2083	9.0038
2041	0.1236	5.9191	0.0684	3.2767	9.1958
2042	0.1170	6.0361	0.0648	3.3415	9.3776
2043	0.1107	6.1469	0.0613	3.4028	9.5496
2044	0.1048	6.2517	0.0580	3.4561	9.6993
2045	0.0992	6.3509	0.0549	3.5157	9.8666
2046	0.0939	6.4448	0.0520	3.5677	10.0125
2047	0.0889	6.5337	0.0492	3.6169	10.1507
2048	0.0841	6.6179	0.0466	3.6635	10.2814
2049	0.0796	6.6975	0.0441	3.7076	10.4051
2050 [c]	0.0754	6.7729	0.0417	3.7493	10.5223

Figures shown may not add due to rounding

a. California has established CO_2e emission targets that would reduce statewide emissions to the 1990 emission rate by 2020, 40 percent below the 1990 rate by 2030, and 80 percent below the 1990 rate by 2050.[1–3] State analysis of these targets related them to cumulative emissions based on consistent linear progress.[4] Data in this table show that steady progress to the targets by all emitting sectors defines a total cumulative emission limit from 2017–2050 of ≈ 10.5 Gigatons (Gt) as CO_2e.

b. Emissions in 2017, the beginning of the cumulative accounting, are petroleum fuel chain, all other (non-petroleum), and total mean baseline emissions observed, which were taken from Table S1.

continued

[1] State Health and Safety Code; Assembly Bill 32, enacted in 2006.
[2] State Health and Safety Code; Senate Bill 32, enacted in 2016.
[3] Executive Order S-3-05; Governor Schwarzenegger, 2005.
[4] *California's 2017 Climate Change Scoping Plan;* Cal. Air Resources Board. *See* pp. 18, 24, 26, figures 5, 6; and *Pathways GHGs by Measure,* "Total GHGs by sector & SP sens" tab, lines 149–151, cell F18.

Table S9. Statewide Cumulative CO_2e Emission Limit Calculation Data *continued*

c. Emission rates at the end of the target years 2030 and 2050 were calculated by subtracting 40% and 80% from the baseline emissions in the last 1/12th of 2030 and 2050, respectively. During the 13-year period from 2018 through 2030, and then the 20-year period from 2031–2050, annual mass emissions were estimated based on equivalent near-monthly (12/year) cuts to the 2030 and then the 2050 targets. Near-monthly (12/yr) increments were used to account for within-year emission rate changes: Annual mass emissions calculated by this method (shown) can differ from those based on the emission rate in the last 1/12th of a year (not shown). Cumulative emissions were calculated by adding the near-monthly emissions in each 1/12th year to the cumulative emissions from 2017 to the preceding 1/12th year. The cumulative limit was thus calculated based on steady progress to the 2030 and 2050 targets as the cumulative emission total from 2017–2050 (10.5223 Gt).

Data quality, system boundary, accumulation period and climate relevance issues were assessed to gauge the precision and accuracy of this cumulative emission limit estimate. Data quality was judged relatively high for the California CO_2e emissions data underlying this estimate (*RS1–RS5,* tables S1–S6). Applying a different system boundary that excludes out-of-state emissions associated with oil and/or electricity system import/export activities changed the absolute value of the cumulative emission limit but not its relationship to current emissions included in the system boundary: the –40% and –80% 2030 and 2050 targets yielded the same proportionate emission cuts to the cumulative emission limit through 2050.* The accumulation period issue arises because emission rate changes cannot reasonably be expected to occur only once on the same date each year, and the same rate change affects cumulative emissions buildup more strongly when it occurs earlier rather than later in the year. Comparison with an annual accounting—which assumed that all emission rate changes will occur on 1 January each year—showed that the more reasonable near-monthly accounting method used here changes the 2050 cumulative emission limit by only ≈ +2%.

The climate relevance issue was assessed in two steps. Since it is now well established that cumulative emission, rather than the emission rate in any one year, is the primary driver of anthropogenic climate forcing, the cumulative emission limit defined by state climate targets was judged to be the most relevant measurement of climate impacts from state emission trajectories. Then, this cumulative limit was compared with global cumulative emission limits (carbon budgets) that the Intergovernmental Panel on Climate Change found compatible with the 1.5ºC and 2ºC temperature increase limits agreed to in the United Nations' 2015 "Paris Accord." *See* Table 10.

---

* An inconsistent or exclusive system boundary could, however, affect analysis of prospective future emission trajectory pathways. Inconsistent or exclusive system boundaries could lead to false conclusions about a future pathway, obscure fuel chain interactions that affect the feasibility of a future pathway, and obscure export accounting problems which could make the future system boundary of a pathway unstable. The background section of the main report gives examples of these problems with inconsistent and exclusive system boundaries. These considerations further supported the consistent and inclusive system boundary used in this analysis.

Table S10. Calculation data for comparison of California's cumulative emission limit through 2050 with global emissions that could meet the "Paris" Accord [a]

		Below 1.5 ºC*		Below 2.0 ºC*
Global data				
Cumulative CO_2 budget [b]	(Gt)	420		1,170
Baseline CO_2 emissions [c]	(Gt/y)		42 ± 3	
Baseline population [d]	(billions)		7.47	
California data				
Cumulative CO_2 target through 2050 [e]	(Gt)		8.80	
Baseline CO_2 emissions [e]	(Gt/y)		0.477	
Baseline population [d]	(millions)		39.5	
Cumulative limits comparisons [f]				
Equivalent emission cuts basis				
Calif. share of baseline emissions	(ratio)	0.011		0.012
Calif. share of global CO_2 budget	(Gt)	4.46		14.3
Difference from Calif. target limit	(%)	– 49 %		+ 62 %
Per-capita emission cuts basis				
Calif. share of baseline population	(ratio)	0.0053		0.0053
Calif. share of global CO_2 budget	(Gt)	2.23		6.20
Difference from Calif. target limit	(%)	– 75 %		– 30 %

Values shown in the table were rounded for simplicity and clarity of presentation.
* 67% chance of this global heating limit with medium confidence

[a] The Paris treaty calls for holding the increase in global average temperature to well below 2 degrees C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 ºC above pre-industrial levels. Data in this table show steady progress to California's climate targets (see Table S9) would limit cumulative emission to the state's share of global emissions that could be compatible with the well below 2ºC threshold but could exceed the 1.5ºC threshold on an *equivalent emission cuts* basis—and that even deeper cuts would be needed here to achieve the state's *per-capita* share of effort.

[b] Global budgets shown are limits on cumulative emissions compatible with a 67% chance of limiting increases in global mean near-surface air temperature to 1.5ºC and 2.0ºC above pre-industrial levels with medium confidence. Those budgets are expressed as CO_2 emitted from 2017, accounting for non-CO_2 climate emission impacts and for Earth System feedbacks (e.g., permafrost melt). The data were taken from the Intergovernmental Panel on Climate Change (IPCC) report *Global Warming of 1.5ºC* (*RS16*). Note that California emissions were adjusted for comparability with these global estimates which are expressed as CO_2 and account for non-CO_2 forcing, as described in note e below.

[c] Global CO_2 emissions in 2017 from the IPCC report referenced in note b (*RS16*).

[d] World population in 2018 and California population in 2017 from U.S. Bureau of the Census *(RS17)*.

[e] California cumulative emission limit defined by state climate targets and baseline emissions from tables S1 and S9, expressed as CO_2 for comparison with the global data shown based on the portion of total CO_2e emitted in the state during 2013–2017 that was CO_2 (83.59%), which was calculated from data for all included ARB Inventory emissions (*RS3*).

continued

Table S10. Calculation data for comparison of California's cumulative emission limit through 2050 with global emissions that could meet the "Paris" Accord *continued*

[f] California's share of the global cumulative CO_2 budgets was compared with its cumulative CO_2 target through 2050 based on the state's current shares of global baseline emissions (0.011–0.012) and global baseline population (0.0053).

California shares on an equivalent emission cuts basis addressed the uncertainty in global baseline emissions (42 ± 3 Gt/y) by applying the upper bound of this estimate (45 Gt/y) in the comparison for 1.5ºC and its lower bound (39 Gt/y) in that for 2.0ºC. Thus, California shares of global baseline emissions were estimated at ratios of 0.011 and 0.012 in the 1.5ºC and 2ºC comparisons, respectively. These ratios for shares of global baseline emissions (0.011, 0.012) and that for California's share of population (0.0053) were applied to the cumulative global climate budgets shown in the table to calculate California's share of the global budgets in each comparison.

As shown, on an *equivalent emission cuts* basis, California's cumulative emission limit falls within the range for the state's share of the global climate budgets, exceeding its share of the 2ºC budget and falling short of its share of the 1.5ºC budget. On a *per capita emission cuts* basis, California's cumulative emission limit does not fall within the range for the state's share of the global climate budgets, falling short of its share of the 2ºC and 1.5ºC budgets. These results further support the cumulative emission limit based on steady progress to state targets as a minimum goal, and support seeking deeper emission cuts more quickly in relatively higher-emitting and wealthier regions such as California.

A note on uncertainty, carbon neutrality and human factors in climate stabilization: The uncertainty in estimating California's cumulative emission limit through 2050 (*see* Table S9 note c) is small compared with the 67% chance of *medium* confidence that 1.5ºC and 2.0ºC limits could be met by global emission trajectories through mid-century within –49% to +62% of this California limit (this table). And even then, getting to net-zero emissions (carbon neutrality) during 2050–2100 to stabilize climate (*RS16*) is subject to still greater uncertainties. Six examples of this: First, engineered and permanent carbon capture sequestration has not been proven in practice at the necessary scale to limit heating to 2ºC, achieve carbon neutrality, or stabilize climate, especially if fossil fuels phaseouts are further delayed. (*Id*.) Second, scaling up biological carbon capture sequestration could threaten land use conflicts, biodiversity losses and food supply impacts of uncertain but potentially unsustainable severity (*RS44*) which could render it infeasible at the necessary scale to stabilize climate if fossil fuels phaseouts are further delayed. (*See* also *RS16*.) Third, self-reinforcing feedbacks (e.g., permafrost melt emissions, forest fires) and droughts, floods, storms, coastal inundation, crop losses and consequent climate-forced migration will worsen through 2100 to an uncertain degree which might include runaway climate forcing. Fourth, these climate related impacts, losses and conflicts might further erode already-strained societal capacity to sustain the political will for climate stabilization actions. Fifth, as recent European and North American responses to climate migration illustrate, there is still uncertainty regarding the types and locations of societal impacts and their effects on societal cohesion. Last, and pivotal, is whether the pace of economic transformation necessary to stabilize climate will be socially sustainable; how much might further delay foreclose a "just transition" that may prove essential to break free from carbon lock-in?

These and other uncertainties present serious risks for climate stabilization pathways. But at the same time, it is known with high certainty that technology switching which cuts mass emission rates and limits cumulative emissions will limit these risks. In this context, it was judged appropriate to interpret the state of California's recently announced carbon neutrality commitment as additional and complementary to, instead of alternative to, is longstanding 2030 and 2050 emission reduction targets. Falling short of the Paris 1.5ºC goal (which *might* be achieved by additional carbon neutrality actions) but compatible with its well-below-2ºC goal, the cumulative emission limit defined by California's 2030 and 2050 emission reduction targets could be labeled, in shorthand, as the state's "1.5–2ºC" limit.

Table S11. Carbon Intensity (CI) Scenarios Calculation Data Summary

CI in kg CO_2e per barrel crude capacity **b:** barrel (oil); 42 U.S. gal.; 0.15898 m^3 **Mt:** 10^6 metric tons

		Petroleum fuel chain data for oil refined in California			
		Refining	Extraction	Products use	Fuel chain
Baseline emissions	Mt/year	35.71	54.04	277.78	367.52
Baseline feed capacity[a]	b/day	1,648,270	1,648,270	1,648,270	1,648,270
Baseline CI	kg/b capacity[a]	59.35	89.82	461.72	610.9
Scenario CI breakdown					
S-1 (no change)[b]	kg/b capacity[a]	59.35	89.82	461.72	610.9
S-2 (2020–2031)[b]	kg/b capacity[a]	77.26	129.26	504.10	710.6
S-3 (2020–2031)[b]	kg/b capacity[a]	109.70	165.70	509.85	785.2
S-4 (2020–2026)[b]	kg/b capacity[a]	41.54	62.87	451.03	555.4
S-5 (2020–2026)[c]	kg/b capacity[a]	0	0	461.72	461.7

Mass emission and volume data from Table S1. See tables S12 and S13 for scenario and CI change estimate details.

Mass emissions from the oil sector are the product of the oil volume fed through the fuel chain (the oil feed rate, e.g., barrels per year; cubic meters per day) and the mass emitted per unit volume (emission intensity, e.g., kilograms per barrel or kg/b). This table summarizes calculation data for the CO_2e emission intensity—carbon intensity (CI)—of oil refined in California in kg/barrel. Estimates are shown for four plausible CI scenarios through 2050 (*see* also note c).

a. Refining feed rate-weighted emission intensity was used instead of maximum equipment capacity-weighted emission intensity, to account for actual demonstrated average ability to use built capacity over time. The multi-year baseline period included years of relatively high and low refined fuels demand, further supporting this method. Baseline emissions and oil feed capacity data shown in this table were taken from Table S1.

b. Carbon intensity (CI) was estimated for a range of plausible scenarios, and differences in CI between scenarios were driven primarily by changes in oil feed quality (*see* tables S12 and S13). Years shown in parenthesis (e.g., Scenario S-4; 2020–2026) indicate the periods over which it was judged feasible (except in one scenario; *see* note c) to accomplish the refinery rebuilding needed to realize the change in CI estimated.

c. Scenario S-5 (install and operate 100% effective carbon capture sequestration for extraction and refining emissions) is not known to be feasible and was investigated as part of a sensitivity analysis only. *See* Table S18. In contrast, scenarios S1–S4 are plausible based on proven technology and technically feasible assumptions.

Details of the data and calculation methods used to estimate CI in scenarios S-2, S-3, and S-4 are given in tables S12 and S13.

Table S12. Estimate Calculation Data Details for CI Scenarios S-2 and S-3

m³: cubic meter; 6.29 barrels (oil); 264 U.S. gallons **GJ:** Gigajoule; 10^9 Joules **Mt:** 10^6 metric tons

Scenario assumptions [a]	Baseline (S-1)	S-2	S-3
Oil feed blend	Current (C)	50/50 C/HO HO: heavy oil	20/40/40 C/HO/NB NB: natural bitumen
Equipment change	None	Rebuilds to expand HO refining capacity	Rebuilds to expand HO & NB refining capacity
Implementation timing	None	Rebuilding 2020–2031	Rebuilding 2020–2031
Oil feed density (kg/m³)	891.7	924.6	974.7
Sulfur content (kg/m³)	11.7	19.8	31.7
Oil refining [b]	Baseline (S-1)	S-2	S-3
Energy intensity (GJ/m³)	4.87	6.80	9.72
Carbon intensity (kg/m³)	373.32	486.00	690.00
Change in CI (kg/m³)	—	+ 112.68	+ 316.68
Oil extraction [c]	Baseline (S-1)	S-2	S-3
Carbon intensity (kg/m³)	564.97	813.06	1,042.29
Change in CI (kg/m³)	—	+ 248.09	+ 477.32
Products (pet coke) use [d]	Baseline (S-1)	S-2	S-3
Oil density change (kg/m³)	—	+ 32.9	+ 83.0
Coke yield change (%)	—	+ 111.4 %	≥ + 126.5 %
Coke use emission (Mt/y)	22.89	48.39	≥ 51.85
Coke use CI (kg/m³ crude)	239.32	505.93	≥ 542.10
CI change (kg/m³)	—	+ 266.60	+ 302.74
Sensitivity analysis [e]		S-2	S-3
Refinery fuel chain CI (this estimate; kg/m³)		4,470	4,939
Refinery fuel chain CI (3rd-party estimates; kg/m³)		4,428	4,812
Difference from third-party estimates (%)		+ 0.9 %	+ 2.6 %

a. Abundant evidence indicates that a statewide switch to refining lower quality grades of imported oil from the Canadian tar sands and elsewhere is plausible (*RS18*). Data shown in the table summarize the range of plausible worst-case refinery fuel chain carbon intensities from this potential oil feed switch based on several prior estimates (*RS18–RS23*) and the baseline data shown in Table S1. In the table "HO" and "NB" refer to heavy oil and natural bitumen, respectively, as defined by the U.S. Geological Survey (*RS24*). Plausible worst-case oil feed blends span a range from Scenario S-2, 50/50 replacement of the current oil feed blend (C) with 50% heavy oil (50/50 C/HO) to Scenario S-3, 80% replacement with equal volumes of heavy oil and natural bitumen (20/40/40 C/HO/NB). (*RS18.*) Oil feed quality (density and sulfur content) estimates were taken from a recent estimate for the San Francisco Bay Area (*RS18.*) Major construction to maintain product slates while processing lower quality oil must be staged over many years to avoid fuel supply disruption and was assumed to occur from 2020–2031.

b. Quality (processing characteristics) of crude feeds is quantitatively related to processing, energy, and CO_2 emission intensities of refining fleets, given well-mixed feeds from multiple sources and refinery processing capacity changes to maintain similar engine fuels-dominated product slates (*RS18–RS23*). Refining impacts were estimated based on fleet-wide oil characteristics shown in the table by a method that had proved able to predict observed California refinery energy and emission intensities well (*RS18*).

Table S12. Estimate Calculation Data Details for CI Scenarios S-2 and S-3 *continued*

Refining energy intensity (*EI*) from the same estimate (*RS18*) is shown in the table for context because refinery CI is causally and quantitatively related to refinery oil feed quality and *EI* (*RS19, RS21*). Higher CI than the S-2 estimate has been observed at a California refinery processing oil roughly as dense as S-2 feed (*RS18*). Baseline CI data were taken from the refining emissions and volume data in Table S1.

c. Extraction impacts were estimated by comparing the baseline observed to Oil-Climate Index (OCI) data for plausible worst-case HO and NB oil streams (*RS23*). The baseline data were taken from the extraction emissions and volume data shown in Table S1. Scenario S-2 extraction CI was estimated based on the OCI estimate for Hamaca crude from Venezuela (1,069 kg/m^3; *RS23*) weighted at 50% of feed volume. Scenario S-3 extraction CI was estimated based on the OCI estimates for Hamaca from Venezuela and for Alberta tar sands-derived Syncrude SCO (1,069 and 1,258 kg/m^3 respectively; *RS23*) weighted at 40% of total feed volume for each of these oils. The baseline CI (556.8 kg/m^3) was weighted to 50% and 20% of total oil feed volume in scenarios S-2 and S-3, respectively.

d. Refined products usage impacts were estimated based on oil feed quality impacts on petroleum coke production. While products CI related to engine fuels is constrained by fuel quality specifications and product slates targeting gasoline, diesel and jet fuel, maintaining those fuels' production from denser crude feeds can greatly increase refiners' by-production and yield of petroleum coke (*RS19, RS22*). For Scenario S-2, the 32.9 kg/m^3 oil feed density increment shown in the table was matched to a similar (≈33 kg/m^3) density increment observed among U.S. refining fleets and years (from 866–868 kg/m^3 to 899–901 kg/m^3; *RS19, RS20*). Observed coke yield increased by +111.4% (from 3.5 to 7.4 vol. % on crude) among these same fleets and years (*RS19, RS20*). For Scenario S-3, the 83 kg/m^3 density increment shown in the table exceeded the maximum oil feed density increment observed across U.S. refining fleets and years (44 kg/m^3, from 858–902 kg/m^3; *RS19, RS20*). Observed coke yield increased by 126.5% (from 3.4 to 7.7 vol. % on crude) with this maximum observed (+44 kg/m^3) density increment (*RS19, RS20*), which was used as a conservative estimate of the increase in Scenario S-3 coke yield. These estimates (+111.4% and +126.5%) were applied to the baseline petroleum coke product use emissions and total oil feed rate from Table S1 (22.89 Mt/y, 262,043 m^3/d) to derive the coke-related products use CI increments shown for scenarios S-2 and S-3.

e. Comparisons with independent estimates for plausible worst-case heavy oil and tar sands scenarios (Venezuelan Hamaca, and Athabasca FC-HC-SCO with deep conversion coking, respectively; *RS23*) showed that this estimate for total refinery fuel chain CI (*see* table) compared reasonably well with the independent estimates for these oils (*RS23*). This estimate is within 0.9 % of the independent estimate in Scenario S-2 and is within 2.6 % of the independent estimate in Scenario S-3.

Table S13. Estimate Calculation Data Details for CI Scenario S-4

m³: cubic meter; 6.29 barrels (oil); 264 U.S. gallons **Mt:** 10^6 metric tons

Scenario assumptions [a]	Baseline (S-1)	S-4
Oil feed blend	Current (C)	Switch to lighter oil, other upgrades
Equipment change	None	Rebuilds for oil switch & upgrades
Implementation timing	None	Rebuilding 2020–2026
Oil feed density (kg/m^3)	891.7	869.4
Sulfur content (kg/m^3)	11.7	12.4

Oil refining	Baseline (S-1)	S-4
Oil quality-driven carbon intensity (kg/m^3)[b]	373.32	310.40
Oil quality-driven change in CI (kg/m^3)[b]	—	– 62.92
CI change from other measures (kg/m^3)[d]	—	– 49.09
ARB maximum assumption (kg/m^3)[d]	—	– 112.01

Oil extraction [c]	Baseline (S-1)	S-4
Oil quality-driven carbon intensity (kg/m^3)[c]	564.97	415.72
Oil quality-driven change in CI (kg/m^3)[c]	—	– 149.25
CI change from other measures (kg/m^3)[d]	—	– 20.26
ARB maximum assumption (kg/m^3)[d]	—	– 169.51

Products (pet coke) use [e]	Baseline (S-1)	S-4
Coke yield (ratio to crude feed volume)	0.0740	0.0532
Coke yield change (%)	—	– 28.11 %
Coke use emission (Mt/y)	22.89	16.46
Coke use CI (kg/m^3 crude)	239.32	172.05
CI change (kg/m^3)	—	– 67.27

Sensitivity analysis [f]	S-4
Refinery fuel chain CI (this estimate; kg/m^3)	3,494
Refinery fuel chain CI (3rd-party estimates; kg/m^3)	3,114–3,548

Extraction CI estimates for representative "lighter" crude oil streams (kg CO_2e/m^3 oil) [c]

U.S., Alaska North Slope: 641.59	Qatar, Dukhan: 522.08
Brazil, Lula: 377.40	Kuwait, Ratawi: 345.95
Nigeria, Pennington: 584.98	Saudi Arabia, Zuluf: 239.02
Iraq, Rumaila: 471.76	Saudi Arabia, Safaniya: 194.99
Iraq, Kirkuk: 446.60	U.S., Texas Spraberry: 264.18
Iraq, West Qurna: 484.34	

a. S-4 is a best-case scenario for minimum plausible carbon intensity (CI) based on proven technology. S-4 CI was estimated based on the ARB's assumption that in-state refining and extraction emissions could be cut by up to 30% through feasible measures such as a switch to lighter oil (*RS25*), and the data given in this table and discussed in notes a–f. "Lighter oil" was defined here as the average U.S. refinery crude feed from 2013–2017 (*RS26*). Major rebuilds needed to replace 100% of current California refinery oil feeds with this lighter oil and to install additional lower-carbon measures (see also note e below) were assumed to be staged more quickly, from 2020–2026, consistent with the best-case based on proven technology assumption. Baseline and Scenario S-4 oil feed density and sulfur content data were taken from Table S1, and the average U.S. crude feed quality observed from 2013–2017 (*RS26*), respectively.

Table S13. Estimate Calculation Data Details for CI Scenario S-4 *continued*

b. Oil quality impacts on refining CI were estimated based on the difference between the CI observed for the baseline (Table S1) and S-4 crude feed qualities shown. Data for observed U.S. refining fleet CI values were available for 1990 and 2000 (309.3 and 311.5 kg/m^3), years when U.S. refinery crude feed quality was approximately identical to the Scenario S-4 crude feed estimate shown in the table (*RS19*). These annual average CI data (309.3 and 311.5 kg/m^3) were taken to derive the mean S-4 CI shown (310.4 kg/m^3). This estimate represents a change from baseline refining CI of –16.9% from switching to lighter oil with the characteristics of the U.S. average oil feed alone. (*See* also note d below.)

c. Oil quality impacts on extraction CI were estimated based on the difference between the CI observed for the baseline (Table S1) and the mean CI of representative lighter oils. Scenario S-4 CI was estimated by calculating the mean CI from OCI estimates (*RS23*) for 11 representative light-medium density major oil streams (*see* data given at the bottom of the table). This mean (415.72 kg/m^3) represents CI for equal shares of each lighter oil stream, thereby approximating continued blending of oils from many sources as the Scenario S-4 oil feed becomes lighter than the baseline oil feed. The resultant estimated reduction due to the oil switch alone represents a change from baseline extraction CI of –26.4% (*see* also note d below).

d. Refining and extraction CI reductions from other upgrades were based on the ARB assumption that these emissions may feasibly be cut 30% by 2030 (*RS25*), a best-case assumption that this reduction could be achieved earlier—by 2025—and professional judgment regarding proven technology upgrades. For example, upgrades could produce hydrogen by electrolysis using renewable electricity instead of fossil-fueled hydrogen steam reforming. Hydrogen steam reforming can account for more than 30% of refinery carbon emissions (Table S24). Renewable-powered hydrolysis could eliminate the portion of those emissions that would otherwise continue after hydrogen production rates are reduced by switching to lighter oil, which reduces refinery-wide hydrogen demand (*RS19*). At –30% effectiveness this proven technology could cut up to 93 kg/m^3 from the post oil-switch CI in Scenario S-4, exceeding the 69.35 kg/m^3 reduction in refining and extraction emissions estimated from other measures in this scenario—*if* the oil switch reduced hydrogen production emissions in proportion to other refining emissions. This measure would likely reduce CI in this scenario less than 69.28 kg/m^3 due to disproportionate hydrogen demand reduction in refining lighter oil, however, other refining and extraction efficiency and fuel switching upgrades could plausibly make up the difference to achieve the ARB's forecast. For these reasons, the ARB assumption of a 30% cut in refining and extraction emissions was judged appropriate based on proven technology and plausible best-case assumptions consistent with this best-case scenario.

e. Oil quality impacts on the CI of refined products usage were estimated based on the change in petroleum coke yield. This method was used for the same reasons discussed in note d to Table S12. Baseline coke product use emissions data for this estimate were taken from Table S1. Baseline coke yield data for this estimate were taken from observed California refining industry coke yield from 2004–2009 (mean: 7.40 vol. % on crude; *RS20*). Scenario S-4 data for this estimate were taken from observed U.S. refinery coke yield from 2013–2017 (mean: 5.32 vol. % on crude; *RS27*). The –28.11% change in coke yield calculated from these data ((5.32 – 7.40) ÷ 7.40 = –0.2811) was applied to the baseline petroleum coke product use emissions and total oil feed rate from Table S1 (22.89 Mt/y, 262,043 m^3/d) to derive the coke-related products use CI decrement shown for Scenario S-4.

f. Sensitivity analysis compared the total refinery fuel chain CI estimated with independent estimates for relatively high-quality light to medium density crude oil streams that are produced in large volumes. Data for this comparison were taken from the OCI (*RS23*) for total refinery fuel chain CI associated from use of the Alaska North Slope (3,548 kg/m^3), Brazil Lula (3,485 kg/m^3), Iraq Rumaila (3,359 kg/m^3), and Saudia Arabia Safaniya (3,114 kg/m^3) crude oil streams. Total refinery fuel chain CI estimated in Scenario S-4 (3,489 kg/m^3) fell within the range of fuel chain CI values that were independently estimated for these oils (3,114–3,548 kg/m^3)

Table S14. Estimate Calculation Data for Scenario S-1 Pathways

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Cumulative emissions assuming no change in feed rate (pathway P1–1)

	Petroleum Fuel Chain					Total
Year	CI [a]	FRΔ [b]	FR [b]	AE [c]	CE [d]	**CE [d]**
2017	610.9	0.000%	1.6483	0.3675	0.3675	0.5710
2018	610.9	0.000%	1.6483	0.3675	0.7350	1.1377
2019	610.9	0.000%	1.6483	0.3675	1.1026	1.6967
2020	610.9	0.000%	1.6483	0.3675	1.4701	2.2484
2021	610.9	0.000%	1.6483	0.3675	1.8376	2.7929
2022	610.9	0.000%	1.6483	0.3675	2.2051	3.3306
2023	610.9	0.000%	1.6483	0.3675	2.5727	3.8618
2024	610.9	0.000%	1.6483	0.3675	2.9402	4.3867
2025	610.9	0.000%	1.6483	0.3675	3.3077	4.9055
2026	610.9	0.000%	1.6483	0.3675	3.6752	5.4185
2027	610.9	0.000%	1.6483	0.3675	4.0427	5.9258
2028	610.9	0.000%	1.6483	0.3675	4.4103	6.4278
2029	610.9	0.000%	1.6483	0.3675	4.7778	6.9246
2030	610.9	0.000%	1.6483	0.3675	5.1453	7.4165
2031	610.9	0.000%	1.6483	0.3675	5.5128	7.9025
2032	610.9	0.000%	1.6483	0.3675	5.8804	8.3822
2033	610.9	0.000%	1.6483	0.3675	6.2479	8.8559
2034	610.9	0.000%	1.6483	0.3675	6.6154	9.3239
2035	610.9	0.000%	1.6483	0.3675	6.9829	9.7866
2036	610.9	0.000%	1.6483	0.3675	7.3504	10.2442
2037	610.9	0.000%	1.6483	0.3675	7.7180	10.6969
2038	610.9	0.000%	1.6483	0.3675	8.0855	11.1451
2039	610.9	0.000%	1.6483	0.3675	8.4530	11.5890
2040	610.9	0.000%	1.6483	0.3675	8.8205	12.0288
2041	610.9	0.000%	1.6483	0.3675	9.1881	12.4648
2042	610.9	0.000%	1.6483	0.3675	9.5556	12.8971
2043	610.9	0.000%	1.6483	0.3675	9.9231	13.3259
2044	610.9	0.000%	1.6483	0.3675	10.2906	13.7514
2045	610.9	0.000%	1.6483	0.3675	10.6582	14.1739
2046	610.9	0.000%	1.6483	0.3675	11.0257	14.5934
2047	610.9	0.000%	1.6483	0.3675	11.3932	15.0101
2048	610.9	0.000%	1.6483	0.3675	11.7607	15.4242
2049	610.9	0.000%	1.6483	0.3675	12.1282	15.8358
2050	610.9	0.000%	1.6483	0.3675	12.4958	16.2451

Cumulative emission (CE) limit through 2050 (*see* Table S9)

Total CE:
10.522 Gt

Petroleum fuel chain CE:
6.773 Gt

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P1-2, P1-25)

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	**CE [d]**	FRΔ [b]	FR [b]	AE [c]	**CE [d]**
2017	0.000%	1.6483	0.3675	0.5710	0.000%	1.6483	0.3675	0.5710
2018	0.000%	1.6483	0.3675	1.1377	0.000%	1.6483	0.3675	1.1377
2019	0.000%	1.6483	0.3675	1.6967	0.000%	1.6483	0.3675	1.6967
2020	–5.031%	1.6030	0.3574	2.2383	–5.031%	1.6030	0.3574	2.2383
2021	–5.031%	1.5223	0.3394	2.7547	–5.031%	1.5223	0.3394	2.7547
2022	–5.031%	1.4458	0.3224	3.2473	–5.031%	1.4458	0.3224	3.2473
2023	–5.031%	1.3730	0.3061	3.7171	–5.031%	1.3730	0.3061	3.7171
2024	–5.031%	1.3039	0.2907	4.1652	–5.031%	1.3039	0.2907	4.1652
2025	–5.031%	1.2383	0.2761	4.5926	–5.031%	1.2383	0.2761	4.5926
2026	–5.031%	1.1760	0.2622	5.0003	–5.031%	1.1760	0.2622	5.0003
2027	–5.031%	1.1169	0.2490	5.3892	–5.031%	1.1169	0.2490	5.3892
2028	–5.031%	1.0607	0.2365	5.7601	–5.031%	1.0607	0.2365	5.7601
2029	–5.031%	1.0073	0.2246	6.1140	–5.031%	1.0073	0.2246	6.1140
2030	–5.031%	0.9566	0.2133	6.4516	–5.031%	0.9566	0.2133	6.4516
2031	–5.031%	0.9085	0.2026	6.7727	–5.031%	0.9085	0.2026	6.7727
2032	–5.031%	0.8628	0.1924	7.0773	–5.031%	0.8628	0.1924	7.0773
2033	–5.031%	0.8194	0.1827	7.3662	–5.031%	0.8194	0.1827	7.3662
2034	–5.031%	0.7782	0.1735	7.6402	–5.031%	0.7782	0.1735	7.6402
2035	–5.031%	0.7390	0.1648	7.9001	–5.031%	0.7390	0.1648	7.9001

Table S14. Estimate Calculation Data for Scenario S-1 Pathways *continued*

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P1-2, P1-25) *continued*

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	**CE** [d]	FRΔ [b]	FR [b]	AE [c]	**CE** [d]
2036	–5.031%	0.7018	0.1565	8.1466	–5.031%	0.7018	0.1565	8.1466
2037	–5.031%	0.6665	0.1486	8.3805	–5.031%	0.6665	0.1486	8.3805
2038	–5.031%	0.6330	0.1411	8.6023	–5.031%	0.6330	0.1411	8.6023
2039	–5.031%	0.6011	0.1340	8.8127	–5.031%	0.6011	0.1340	8.8127
2040	–5.031%	0.5709	0.1273	9.0123	–5.031%	0.5709	0.1273	9.0123
2041	–5.031%	0.5422	0.1209	9.2016	–5.031%	0.5422	0.1209	9.2016
2042	–5.031%	0.5149	0.1148	9.3812	–5.031%	0.5149	0.1148	9.3812
2043	–5.031%	0.4890	0.1090	9.5515	–5.031%	0.4890	0.1090	9.5515
2044	–5.031%	0.4644	0.1035	9.7131	–5.031%	0.4644	0.1035	9.7131
2045	–5.031%	0.4410	0.0983	9.8664	–5.031%	0.4410	0.0983	9.8664
2046	–5.031%	0.4188	0.0934	10.0118	–5.031%	0.4188	0.0934	10.0118
2047	–5.031%	0.3978	0.0887	10.1497	–5.031%	0.3978	0.0887	10.1497
2048	–5.031%	0.3777	0.0842	10.2805	–5.031%	0.3777	0.0842	10.2805
2049	–5.031%	0.3587	0.0800	10.4056	–5.031%	0.3587	0.0800	10.4056
2050	–5.031%	0.3407	0.0760	10.5223	–5.031%	0.3407	0.0760	10.5223

Severity and duration of annual feed rate cuts to the 2050 cumulative limit by starting date and pathway

Fuel chain (≥ 10% through 2050) [e]				Fuel chain (≥ 20% through 2050) [e]			
Start date	Path	FRΔ (%) [b]	FRΔ mos [f]	Start date	Path	FRΔ (%) [b]	FRΔ mos [f]
Jan 2020	P1-2	–5.031	372	Jan 2020	P1-25	–5.031	372
Jan 2021	P1-3	–5.486	360	Jan 2021	P1-26	–5.494	341
Jan 2022	P1-4	–6.008	348	Jan 2022	P1-27	–6.051	309
Jan 2023	P1-5	–6.613	336	Jan 2023	P1-28	–6.731	277
Jan 2024	P1-6	–7.321	324	Jan 2024	P1-29	–7.591	244
Jan 2025	P1-7	–8.157	312	Jan 2025	P1-31	–8.693	212
Jan 2026	P1-8	–9.167	287	Jan 2026	P1-33	–10.167	180
Jan 2027	P1-10	–10.454	250	Jan 2027	P1-35	–12.277	147
Jan 2028	P1-12	–12.160	213	Jan 2028	P1-37	–15.430	115
Jan 2029	P1-14	–14.529	176	Jan 2029	P1-39	–20.741	83
Jan 2030	P1-16	–18.083	138	Jan 2030	P1-41	–31.947	50
Jan 2031	P1-18	–23.862	101	Jan 2031	P1-43	–63.865	19
Jan 2032	P1-20	–34.975	64	Mar 2031	P1-45	–77.332	13
Jan 2033	P1-22	–63.967	27	Mar 2031	P1-45	–79.845	12
Jun 2033	P1-24	–90.000	12				

[a] CI: scenario carbon intensity in kg/barrel oil feed. There is no change from baseline CI (Table S11) in this scenario (Scenario S-1).

[b] FRΔ: pathway feed rate change in percent/yr; and FR: annual feed rate in MM b/d (mean accounting for any FR change in 12 equal increments/year) are shown. *See* also notes c, d. Baseline FR from Table S1.

[c] AE: annual emissions in Gt/yr. AE shown was calculated as annual mass from the sum of CI • FR over 12 equal increments/year; year-end emission rates are not shown (*see* also notes a, b, d, Table S9 note c).

[d] CE: cumulative emissions in Gt. Fuel chain and total (including all other non-petroleum emissions) CE were calculated as the sum of emissions from 2017 (*see* also notes a–c, Table S9 note c). All other (non-petroleum) emissions were taken from Table S9. These estimates therefore assume that all other (non-petroleum) emissions will make steady progress to the State's 2030 and 2050 climate targets.

[e] A minimum of 10–20% of baseline refining capacity was assumed to remain in service through 2050 despite proven alternatives to petroleum ground transportation, based on uncertainty regarding the extent to which petroleum jet fuel (15.5% of baseline refinery production; *see* Table S1 data) could be replaced.

[f] The notation "FRΔ mos" in the table refers to the number of months that the feed rate reductions assumed in the pathway must be sustained to meet the cumulative emission limit while allowing the percentage of baseline refining capacity assumed in the pathway to remain in service.

Table S15. Estimate Calculation Data for Scenario S-2 Pathways

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Cumulative emissions assuming no change in feed rate (pathway P2–1)

	Petroleum Fuel Chain					Total
Year	CI [a]	FRΔ [b]	FR [b]	AE [c]	CE [d]	**CE [d]**
2017	610.9	0.000%	1.6483	0.3675	0.3675	0.5710
2018	610.9	0.000%	1.6483	0.3675	0.7350	1.1377
2019	610.9	0.000%	1.6483	0.3675	1.1026	1.6967
2020	615.4	0.000%	1.6483	0.3702	1.4728	2.2511
2021	623.7	0.000%	1.6483	0.3752	1.8480	2.8033
2022	632.0	0.000%	1.6483	0.3802	2.2286	3.3538
2023	640.3	0.000%	1.6483	0.3852	2.6135	3.9026
2024	648.6	0.000%	1.6483	0.3902	3.0037	4.4502
2025	656.9	0.000%	1.6483	0.3952	3.3989	4.9967
2026	665.2	0.000%	1.6483	0.4002	3.7992	5.5424
2027	673.5	0.000%	1.6483	0.4052	4.2044	6.0875
2028	681.9	0.000%	1.6483	0.4102	4.6146	6.6322
2029	690.2	0.000%	1.6483	0.4152	5.0298	7.1767
2030	698.5	0.000%	1.6483	0.4202	5.4500	7.7212
2031	706.8	0.000%	1.6483	0.4252	5.8753	8.2649
2032	710.6	0.000%	1.6483	0.4275	6.3028	8.8046
2033	710.6	0.000%	1.6483	0.4275	6.7303	9.3383
2034	710.6	0.000%	1.6483	0.4275	7.1578	9.8663
2035	710.6	0.000%	1.6483	0.4275	7.5853	10.3890
2036	710.6	0.000%	1.6483	0.4275	8.0128	10.9065
2037	710.6	0.000%	1.6483	0.4275	8.4403	11.4193
2038	710.6	0.000%	1.6483	0.4275	8.8678	11.9274
2039	710.6	0.000%	1.6483	0.4275	9.2953	12.4313
2040	710.6	0.000%	1.6483	0.4275	9.7229	12.9311
2041	710.6	0.000%	1.6483	0.4275	10.1504	13.4271
2042	710.6	0.000%	1.6483	0.4275	10.5779	13.9193
2043	710.6	0.000%	1.6483	0.4275	11.0054	14.4082
2044	710.6	0.000%	1.6483	0.4275	11.4329	14.8937
2045	710.6	0.000%	1.6483	0.4275	11.8604	15.3761
2046	710.6	0.000%	1.6483	0.4275	12.2879	15.8556
2047	710.6	0.000%	1.6483	0.4275	12.7154	16.3323
2048	710.6	0.000%	1.6483	0.4275	13.1429	16.8064
2049	710.6	0.000%	1.6483	0.4275	13.5704	17.2780
2050	710.6	0.000%	1.6483	0.4275	13.9980	17.7473

Cumulative emission (CE) limit through 2050 (*see* Table S9)

Total CE:
10.522 Gt

Petroleum fuel chain CE:
6.773 Gt

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P2–2, P2–23)

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	**CE [d]**	FRΔ [b]	FR [b]	AE [c]	**CE [d]**
2017	0.000%	1.6483	0.3675	0.5710	0.000%	1.6483	0.3675	0.5710
2018	0.000%	1.6483	0.3675	1.1377	0.000%	1.6483	0.3675	1.1377
2019	0.000%	1.6483	0.3675	1.6967	0.000%	1.6483	0.3675	1.6967
2020	–5.891%	1.5952	0.3583	2.2391	–5.977%	1.5944	0.3581	2.2389
2021	–5.891%	1.5012	0.3417	2.7579	–5.977%	1.4991	0.3412	2.7572
2022	–5.891%	1.4128	0.3259	3.2540	–5.977%	1.4095	0.3251	3.2525
2023	–5.891%	1.3296	0.3107	3.7283	–5.977%	1.3252	0.3097	3.7259
2024	–5.891%	1.2512	0.2962	4.1819	–5.977%	1.2460	0.2950	4.1782
2025	–5.891%	1.1775	0.2823	4.6155	–5.977%	1.1715	0.2809	4.6104
2026	–5.891%	1.1082	0.2691	5.0301	–5.977%	1.1015	0.2674	5.0233
2027	–5.891%	1.0429	0.2564	5.4263	–5.977%	1.0357	0.2546	5.4178
2028	–5.891%	0.9815	0.2442	5.8050	–5.977%	0.9738	0.2423	5.7946
2029	–5.891%	0.9236	0.2327	6.1669	–5.977%	0.9156	0.2306	6.1545
2030	–5.891%	0.8692	0.2216	6.5128	–5.977%	0.8608	0.2194	6.4982
2031	–5.891%	0.8180	0.2110	6.8424	–5.977%	0.8094	0.2088	6.8255
2032	–5.891%	0.7698	0.1997	7.1542	–5.977%	0.7610	0.1974	7.1351
2033	–5.891%	0.7245	0.1879	7.4483	–5.977%	0.7155	0.1856	7.4268
2034	–5.891%	0.6818	0.1768	7.7257	–5.977%	0.6727	0.1745	7.7018
2035	–5.891%	0.6417	0.1664	7.9872	–5.977%	0.6325	0.1641	7.9610

Table S15. Estimate Calculation Data for Scenario S-2 Pathways *continued*

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P2–2, P2–23) *continued*

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	CE [d]	FRΔ [b]	FR [b]	AE [c]	CE [d]
2036	–5.891%	0.6039	0.1566	8.2339	–5.977%	0.5947	0.1542	8.2053
2037	–5.891%	0.5683	0.1474	8.4665	–5.977%	0.5592	0.1450	8.4356
2038	–5.891%	0.5348	0.1387	8.6859	–5.977%	0.5257	0.1364	8.6526
2039	–5.891%	0.5033	0.1305	8.8928	–5.977%	0.4943	0.1282	8.8572
2040	–5.891%	0.4737	0.1228	9.0880	–5.977%	0.4648	0.1205	9.0500
2041	–5.891%	0.4458	0.1156	9.2720	–5.977%	0.4370	0.1133	9.2318
2042	–5.891%	0.4195	0.1088	9.4456	–5.977%	0.4109	0.1066	9.4031
2043	–5.891%	0.3948	0.1024	9.6093	–5.977%	0.3863	0.1002	9.5646
2044	–5.891%	0.3715	0.0964	9.7637	–5.977%	0.3632	0.0942	9.7169
2045	–5.891%	0.3496	0.0907	9.9093	–5.977%	0.3415	0.0886	9.8604
2046	–5.891%	0.3290	0.0853	10.0466	–0.512%	0.3302	0.0856	9.9980
2047	–5.891%	0.3097	0.0803	10.1762	0.000%	0.3302	0.0856	10.1329
2048	–5.891%	0.2914	0.0756	10.2983	0.000%	0.3302	0.0856	10.2651
2049	–5.891%	0.2743	0.0711	10.4136	0.000%	0.3302	0.0856	10.3949
2050	–5.891%	0.2581	0.0669	10.5223	0.000%	0.3302	0.0856	10.5223

Severity and duration of annual feed rate cuts to the 2050 cumulative limit by starting date and pathway

Fuel chain (≥ 10% through 2050) [e]				Fuel chain (≥ 20% through 2050) [e]			
Start date	Path	FRΔ (%) [b]	FRΔ mos [f]	Start date	Path	FRΔ (%) [b]	FRΔ mos [f]
Jan 2020	P2-2	–5.891	372	Jan 2020	P2-23	–5.977	313
Jan 2021	P2-3	–6.435	360	Jan 2021	P2-24	–6.617	282
Jan 2022	P2-4	–7.066	348	Jan 2022	P2-25	–7.419	250
Jan 2023	P2-5	–7.806	336	Jan 2023	P2-26	–8.434	219
Jan 2024	P2-6	–8.698	303	Jan 2024	P2-28	–9.791	187
Jan 2025	P2-8	–9.822	267	Jan 2025	P2-30	–11.640	156
Jan 2026	P2-10	–11.290	230	Jan 2026	P2-32	–14.047	124
Jan 2027	P2-12	–13.264	194	Jan 2027	P2-34	–18.901	92
Jan 2028	P2-14	–16.106	157	Jan 2028	P2-36	–27.465	60
Jan 2029	P2-16	–20.509	120	Jan 2029	P2-38	–49.749	28
Jan 2030	P2-18	–28.222	83	Jul 2029	P2-39	–80.000	12
Jan 2031	P2-20	–45.014	46				
Jul 2031	P2-21	–62.662	28				
Dec 2031	P2-22	–90.000	12				

[a] CI: scenario carbon intensity in kg/barrel oil feed. Annual means accounting for changes from baseline CI (Table S11) in twelve equal increments/year are shown. *See* also notes b–d.

[b] FRΔ: pathway feed rate change in percent/yr; and FR: annual feed rate in MM b/d (mean accounting for any FR change in 12 equal increments/year) are shown. *See* also notes c, d. Baseline FR from Table S1.

[c] AE: annual emissions in Gt/yr. AE shown was calculated as annual mass from the sum of CI • FR over 12 equal increments/year; year-end emission rates are not shown (*see* also notes a, b, d, Table S9 note c).

[d] CE: cumulative emissions in Gt. Fuel chain and total (including all other non-petroleum emissions) CE were calculated as the sum of emissions from 2017 (*see* also notes a–c, Table S9 note c). All other (non-petroleum) emissions were taken from Table S9. These estimates therefore assume that all other (non-petroleum) emissions will make steady progress to the State's 2030 and 2050 climate targets.

[e] A minimum of 10–20% of baseline refining capacity was assumed to remain in service through 2050 despite proven alternatives to petroleum ground transportation, based on uncertainty regarding the extent to which petroleum jet fuel (15.5% of baseline refinery production; *see* Table S1 data) could be replaced.

[f] The notation "FRΔ mos" in the table refers to the number of months that the feed rate reductions assumed in the pathway must be sustained to meet the cumulative emission limit while allowing the percentage of baseline refining capacity assumed in the pathway to remain in service.

Table S16. Estimate Calculation Data for Scenario S-3 Pathways

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Cumulative emissions assuming no change in feed rate (pathway P3-1)

	Petroleum Fuel Chain					Total
Year	CI [a]	FRΔ [b]	FR [b]	AE [c]	CE [d]	**CE [d]**
2017	610.9	0.000%	1.6483	0.3675	0.3675	0.5710
2018	610.9	0.000%	1.6483	0.3675	0.7350	1.1377
2019	610.9	0.000%	1.6483	0.3675	1.1026	1.6967
2020	618.8	0.000%	1.6483	0.3723	1.4748	2.2531
2021	633.3	0.000%	1.6483	0.3810	1.8558	2.8111
2022	647.8	0.000%	1.6483	0.3897	2.2455	3.3711
2023	662.3	0.000%	1.6483	0.3985	2.6440	3.9332
2024	676.9	0.000%	1.6483	0.4072	3.0512	4.4977
2025	691.4	0.000%	1.6483	0.4159	3.4672	5.0650
2026	705.9	0.000%	1.6483	0.4247	3.8919	5.6351
2027	720.4	0.000%	1.6483	0.4334	4.3253	6.2084
2028	735.0	0.000%	1.6483	0.4422	4.7675	6.7850
2029	749.5	0.000%	1.6483	0.4509	5.2184	7.3652
2030	764.0	0.000%	1.6483	0.4596	5.6780	7.9492
2031	778.5	0.000%	1.6483	0.4684	6.1464	8.5361
2032	785.2	0.000%	1.6483	0.4724	6.6188	9.1206
2033	785.2	0.000%	1.6483	0.4724	7.0912	9.6992
2034	785.2	0.000%	1.6483	0.4724	7.5636	10.2721
2035	785.2	0.000%	1.6483	0.4724	8.0360	10.8396
2036	785.2	0.000%	1.6483	0.4724	8.5084	11.4021
2037	785.2	0.000%	1.6483	0.4724	8.9808	11.9597
2038	785.2	0.000%	1.6483	0.4724	9.4532	12.5128
2039	785.2	0.000%	1.6483	0.4724	9.9255	13.0615
2040	785.2	0.000%	1.6483	0.4724	10.3979	13.6062
2041	785.2	0.000%	1.6483	0.4724	10.8703	14.4703
2042	785.2	0.000%	1.6483	0.4724	11.3427	14.6842
2043	785.2	0.000%	1.6483	0.4724	11.8151	15.2179
2044	785.2	0.000%	1.6483	0.4724	12.2875	15.7483
2045	785.2	0.000%	1.6483	0.4724	12.7599	16.2756
2046	785.2	0.000%	1.6483	0.4724	13.2323	16.8000
2047	785.2	0.000%	1.6483	0.4724	13.7047	17.3216
2048	785.2	0.000%	1.6483	0.4724	14.1771	17.8406
2049	785.2	0.000%	1.6483	0.4724	14.6495	18.3570
2050	785.2	0.000%	1.6483	0.4724	15.1218	18.8712

Cumulative emission (CE) limit through 2050 (*see* Table S9)

Total CE:
10.522 Gt

Petroleum fuel chain CE:
6.773 Gt

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P3-2, P3-21)

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	**CE [d]**	FRΔ [b]	FR [b]	AE [c]	**CE [d]**
2017	0.000%	1.6483	0.3675	0.5710	0.000%	1.6483	0.3675	0.5710
2018	0.000%	1.6483	0.3675	1.1377	0.000%	1.6483	0.3675	1.1377
2019	0.000%	1.6483	0.3675	1.6967	0.000%	1.6483	0.3675	1.6967
2020	–6.472%	1.5899	0.3590	2.2399	–6.743%	1.5874	0.3585	2.2393
2021	–6.472%	1.4870	0.3437	2.7606	–6.743%	1.4804	0.3421	2.7585
2022	–6.472%	1.3908	0.3288	3.2596	–6.743%	1.3805	0.3264	3.2551
2023	–6.472%	1.3007	0.3144	3.7377	–6.743%	1.2874	0.3112	3.7299
2024	–6.472%	1.2166	0.3005	4.1955	–6.743%	1.2006	0.2966	4.1839
2025	–6.472%	1.1378	0.2871	4.6339	–6.743%	1.1197	0.2825	4.6177
2026	–6.472%	1.0642	0.2752	5.0535	–6.743%	1.0442	0.2690	5.0321
2027	–6.472%	0.9953	0.2617	5.4551	–6.743%	0.9737	0.2560	5.4280
2028	–6.472%	0.9309	0.2497	5.8393	–6.743%	0.9081	0.2436	5.8060
2029	–6.472%	0.8706	0.2381	6.2067	–6.743%	0.8468	0.2316	6.1670
2030	–6.472%	0.8143	0.2271	6.5580	–6.743%	0.7897	0.2202	6.5115
2031	–6.472%	0.7616	0.2164	6.8930	–6.743%	0.7365	0.2093	6.8392
2032	–6.472%	0.7123	0.2041	7.2093	–6.743%	0.6868	0.1968	7.1483
2033	–6.472%	0.6662	0.1909	7.5064	–6.743%	0.6405	0.1836	7.4380
2034	–6.472%	0.6231	0.1786	7.7855	–6.743%	0.5973	0.1712	7.7097
2035	–6.472%	0.5828	0.1670	8.0476	–6.743%	0.5570	0.1596	7.9645

Table S16. Estimate Calculation Data for Scenario S-3 Pathways *continued*

Annual **(AE)** and cumulative **(CE)** emissions in Gt.   **CI:** carbon intensity (kg/b)   **FR:** feed rate (MM b/d)

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P3-2, P3-21) *continued*

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	CE [d]	FRΔ [b]	FR [b]	AE [c]	CE [d]
2036	–6.472%	0.5450	0.1562	8.2939	–6.743%	0.5195	0.1489	8.2034
2037	–6.472%	0.5098	0.1461	8.5252	–6.743%	0.4844	0.1388	8.4275
2038	–6.472%	0.4768	0.1366	8.7426	–6.743%	0.4518	0.1295	8.6377
2039	–6.472%	0.4459	0.1278	8.9467	–6.743%	0.4213	0.1207	8.8348
2040	–6.472%	0.4171	0.1195	9.1385	–6.743%	0.3929	0.1126	9.0197
2041	–6.472%	0.3901	0.1118	9.3188	–6.743%	0.3664	0.1050	9.1931
2042	–6.472%	0.3648	0.1046	9.4881	–6.743%	0.3417	0.0979	9.3558
2043	–6.472%	0.3412	0.0978	9.6472	0.000%	0.3309	0.0948	9.5119
2044	–6.472%	0.3191	0.0915	9.7967	0.000%	0.3309	0.0948	9.6648
2045	–6.472%	0.2985	0.0855	9.9371	0.000%	0.3309	0.0948	9.8145
2046	–6.472%	0.2792	0.0800	10.0691	0.000%	0.3309	0.0948	9.9613
2047	–6.472%	0.2611	0.0748	10.1932	0.000%	0.3309	0.0948	10.1054
2048	–6.472%	0.2442	0.0700	10.3098	0.000%	0.3309	0.0948	10.2468
2049	–6.472%	0.2284	0.0655	10.4193	0.000%	0.3309	0.0948	10.3857
2050	–6.472%	0.2136	0.0612	10.5223	0.000%	0.3309	0.0948	10.5223

Severity and duration of annual feed rate cuts to the 2050 cumulative limit by starting date and pathway

Fuel chain (≥ 10% through 2050) [e]				Fuel chain (≥ 20% through 2050) [e]			
Start date	Path	FRΔ (%) [b]	FRΔ mos [f]	Start date	Path	FRΔ (%) [b]	FRΔ mos [f]
Jan 2020	P3-2	–6.472	372	Jan 2020	P3-21	–6.743	276
Jan 2021	P3-3	–7.080	360	Jan 2021	P3-22	–7.545	246
Jan 2022	P3-4	–7.791	340	Jan 2022	P3-23	–8.579	215
Jan 2023	P3-5	–8.656	306	Jan 2023	P3-24	–9.947	184
Jan 2024	P3-6	–9.750	269	Jan 2024	P3-25	–11.840	153
Jan 2025	P3-8	–11.163	233	Jan 2025	P3-27	–14.625	122
Jan 2026	P3-10	–13.065	197	Jan 2026	P3-29	–19.120	91
Jan 2027	P3-12	–15.754	161	Jan 2027	P3-31	–27.882	59
Jan 2028	P3-14	–19.908	124	Jan 2028	P3-33	–51.029	27
Jan 2029	P3-16	–26.907	88	Jun 2028	P3-34	–74.806	14
Jan 2030	P3-18	–41.725	51	Jun 2028	P3-34	–77.232	13
Jan 2031	P3-20	–85.991	14	Jun 2028	P3-34	–79.770	12
Jan 2031	P3-20	–87.516	12				
Jan 2031	P3-20	–89.677	11				

[a] CI: scenario carbon intensity in kg/barrel oil feed. Annual means accounting for changes from baseline CI (Table S11) in twelve equal increments/year are shown. *See* also notes b–d.

[b] FRΔ: pathway feed rate change in percent/yr; and FR: annual feed rate in MM b/d (mean accounting for any FR change in 12 equal increments/year) are shown. *See* also notes c, d. Baseline FR from Table S1.

[c] AE: annual emissions in Gt/yr. AE shown was calculated as annual mass from the sum of CI • FR over 12 equal increments/year; year-end emission rates are not shown (*see* also notes a, b, d, Table S9 note c).

[d] CE: cumulative emissions in Gt. Fuel chain and total (including all other non-petroleum emissions) CE were calculated as the sum of emissions from 2017 (*see* also notes a–c, Table S9 note c). All other (non-petroleum) emissions were taken from Table S9. These estimates therefore assume that all other (non-petroleum) emissions will make steady progress to the State's 2030 and 2050 climate targets.

[e] A minimum of 10–20% of baseline refining capacity was assumed to remain in service through 2050 despite proven alternatives to petroleum ground transportation, based on uncertainty regarding the extent to which petroleum jet fuel (15.5% of baseline refinery production; *see* Table S1 data) could be replaced.

[f] The notation "FRΔ mos" in the table refers to the number of months that the feed rate reductions assumed in the pathway must be sustained to meet the cumulative emission limit while allowing the percentage of baseline refining capacity assumed in the pathway to remain in service.

Table S17. Estimate Calculation Data for Scenario S-4 Pathways

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Cumulative emissions assuming no change in feed rate (pathway P4-1)

	Petroleum Fuel Chain					Total
Year	CI [a]	FRΔ [b]	FR [b]	AE [c]	CE [d]	**CE [d]**
2017	610.9	0.000%	1.6483	0.3675	0.3675	0.5710
2018	610.9	0.000%	1.6483	0.3675	0.7350	1.1377
2019	610.9	0.000%	1.6483	0.3675	1.1026	1.6967
2020	606.6	0.000%	1.6483	0.3649	1.4675	2.2458
2021	598.7	0.000%	1.6483	0.3602	1.8277	2.7830
2022	590.7	0.000%	1.6483	0.3554	2.1831	3.3086
2023	582.8	0.000%	1.6483	0.3506	2.5337	3.8229
2024	574.9	0.000%	1.6483	0.3459	2.8796	4.3261
2025	567.0	0.000%	1.6483	0.3411	3.2207	4.8185
2026	559.0	0.000%	1.6483	0.3363	3.5570	5.3002
2027	555.4	0.000%	1.6483	0.3341	3.8911	5.7742
2028	555.4	0.000%	1.6483	0.3341	4.2253	6.2428
2029	555.4	0.000%	1.6483	0.3341	4.5594	6.7063
2030	555.4	0.000%	1.6483	0.3341	4.8935	7.1647
2031	555.4	0.000%	1.6483	0.3341	5.2277	7.6173
2032	555.4	0.000%	1.6483	0.3341	5.5618	8.0637
2033	555.4	0.000%	1.6483	0.3341	5.8960	8.5040
2034	555.4	0.000%	1.6483	0.3341	6.2301	8.9386
2035	555.4	0.000%	1.6483	0.3341	6.5642	9.3679
2036	555.4	0.000%	1.6483	0.3341	6.8984	9.7921
2037	555.4	0.000%	1.6483	0.3341	7.2325	10.2115
2038	555.4	0.000%	1.6483	0.3341	7.5667	10.6263
2039	555.4	0.000%	1.6483	0.3341	7.9008	11.0368
2040	555.4	0.000%	1.6483	0.3341	8.2349	11.4432
2041	555.4	0.000%	1.6483	0.3341	8.5691	11.8458
2042	555.4	0.000%	1.6483	0.3341	8.9032	12.2447
2043	555.4	0.000%	1.6483	0.3341	9.2373	12.6401
2044	555.4	0.000%	1.6483	0.3341	9.5715	13.0323
2045	555.4	0.000%	1.6483	0.3341	9.9056	13.4214
2046	555.4	0.000%	1.6483	0.3341	10.2398	13.8075
2047	555.4	0.000%	1.6483	0.3341	10.5739	14.1908
2048	555.4	0.000%	1.6483	0.3341	10.9080	14.5716
2049	555.4	0.000%	1.6483	0.3341	11.2422	14.9498
2050	555.4	0.000%	1.6483	0.3341	11.5763	15.3257

Cumulative emission (CE) limit through 2050 (*see* Table S9)

Total CE:
10.522 Gt

Petroleum fuel chain CE:
6.773 Gt

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P4-2, P4-26)

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	**CE [d]**	FRΔ [b]	FR [b]	AE [c]	**CE [d]**
2017	–0.000%	1.6483	0.3675	0.5710	–0.000%	1.6483	0.3675	0.5710
2018	–0.000%	1.6483	0.3675	1.1377	–0.000%	1.6483	0.3675	1.1377
2019	–0.000%	1.6483	0.3675	1.6967	–0.000%	1.6483	0.3675	1.6967
2020	–4.412%	1.6086	0.3562	2.2370	–4.412%	1.6086	0.3562	2.2370
2021	–4.412%	1.5376	0.3360	2.7500	–4.412%	1.5376	0.3360	2.7500
2022	–4.412%	1.4698	0.3169	3.2372	–4.412%	1.4698	0.3169	3.2372
2023	–4.412%	1.4049	0.2989	3.6997	–4.412%	1.4049	0.2989	3.6997
2024	–4.412%	1.3430	0.2818	4.1389	–4.412%	1.3430	0.2818	4.1389
2025	–4.412%	1.2837	0.2657	4.5558	–4.412%	1.2837	0.2657	4.5558
2026	–4.412%	1.2271	0.2504	4.9517	–4.412%	1.2271	0.2504	4.9517
2027	–4.412%	1.1729	0.2378	5.3293	–4.412%	1.1729	0.2378	5.3293
2028	–4.412%	1.1212	0.2273	5.6911	–4.412%	1.1212	0.2273	5.6911
2029	–4.412%	1.0717	0.2173	6.0376	–4.412%	1.0717	0.2173	6.0376
2030	–4.412%	1.0244	0.2077	6.3696	–4.412%	1.0244	0.2077	6.3696
2031	–4.412%	0.9792	0.1985	6.6866	–4.412%	0.9792	0.1985	6.6866
2032	–4.412%	0.9360	0.1897	6.9885	–4.412%	0.9360	0.1897	6.9885
2033	–4.412%	0.8947	0.1814	7.2761	–4.412%	0.8947	0.1814	7.2761
2034	–4.412%	0.8552	0.1734	7.5500	–4.412%	0.8552	0.1734	7.5500
2035	–4.412%	0.8175	0.1657	7.8108	–4.412%	0.8175	0.1657	7.8108

Table S17. Estimate Calculation Data for Scenario S-4 Pathways *continued*

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Sustained feed rate cuts from 2020 to the 2050 cumulative limit (paths P4-2, P4-26) ***continued***

	Fuel chain (≥ 10% through 2050) [e]			Total	Fuel chain (≥ 20% through 2050) [e]			Total
Year	FRΔ [b]	FR [b]	AE [c]	CE [d]	FRΔ [b]	FR [b]	AE [c]	CE [d]
2036	–4.412%	0.7814	0.1584	8.0593	–4.412%	0.7814	0.1584	8.0593
2037	–4.412%	0.7470	0.1514	8.2960	–4.412%	0.7470	0.1514	8.2960
2038	–4.412%	0.7140	0.1447	8.5214	–4.412%	0.7140	0.1447	8.5214
2039	–4.412%	0.6825	0.1384	8.7361	–4.412%	0.6825	0.1384	8.7361
2040	–4.412%	0.6524	0.1322	8.9406	–4.412%	0.6524	0.1322	8.9406
2041	–4.412%	0.6236	0.1264	9.1355	–4.412%	0.6236	0.1264	9.1355
2042	–4.412%	0.5961	0.1208	9.3211	–4.412%	0.5961	0.1208	9.3211
2043	–4.412%	0.5698	0.1155	9.4979	–4.412%	0.5698	0.1155	9.4979
2044	–4.412%	0.5446	0.1104	9.6663	–4.412%	0.5446	0.1104	9.6663
2045	–4.412%	0.5206	0.1055	9.8268	–4.412%	0.5206	0.1055	9.8268
2046	–4.412%	0.4977	0.1009	9.9797	–4.412%	0.4977	0.1009	9.9797
2047	–4.412%	0.4757	0.0964	10.1253	–4.412%	0.4757	0.0964	10.1253
2048	–4.412%	0.4547	0.0922	10.2641	–4.412%	0.4547	0.0922	10.2641
2049	–4.412%	0.4346	0.0881	10.3963	–4.412%	0.4346	0.0881	10.3963
2050	–4.412%	0.4155	0.0842	10.5223	–4.412%	0.4155	0.0842	10.5223

Severity and duration of annual feed rate cuts to the 2050 cumulative limit by starting date and pathway

Fuel chain (≥ 10% through 2050) [e]				Fuel chain (≥ 20% through 2050) [e]			
Start date	Path	FRΔ (%) [b]	FRΔ mos [f]	Start date	Path	FRΔ (%) [b]	FRΔ mos [f]
Jan 2020	P4-2	–4.412	372	Jan 2020	P4-26	–4.412	372
Jan 2021	P4-3	–4.801	360	Jan 2021	P4-27	–4.801	360
Jan 2022	P4-4	–5.244	348	Jan 2022	P4-28	–5.244	348
Jan 2023	P4-5	–5.752	336	Jan 2023	P4-29	–5.755	325
Jan 2024	P4-6	–6.340	324	Jan 2024	P4-30	–6.373	293
Jan 2025	P4-7	–7.026	312	Jan 2025	P4-31	–7.139	260
Jan 2026	P4-8	–7.836	300	Jan 2026	P4-32	–8.108	228
Jan 2027	P4-9	–8.805	288	Jan 2027	P4-34	–9.377	196
Jan 2028	P4-11	–9.993	262	Jan 2028	P4-36	–11.140	163
Jan 2029	P4-13	–11.542	225	Jan 2029	P4-38	–13.680	131
Jan 2030	P4-15	–13.657	188	Jan 2030	P4-40	–17.706	99
Jan 2031	P4-17	–16.717	151	Jan 2031	P4-42	–25.287	66
Jan 2032	P4-19	–21.604	113	Jan 2032	P4-44	–43.252	34
Jan 2033	P4-21	–30.371	76	Jul 2032	P4-45	–65.728	18
Jan 2034	P4-23	–50.623	39	Sep 2032	P4-47	–77.352	13
Jan 2035	P4-25	–87.652	13	Oct 2032	P4-48	–79.948	10

[a] CI: scenario carbon intensity in kg/barrel oil feed. Annual means accounting for changes from baseline CI (Table S11) in twelve equal increments/year are shown. *See* also notes b–d.

[b] FRΔ: pathway feed rate change in percent/yr; and FR: annual feed rate in MM b/d (mean accounting for any FR change in 12 equal increments/year) are shown. *See* also notes c, d. Baseline FR from Table S1.

[c] AE: annual emissions in Gt/yr. AE shown was calculated as annual mass from the sum of CI • FR over 12 equal increments/year; year-end emission rates are not shown (*see* also notes a, b, d, Table S9 note c).

[d] CE: cumulative emissions in Gt. Fuel chain and total (including all other non-petroleum emissions) CE were calculated as the sum of emissions from 2017 (*see* also notes a–c, Table S9 note c). All other (non-petroleum) emissions were taken from Table S9. These estimates therefore assume that all other (non-petroleum) emissions will make steady progress to the State's 2030 and 2050 climate targets.

[e] A minimum of 10–20% of baseline refining capacity was assumed to remain in service through 2050 despite proven alternatives to petroleum ground transportation, based on uncertainty regarding the extent to which petroleum jet fuel (15.5% of baseline refinery production; *see* Table S1 data) could be replaced.

[f] The notation "FRΔ mos" in the table refers to the number of months that the feed rate reductions assumed in the pathway must be sustained to meet the cumulative emission limit while allowing the percentage of baseline refining capacity assumed in the pathway to remain in service.

Table S18. Estimate Calculation for Feed Rate Sensitivity Analysis Scenario S-5

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Cumulative emissions assuming no change in feed rate

	Petroleum Fuel Chain					Total
Year	CI [a]	FRΔ [b]	FR [b]	AE [c]	CE [d]	**CE [d]**
2017	610.9	0.000%	1.6483	0.3675	0.3675	0.5710
2018	610.9	0.000%	1.6483	0.3675	0.7350	1.1377
2019	610.9	0.000%	1.6483	0.3675	1.1026	1.6967
2020	599.3	0.000%	1.6483	0.3606	1.4631	2.2414
2021	578.0	0.000%	1.6483	0.3477	1.8109	2.7662
2022	556.7	0.000%	1.6483	0.3349	2.1458	3.2713
2023	535.4	0.000%	1.6483	0.3221	2.4679	3.7571
2024	514.1	0.000%	1.6483	0.3093	2.7772	4.2237
2025	492.8	0.000%	1.6483	0.2965	3.0737	4.6715
2026	471.5	0.000%	1.6483	0.2836	3.3573	5.1006
2027	461.7	0.000%	1.6483	0.2778	3.6351	5.5182
2028	461.7	0.000%	1.6483	0.2778	3.9129	5.9304
2029	461.7	0.000%	1.6483	0.2778	4.1906	6.3375
2030	461.7	0.000%	1.6483	0.2778	4.4684	6.7396
2031	461.7	0.000%	1.6483	0.2778	4.7462	7.1358
2032	461.7	0.000%	1.6483	0.2778	5.0239	7.5258
2033	461.7	0.000%	1.6483	0.2778	5.3017	7.9097
2034	461.7	0.000%	1.6483	0.2778	5.5795	8.2880
2035	461.7	0.000%	1.6483	0.2778	5.8572	8.6609
2036	461.7	0.000%	1.6483	0.2778	6.1350	9.0287
2037	461.7	0.000%	1.6483	0.2778	6.4128	9.3917
2038	461.7	0.000%	1.6483	0.2778	6.6905	9.7502
2039	461.7	0.000%	1.6483	0.2778	6.9683	10.1043
2040	461.7	0.000%	1.6483	0.2778	7.2461	10.4544
2041	461.7	0.000%	1.6483	0.2778	7.5238	10.8005
2042	461.7	0.000%	1.6483	0.2778	7.8016	11.1431
2043	461.7	0.000%	1.6483	0.2778	8.0794	11.4822
2044	461.7	0.000%	1.6483	0.2778	8.3571	11.8179
2045	461.7	0.000%	1.6483	0.2778	8.6349	12.1506
2046	461.7	0.000%	1.6483	0.2778	8.9127	12.4804
2047	461.7	0.000%	1.6483	0.2778	9.1905	12.8074
2048	461.7	0.000%	1.6483	0.2778	9.4682	13.1317
2049	461.7	0.000%	1.6483	0.2778	9.7460	13.4536
2050	461.7	0.000%	1.6483	0.2778	10.0238	13.7731

Cumulative emission (CE) limit through 2050 (*see* Table S9)

Total CE:
10.522 Gt

Petroleum fuel chain CE:
6.773 Gt

Scenario S-5 emissions were estimated only for the pathway with no change in feed rate. This was done to support a complete sensitivity analysis for the finding that feed rate cuts are essential to meet the cumulative limit by investigating an implausibly low-CI scenario. The Scenario S-5 assumption, 100% effective CCS that eliminates extraction and refining emissions by 2025, is not known to be feasible.

[a] CI: scenario carbon intensity in kg/barrel oil feed. Annual means accounting for changes from baseline CI (Table S11) in twelve equal increments/year are shown. *See* also notes b–d.

[b] FRΔ: pathway feed rate change in percent/yr; and FR: annual feed rate in MM b/d (mean accounting for any FR change in 12 equal increments/year) are shown. *See* also notes c, d. Baseline FR from Table S1.

[c] AE: annual emissions in Gt/yr. AE shown was calculated as annual mass from the sum of CI • FR over 12 equal increments/year; year-end emission rates are not shown (*see* also notes a, b, d, Table S9 note c).

[d] CE: cumulative emissions in Gt. Fuel chain and total (including all other non-petroleum emissions) CE were calculated as the sum of emissions from 2017 (*see* also notes a–c, Table S9 note c). All other (non-petroleum) emissions were taken from Table S9. These estimates therefore assume that all other (non-petroleum) emissions will make steady progress to the State's 2030 and 2050 climate targets.

Table S19. A: Fuel chain emissions associated with California oil imports and fuels exports

Total mass emitted from 2013 through 2017

Mt: Megaton, 1 million metric tons **t:** metric ton

Emissions associated with crude oil imports

	Extraction [a,d]	Refining [b]	Refined fuels [b]	Subtotal	% of Total [c]
CO_2e (Mt)	162	118	918	1,198	65 %
$PM_{2.5}$ (t) *	5,440	6,960	77,700	90,100	

Emissions associated with refinery exports

	Extraction [e]	Refining [e]	Refined fuels [d,f]	Subtotal [d,g–i]	% of Total [c]
CO_2e (Mt)	53	58	506	617	34 %
$PM_{2.5}$ (t) *	1,780	3,420	42,900	48,100	

Refinery emissions permitted free of charge under cap-and-trade [h]

Total:	179 Mt	Allocation:	81 %	145 Mt

* $PM_{2.5}$ emissions shown were estimated based on CO_2e co-emission factors derived from reported data as shown in Table S7.

[a] Emissions from extracting crude oil imported by California refiners from Table S1.

[b] Portions of refining and refined fuels emissions associated with imported crude, from Table S1 data.

[c] Percentage based on total 2013–2017 petroleum fuel chain emissions from Table S1 (1,838 Mt).

[d] CO_2e emissions that were geographically exempt from either the state's cap-and-trade program because the emissions occurred outside the state (36% of the total petroleum fuel chain emissions), or were geographically exempt from its Low Carbon Fuel Standard because the emissions were associated with making and burning fuels sold outside the state (34% of the total petroleum fuel chain emissions). Overall, 44.2 % of total petroleum fuel chain CO_2e associated with oil refined in California was exempt from or permitted free of charge by cap-and-trade, the LCFS, or both from 2013–2017.

[e] Portions of imported crude extraction and in-state refining emissions associated with making fuels exported to other states or nations based on volume percentage and emissions data in Table S1.

[f] Emissions from burning refined fuels exported to other states and nations based on data in Table S1.

[g] This 617 Mt CO_2e that emitted from 2013–2017 represents current annual emissions associated with exports of 0.1234 Gt/yr. Although additional cuts from switching to non-petroleum fuels will be needed here for climate protection, these emissions alone (0.1234 Gt/yr) exceed the total cut in annual petroleum fuel chain emissions in the first 7–9 years along pathways to the state climate limit that start in 2020. *See* tables S14–S17. This example shows that early actions to decommission in-state refining capacity along pathways to the state's climate limit need not risk disruption of currently used fuel supplies for California.

In the same example comparing climate stabilization paths that start in 2020 (tables S14–S17), the $PM_{2.5}$ co-emission and health cost factors in Table S8 (4.563 deaths/Mt CO_2e; $9 million cost/premature death) suggest this path to the climate limit could avert 21,900–38,100 premature deaths, and more than $197 billion to $343 billion in health costs, associated with $PM_{2.5}$ air pollution through 2050. Phasing out fuel chain emissions associated with extracting imported oil to refine and burn exported fuels Californians do not now use or need could account for more than one-third of the portion of these health benefits that is associated with oil sector emissions, as shown in this table.

Table S19 *continued.*

[h] Total from Table S1; allocation from ARB cap-and-trade allocation data; www.arb.gov/cc/capandtrade/allowanceallocation/publicallocation.htm

[i] The prospective assessment in note g was supplemented by a retrospective assessment to provide further context. Table S19-B shows that, had petroleum fuel chain emissions associated with refinery exports been phased out by 2017 along paths P1-2 or P1-25 (*see* Table S14, including table notes), the 2050 climate limit could have been met by decommissioning approximately 1.5% of refining capacity annually, which is less than the 1.6–2.3%/year refining capacity wear-out rate documented in Table S-20. Estimate calculation data for this additional context is shown in Table S19-B directly below.

Table S19. B. Estimate Calculation Data for Pathway P1-2 or P1-25 assuming that emissions associated with refinery exports had been phased out by 2017—*see* note i, this table.

Annual **(AE)** and cumulative **(CE)** emissions in Gt. **CI:** carbon intensity (kg/b) **FR:** feed rate (MM b/d)

Cumulative emissions assuming no change in carbon intensity and minimum feed rate reduction to meet 2050 CE limit

	Petroleum Fuel Chain					**Total**
Year	CI [a]	FRΔ [b]	FR [b]	AE [c]	CE [d]	**CE [d]**
2017	610.9	0.000%	1.0949	0.2441	0.2441	0.4476
2018	610.9	0.000%	1.0949	0.2441	0.4883	0.8909
2019	610.9	0.000%	1.0949	0.2441	0.7324	1.3266
2020	610.9	–1.498%	1.0860	0.2422	0.9746	1.7529
2021	610.9	–1.498%	1.0698	0.2385	1.2131	2.1684
2022	610.9	–1.498%	1.0537	0.2350	1.4481	2.5736
2023	610.9	–1.498%	1.0380	0.2314	1.6795	2.9687
2024	610.9	–1.498%	1.0224	0.2280	1.9075	3.3540
2025	610.9	–1.498%	1.0071	0.2246	2.1320	3.7298
2026	610.9	–1.498%	0.9920	0.2212	2.3532	4.0965
2027	610.9	–1.498%	0.9771	0.2179	2.5711	4.4542
2028	610.9	–1.498%	0.9625	0.2146	2.7857	4.8033
2029	610.9	–1.498%	0.9481	0.2114	2.9971	5.1440
2030	610.9	–1.498%	0.9339	0.2082	3.2053	5.4765
2031	610.9	–1.498%	0.9199	0.2051	3.4105	5.8001
2032	610.9	–1.498%	0.9061	0.2020	3.6125	6.1143
2033	610.9	–1.498%	0.8925	0.1990	3.8115	6.4195
2034	610.9	–1.498%	0.8791	0.1960	4.0075	6.7160
2035	610.9	–1.498%	0.8660	0.1931	4.2006	7.0043
2036	610.9	–1.498%	0.8530	0.1902	4.3908	7.2845
2037	610.9	–1.498%	0.8402	0.1873	4.5782	7.5571
2038	610.9	–1.498%	0.8276	0.1845	4.7627	7.8223
2039	610.9	–1.498%	0.8152	0.1818	4.9445	8.0805
2040	610.9	–1.498%	0.8030	0.1790	5.1235	8.3318
2041	610.9	–1.498%	0.7910	0.1764	5.2999	8.5766
2042	610.9	–1.498%	0.7791	0.1737	5.4736	8.8151
2043	610.9	–1.498%	0.7675	0.1711	5.6447	9.0475
2044	610.9	–1.498%	7.5596	1.6856	5.8133	9.2741
2045	610.9	–1.498%	0.7746	0.1660	5.9793	9.4951
2046	610.9	–1.498%	0.7335	0.1635	6.1429	9.7106
2047	610.9	–1.498%	0.7225	0.1611	6.3040	9.9209
2048	610.9	–1.498%	0.7117	0.1587	6.4627	10.1262
2049	610.9	–1.498%	0.7010	0.1563	6.6190	10.3266
2050	610.9	–1.498%	0.6905	0.1540	6.7729	10.5223

Cumulative emission (CE) limit through 2050 (*see* Table S9)

Total CE:
10.522 Gt

Petroleum fuel chain CE:
6.773 Gt

Table S20. Non-intervention[a] Decommissioning Trajectory Estimate Calculation

Statewide refinery feed rate change (%/yr) and trajectory (10^6 barrels/yr)

	Lower Bound Estimate		Upper Bound Estimate	
Period[b]	FRΔ (%)[c]	Trajectory[d]	FRΔ (%)[c]	Trajectory[d]
Baseline[e]	NA	602	NA	602
2019	– 2.34 %	587	– 1.59 %	592
2020	– 2.34 %	574	– 1.59 %	583
2021	– 2.34 %	560	– 1.59 %	573
2022	– 2.34 %	547	– 1.59 %	564
2023	– 2.34 %	534	– 1.59 %	555
2024	– 2.34 %	522	– 1.59 %	546
2025	– 2.34 %	510	– 1.59 %	538
2026	– 2.34 %	498	– 1.59 %	529
2027	– 2.34 %	486	– 1.59 %	521
2028	– 2.34 %	475	– 1.59 %	512
2029	– 2.34 %	464	– 1.59 %	504
2030	– 2.34 %	453	– 1.59 %	496
2031	– 2.34 %	442	– 1.59 %	488
2032	– 2.34 %	432	– 1.59 %	481
2033	– 2.34 %	422	– 1.59 %	473
2034	– 2.34 %	412	– 1.59 %	465
2035	– 2.34 %	402	– 1.59 %	458

a. The range of declining statewide refinery oil feed rates shown was estimated based on the data and methods documented below for non-intervention conditions only. Non-intervention in this context means continued maintenance of existing refinery equipment without rebuilding it in any way that would otherwise prolong the operable duration of its original design or change its feed rate. Interventions could result in very different trajectories. Installing new equipment with similar or greater feed rate capacity than the equipment it is added to or replaces—the current oil industry practice—would keep refineries operable longer than the trajectory shown and could increase feed rates instead of decreasing them. Such incremental replacements of refining equipment could continue to be folded into "turnarounds," the frequent temporary shutdowns for major maintenance that are required for continued operation and to meet refinery safety requirements. Conversely, incrementally decommissioning capacity during turnarounds could reduce the statewide refinery feed rate more quickly than the trajectory shown. The non-intervention trajectory estimate thus provides a measurement of existing oil infrastructure inertia.

b. The 2019–2035 estimate period was based on the critical period when sustained refinery feed rate reduction must begin to avert irreversible climate, health, and socioeconomic impacts (*see* tables S14–S18). This 17-year forecast period is within the refinery-level difference between median equipment age and operable duration from California refinery operating data (21.4–31.4 years; *see* Table S21), further supporting the reliability of prediction through 2035.

c. The feed rate change (FRΔ %) estimates shown represent initial capacity loss per year assuming the non-intervention conditions (note a), based on the median age and the operable duration of existing California refineries (*see* Table S21). Process-level data for 1,637 California refinery "process units" spanning twelve types of critical equipment were assessed to derive conservative estimates for the range of refinery-level initial capacity loss/year that account for age, duration, and relative value of the equipment mix in refinery process configurations (*see* Table S21). The refinery-level operable duration

Table S20. Non-intervention[a] Decommissioning Trajectory Estimate Calculation *continued*

estimated is a statewide average range that compares reasonably well to generalized estimates by others for refineries which were used in global climate mitigation analyses (*RS28–RS30, RS45*). These initial capacity loss/year values are based on direct observations of California equipment during a long period of refining industry expansion and do not by themselves account for certain types of infrastructure resistance to change that can occur during periods of industry-wide decommissioning (*see* note d).

d. Trajectories were calculated sequentially by applying the FRΔ (%) values to the remaining feed rate capacity in each prior year. Year-to-year absolute feed rate cuts shown in the table are thus attenuated (smaller) in the later years of the forecast period. This calculation method was used to account, at least in part, for two intrinsic effects of built infrastructure that tend to delay decommissioning: reduced wear as equipment operates at reduced feed rate; and the "last capacity standing" effect. The "last capacity standing" effect refers to a type of infrastructure resistance to change caused by increased value to its owner of the equipment that remains in service when other similar production capacity is decommissioned. (*See RS28.*)

Other "extrinsic" effects, related to returns to scale and to the greater sunk-cost and production value of California refining capacity relative to competing refinery fleets (*see* Table S22) were not quantified in this estimate, further suggesting that this estimate is conservative (is more likely than not to overestimate the extent of decommissioning in the non-intervention condition).

e. The baseline capacity (601.62 million barrels/year; 1,648,270 b/d) represents the actual average capacity of existing equipment demonstrated based on the actual average statewide refinery crude feed rate from 2013–2017 reported by the California Air Resources Board (*see* Table S1).

Table S21. California Refining Infrastructure Inertia Analysis Method Data Inputs

Process-level data inputs[a]	Median age (years)	Operable duration (years) Lower bound	Upper bound
Atm. crude distillation	39.7	64.4	70.7
Coking	21.4	62.3	67.9
Catalytic cracking	23.3	58.7	70.7
Hydrocracking	34.3	52.3	54.3
Hydrotreating	44.8	52.3	64.0
Hydrogen production	22.9	51.5	54.1
Catalytic reforming	44.7	51.9	62.9
Alkylation	39.0	53.0	58.3
Sulfur recovery	42.3	49.3	55.9
Marine ship loading	40.1	68.8	90.3
Storage tanks	49.3	69.3	84.3
Heat/steam/power*	46.0	52.0	67.0

	Weighting factor inputs		Weighting factor
	Complexity factor[b]	Equivalent capacity[c]	(WF)
Atm. crude distillation	1.00	1.000	1.000
Coking	7.50	0.231	1.733
Catalytic cracking	6.00	0.332	1.992
Hydrocracking	8.00	0.253	2.024
Hydrotreating	2.50	0.928	2.320
Hydrogen production	1.00	0.668	0.668
Catalytic reforming	5.00	0.192	0.960
Alkylation	10.0	0.093	0.930
Sulfur recovery	240	0.002	0.480
Marine ship loading	1.77	1.000	1.770
Storage tanks	1.00	1.000	1.000
Heat/steam/power*	1.00	1.000	1.000

Refinery-level results[d]	Median age (years)	Operable duration (years) Lower bound	Upper bound
Median age & total operable duration	36.4	57.7	67.8
Time to median capacity loss (years)		21.4	31.4
Initial capacity loss per year (%)		– 2.34 %/yr	– 1.59 %/yr

* Refinery furnaces, heaters, boilers and turbines

a. Process-level data inputs shown include the median age in years from commissioning or, where applicable, recommissioning after major rebuild, of equipment remaining in service; and the operable duration from commissioning/re-commissioning to decommissioning or, for equipment still operating, to 1 May 2018. Data were taken from direct observations of 1,637 process units, marine ship berths or tanks at California refining facilities (*see* Table S23), and included all California equipment of the types shown for which a commissioning date was available. The range of operable duration estimates was bounded by the minimum number of years that the longest-lasting 5–30 percent of the equipment was in service, based on the 70th Percentile (30%) and 95th Percentile (5%) of the data.

Table S21. California Refining Infrastructure Inertia Analysis Method Data Inputs *continued*

Lower bound estimates thus represent the minimum time that 30% of equipment had been in service, including some equipment that may operate long after 1 May 2018, and are therefore more likely to underestimate than overestimate operable duration. *See* notes c and d in Table S20 for additional operable duration considerations.

b. Process-specific weighting used Nelson Complexity, a capital cost-based measurement that also estimates the product slate-related value of equipment in ongoing refining operation (*RS31*). Data shown are modified Nelson Complexity indices from the California Air Resources Board (*RS32*) except the marine ship loading factor is a conservative "off-site" Nelson adjustment factor (*RS31*) and conservative heat/steam/power and tanks factors were based on professional judgment. Nelson Complexity factors are unit-less and are applied to the equivalent capacity (*see* note c below) of a particular refinery or refining system process configuration (*RS31; RS32*).

c. Process-specific equivalent capacity relative to the atmospheric crude distillation capacity of the California refining fleet. Data for 2018 capacities were taken from the *Oil & Gas Journal* Worldwide Refining Survey (*see* Table S22) except for marine loading, storage tanks, and heat/steam/power, which were assumed to match crude refining capacity (EC = 1.000) based on professional judgment. The weighting factor (WF) shown in the table for each equipment type was calculated as the product of its complexity factor and its equivalent capacity.

d. Refinery-level results account for the age and operable duration of each equipment type shown in the table (process-level median age and operable duration) and its relative capital cost and production value in ongoing refining (process-level weighting factor). The refinery-level median age (36.4 years) and total operable duration (57.7–67.8 yrs) estimates were calculated as the sum of the products of process-level median age (or operable duration) and process-level weighting factor, divided by the sum of process-level weighting factors. The refinery-level time to median (50%) capacity loss estimate was then calculated as the difference between total operable duration and median age: the upper bound was thus calculated as 67.8 years – 36.4 years = 31.4 years.[1] Initial capacity loss per year was then calculated as the median capacity loss (–50 %) divided by the time to median capacity loss in years. For example, the upper bound estimate was calculated as –50 % ÷ 31.4 years = –1.59 %/year. These estimates assume continued maintenance without new projects (the "non-intervention" conditions described in note a to Table S20), will not apply when those conditions are not met (Id.), and can be affected during decommissioning by the additional considerations described in notes c and d to Table S20. The trajectory estimate shown in Table S20 accounts in part for those additional considerations (*see* notes c and d to Table S20).

[1] The apparent discrepancy for the lower bound time to median capacity loss shown at the bottom of Table S21 (57.7 – 36.4 ≠ 21.4) is not an error; it is only an artifact of rounding the figures shown.

Table S22. Relative Capacities of California and Pacific Rim Refinery Fleets, 2018

	Capacity as of 2018[a]				Equivalent Capacity v. Atm. Distillation[a]				Nelson
	(units)	California	Other West Coast	Oth. Pacific Rim	(units)	Calif.	Other WC	Other PC	Complexity[b]
Process-level									
Atm. Distillation	b/d	1,969,160	948,125	34,465,246	b/b	1.000	1.000	1.000	1.00
Vacuum Distillation	b/d	1,140,900	372,150	7,533,884	b/b	0.579	0.393	0.219	1.30
Coking Processes	b/d	454,460	74,520	1,318,715	b/b	0.231	0.079	0.038	7.50
Thermal Processes	b/d	4,500	9,900	689,093	b/b	0.002	0.010	0.020	2.75
Catalytic Cracking	b/d	654,370	153,910	5,072,188	b/b	0.332	0.162	0.147	6.00
Naphtha Reforming	b/d	377,300	149,137	3,263,900	b/b	0.192	0.157	0.095	5.00
Hydrocracking	b/d	498,620	87,750	1,980,424	b/b	0.253	0.093	0.057	8.00
Hydrotreating	b/d	1,826,560	483,633	13,136,647	b/b	0.928	0.510	0.381	2.50
HO hydrotreating	b/d	625,950	23,850	3,547,198	b/b	0.318	0.025	0.103	NA
Alkylation	b/d	183,030	38,435	602,673	b/b	0.093	0.041	0.017	10.0
Aromatics	b/d	1,350	0	512,788	b/b	0.001	0.000	0.015	20.0
Isomerization	b/d	144,700	40,535	309,164	b/b	0.073	0.043	0.009	3.00
Hydrogen Plants	Mscfd	1,315,000	213,000	4,812,000	Mscf/b	0.668	0.225	0.140	1.00
Sulfur Recovery	t/d	4,519	794	50,087	t/b	0.002	0.001	0.001	240

Refinery-level	California	Other West Coast	Oth. Pacific Rim
Number of refineries[a]	13	12	193
Avg. crude capacity (b/d)[c]	151,474	79,010	178,576
Nelson Complexity[d]	13.17	6.86	5.38
PI [e]	1.71	0.75	0.56

b: barrel (oil); 42 U.S. gallons
b/d: barrels per day
Mscfd: thousand standard cubic feet per day
t/d: metric tons per day

Other West Coast: oil refineries in other U.S. West Coast states; Alaska, Hawaii, and Washington. (*See* note a for data.)

Other Pacific Rim: oil refineries in other West Coast states and the countries of Australia, Bolivia, Brunei, Canada, Chile, China, Colombia, Costa Rica, Ecuador, El Salvador, India, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Nicaragua, Papua New Guinea, Peru, the Phillipines, Singapore, Sri Lanka, Taiwan, Thailand, Venezuela, and Vietnam. (*See* note a for data.)

See next page for notes to this table.

Table S22. Relative Capacities of California and Pacific Rim Refinery Fleets, 2018 *continued*

a. Data from *Oil & Gas Journal* 2018 Worldwide Refining Survey (*RS8*). Equivalent capacities and primary processing (***PI***) capacities shown in the table are based on these data. *Oil & Gas Journal* Worldwide Refining plant capacities are given in barrels per calendar day (b/cd) or as estimated b/cd (generally 90% of barrels per stream day capacity) and compare to U.S. Energy Information Administration (EIA) capacity data well for U.S. refineries. EIA reports plant-level capacities only for U.S. refineries. *Oil & Gas Journal* Worldwide Refining plant counts generally include multiple sites, where refiner-owned facilities operate as parts of a single refinery in multiple California jurisdictions, as a single refinery, so the plant counts shown in the table may differ from those reported by the U.S. EIA or the state of California.

b. Modified Nelson Complexity indices from the California Air Resources Board. (*RS32.*) *See* also note b to Table S21 and note d to this table below.

c. Average refinery crude capacity by refining fleet, based on 2018 data (note a). Consistent with increasing returns to scale, refineries with crude capacities of 100,000 b/d or greater have been shown to operate longer than smaller refineries (*RS31, RS33*). Thus, the average California refinery crude capacity (151,474 b/d) further supports the finding that the estimate in Table S20 is reliable and conservative.

d. Nelson Complexity based on the data shown and the sum of (equivalent capacity • Nelson Complexity). Nelson Complexity is a capital cost-based measurement of refinery assets that also estimates the relative value of the product slate a refinery can produce (*RS31*). Since California refineries export products to other West Coast states and Pacific Rim countries, the California refining fleet's much greater Nelson Complexity relative to those of other West Coast and Pacific Rim refining fleets further supports the finding that the Table S20 estimate is reliable and conservative.

e. ***PI;*** primary processing intensity; the sum of vacuum distillation, coking, catalytic cracking, hydrocracking, and heavy oil hydrotreating (gas oil, resid, "other" feeds), relative to atmospheric crude distillation capacity. (*RS19.*) ***PI*** is directly related to capacity for converting lower quality, "heavier" oil into engine fuels. (*RS19.*) Since lower quality oil is price-discounted at the refinery gate, the much greater ***PI*** of California refineries relative to those of other West Coast and Pacific Rim refining fleets further supports the finding that the Table S20 estimate is reliable and conservative.

Finally, comparison of the non-intervention decommissioning estimate (Table S20) with decommissioning rates needed to meet the cumulative emission limit defined by state climate targets (tables S14–S17) is consistent with a recently updated estimate indicating that global fossil fuel infrastructure likely must be retired early to achieve climate stabilization (*RS45*).

Table S23. Age and Operable Duration Data for California Oil Refining Equipment
(28 pages including table reference key and notes followed by a 27–page data table.)

KEY: Status: **O** (operating); **D** (decommissioned)

Heat/steam/power: furnaces, heaters, boilers and turbines

NOTES:

a. The "ID#" is the facility-specific equipment identifier assigned to each unit by the San Francisco Bay Area, San Luis Obispo County, or South Coast (greater Los Angeles Area) air quality management district. Unit-specific data shown in the table were gathered from the specific sources identified below, which were supplemented by historic and current operating data from the U.S. Energy Information Administration (*RS34*) and operating permits issued under Title V of the U.S. Clean Air Act. <u>See</u> also note f for additional details that are relevant to some of this equipment.

b. Process unit-specific data for "emitting source" units from San Francisco Bay Area Air Quality Management District (BAAQMD) permit records.[1] Data were taken from BAAQMD records provided for review pursuant to California Public Records Act requests dated 18 September 2009, 7 June 2017, 12 January 2018, and 17 January 2018. This database accounts for the vast majority of the data shown in the table because BAAQMD reported relatively detailed and comprehensive data for commissioning (startup), modification (rebuild), and permanent shutdown (decommissioning) of refining equipment units. <u>See</u> also notes c and d. In all cases a 5/1/18 end-date was given equipment that was still in service.

c. Chevron El Segundo coker startup and rebuild (drum replacement) data from South Coast Air Quality Management District (SCAQMD) Environmental Impact Report (*RS35*). PBF (formerly ExxonMobil, Mobil) Torrance Refinery catalytic cracking unit startup data from *Oil & Gas Journal* (*RS36*). The catalytic cracker was rebuilt and restarted in May 2016 following a major incident involving most of the unit resulting in its Electrostatic Precipitator exploding in early 2015 (*RS10, RS11*). SCAQMD reported that no historic refinery permit records comparable to those provided for review by the BAAQMD were available (*RS37*).

d. Phillips 66 Nipomo (Arroyo Grande) facility coking and crude unit startup data were taken from the California Energy Commission (*RS38*). The San Luis Obispo County Air Pollution Control District (SLOCAPCD) reported no known major change to these units and no detailed information for startup dates (*RS39*). Operating status data were taken from the SLOCAPCD (*RS39*), Title V operating permit, a recent EIR (*RS40*), and the U.S. Energy Information Administration refinery capacity database (*RS34*).

e. New hydrogen plant units 4449/50 at the Chevron Richmond refinery replace existing hydrogen unit 4250 which is being decommissioned (*RS41*). This was assumed to occur in 2018 based on the schedule for commissioning the new hydrogen plant (units 4449/50) reported in April 2018 (*RS42*) and was confirmed by flaring from the new units during late 2018 that was reported by Chevron.

f. In these (few) cases two different sets of equipment appear to share the same source number due to a past decision by the air district to include it in a more broadly-defined refining complex or facility (e.g., Phillips 66 Rodeo Source 300 includes both a coking unit and a crude distillation unit).

[1] BAAQMD facility ID (site) numbers: A0010 (Chevron Richmond); B2758 and B2759 (Marathon, formerly Tesoro, Martinez); B0295 (Air Products Martinez, a hydrogen plant serving Marathon); A1820 (Martinez Cogen LLC, a utility serving Marathon); A0016 (Phillips 66 Rodeo); B7419 (Air Liquide Rodeo, a hydrogen plant serving Phillips 66); A0011 (Shell Martinez); B2626 (Valero Benicia); and A0901 (Valero Benicia Asphalt Plant).

Refining Facility	(notes)	Equipment Unit ID#[a]	Type	Age and Operational Data (dates Startup	Rebuild	End-date	Status
Air Liquide, Rodeo	b	1/2	Hydrogen plant	7/2/09	—	5/1/18	O
Air Products, Martinez	b	1030	Hydrogen plant	1/1/02	—	5/1/18	O
Air Products, Martinez	b	1031	Heat/steam/power	7/6/09	—	5/1/18	O
Chevron, El Segundo	c	Proc. 2	Coking	1/1/68	1/1/14	5/1/18	O
Chevron, Richmond	b	21	Storage tank	5/7/92	—	5/1/18	O
Chevron, Richmond	b	25	Storage tank	3/9/97	—	5/1/18	O
Chevron, Richmond	b	231	Storage tank	1/1/61	—	5/1/18	O
Chevron, Richmond	b	232	Storage tank	1/1/28	—	5/1/18	O
Chevron, Richmond	b	297	Storage tank	1/1/28	—	5/1/18	O
Chevron, Richmond	b	298	Storage tank	1/1/28	—	5/1/18	O
Chevron, Richmond	b	399	Storage tank	8/30/89	—	5/1/18	O
Chevron, Richmond	b	605	Storage tank	8/1/98	—	1/1/11	D
Chevron, Richmond	b	610	Storage tank	8/1/98	—	1/1/11	D
Chevron, Richmond	b	634	Storage tank	1/1/28	—	5/1/18	O
Chevron, Richmond	b	660	Storage tank	8/1/98	—	1/1/11	D
Chevron, Richmond	b	679	Storage tank	1/1/49	—	5/1/18	O
Chevron, Richmond	b	870	Storage tank	5/27/94	—	5/1/18	O
Chevron, Richmond	b	953	Storage tank	1/1/49	—	5/1/18	O
Chevron, Richmond	b	954	Storage tank	1/1/28	—	5/1/18	O
Chevron, Richmond	b	957	Storage tank	1/1/28	—	5/1/18	O
Chevron, Richmond	b	990	Storage tank	1/1/49	—	5/1/18	O
Chevron, Richmond	b	991	Storage tank	1/1/28	—	5/1/18	O
Chevron, Richmond	b	992	Storage tank	10/15/91	—	5/1/18	O
Chevron, Richmond	b	1287	Storage tank	1/1/47	—	5/1/18	O
Chevron, Richmond	b	1289	Storage tank	1/1/53	—	5/1/18	O
Chevron, Richmond	b	1292	Storage tank	1/1/56	—	5/1/18	O
Chevron, Richmond	b	1296	Storage tank	1/1/57	—	5/1/18	O
Chevron, Richmond	b	1431	Storage tank	1/1/42	—	5/1/18	O
Chevron, Richmond	b	1444	Storage tank	1/1/52	—	5/1/18	O
Chevron, Richmond	b	1459	Storage tank	1/1/54	—	5/1/18	O
Chevron, Richmond	b	1488	Storage tank	1/1/44	—	5/1/18	O
Chevron, Richmond	b	1489	Storage tank	1/1/44	—	5/1/18	O
Chevron, Richmond	b	1491	Storage tank	1/1/45	—	5/1/18	O
Chevron, Richmond	b	1504	Storage tank	1/1/49	—	5/1/18	O
Chevron, Richmond	b	1514	Storage tank	1/1/56	—	5/1/18	O
Chevron, Richmond	b	1518	Storage tank	1/1/58	—	5/1/18	O
Chevron, Richmond	b	1633	Storage tank	1/1/47	—	5/1/18	O
Chevron, Richmond	b	1635	Storage tank	3/11/99	—	5/1/18	O
Chevron, Richmond	b	1637	Storage tank	1/1/47	—	5/1/18	O
Chevron, Richmond	b	1645	Storage tank	1/1/47	—	5/1/18	O
Chevron, Richmond	b	1653	Storage tank	1/1/47	—	5/1/18	O
Chevron, Richmond	b	1686	Storage tank	1/1/59	—	5/1/18	O
Chevron, Richmond	b	1687	Storage tank	1/1/59	—	5/1/18	O
Chevron, Richmond	b	1688	Storage tank	1/1/59	—	5/1/18	O
Chevron, Richmond	b	1726	Storage tank	1/1/48	—	1/1/08	D
Chevron, Richmond	b	1727	Storage tank	1/1/48	—	1/1/08	D
Chevron, Richmond	b	1757	Storage tank	1/1/51	—	1/1/08	D
Chevron, Richmond	b	1758	Storage tank	1/1/51	—	1/1/08	D
Chevron, Richmond	b	1798	Storage tank	1/1/57	—	5/1/18	O
Chevron, Richmond	b	1843	Storage tank	1/1/59	—	5/1/18	O
Chevron, Richmond	b	1908	Storage tank	6/20/90	—	5/1/18	O
Chevron, Richmond	b	1909	Storage tank	5/27/94	—	5/1/18	O
Chevron, Richmond	b	1911	Storage tank	5/27/94	—	5/1/18	O
Chevron, Richmond	b	1966	Storage tank	1/1/61	—	5/1/18	O
Chevron, Richmond	b	2917	Storage tank	6/20/90	—	5/1/18	O
Chevron, Richmond	b	2918	Storage tank	6/20/90	—	5/1/18	O
Chevron, Richmond	b	2921	Storage tank	6/20/90	—	5/1/18	O
Chevron, Richmond	b	3071	Storage tank	1/1/72	—	5/1/18	O
Chevron, Richmond	b	3072	Storage tank	1/1/77	—	5/1/18	O
Chevron, Richmond	b	3073	Storage tank	1/1/80	—	5/1/18	O
Chevron, Richmond	b	3075	Storage tank	1/1/82	—	5/1/18	O
Chevron, Richmond	b	3076	Storage tank	1/1/80	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Chevron, Richmond	b	3100	Storage tank	6/7/89	—	5/1/18	O
Chevron, Richmond	b	3101	Storage tank	1/1/73	—	5/1/18	O
Chevron, Richmond	b	3102	Storage tank	1/1/74	—	5/1/18	O
Chevron, Richmond	b	3103	Storage tank	1/1/74	—	5/1/18	O
Chevron, Richmond	b	3104	Storage tank	1/1/75	—	5/1/18	O
Chevron, Richmond	b	3105	Storage tank	1/1/75	—	5/1/18	O
Chevron, Richmond	b	3106	Storage tank	1/1/76	—	5/1/18	O
Chevron, Richmond	b	3107	Storage tank	1/1/79	—	5/1/18	O
Chevron, Richmond	b	3110	Storage tank	8/1/91	—	5/1/18	O
Chevron, Richmond	b	3111	Storage tank	8/1/91	—	5/1/18	O
Chevron, Richmond	b	3126	Storage tank	1/1/74	—	5/1/18	O
Chevron, Richmond	b	3127	Storage tank	1/1/74	—	5/1/18	O
Chevron, Richmond	b	3128	Storage tank	1/1/74	—	5/1/18	O
Chevron, Richmond	b	3129	Storage tank	1/1/75	—	5/1/18	O
Chevron, Richmond	b	3133	Storage tank	1/1/75	—	5/1/18	O
Chevron, Richmond	b	3134	Storage tank	1/1/74	—	5/1/18	O
Chevron, Richmond	b	3140	Storage tank	1/1/75	—	5/1/18	O
Chevron, Richmond	b	3141	Storage tank	1/1/75	—	5/1/18	O
Chevron, Richmond	b	3144	Storage tank	1/1/76	—	5/1/18	O
Chevron, Richmond	b	3180	Storage tank	7/10/90	—	5/1/18	O
Chevron, Richmond	b	3185	Storage tank	7/1/91	—	5/1/18	O
Chevron, Richmond	b	3189	Storage tank	10/7/92	—	5/1/18	O
Chevron, Richmond	b	3190	Storage tank	1/6/93	—	5/1/18	O
Chevron, Richmond	b	3191	Storage tank	5/28/93	—	5/1/18	O
Chevron, Richmond	b	3193	Storage tank	9/11/92	—	5/1/18	O
Chevron, Richmond	b	3196	Storage tank	10/7/92	—	5/1/18	O
Chevron, Richmond	b	3197	Storage tank	9/11/92	—	5/1/18	O
Chevron, Richmond	b	3198	Storage tank	11/10/93	—	5/1/18	O
Chevron, Richmond	b	3201	Storage tank	10/10/95	—	5/1/18	O
Chevron, Richmond	b	3202	Storage tank	12/1/93	—	5/1/18	O
Chevron, Richmond	b	3213	Storage tank	2/28/96	—	5/1/18	O
Chevron, Richmond	b	3214	Storage tank	10/1/95	—	5/1/18	O
Chevron, Richmond	b	3220	Storage tank	11/1/01	—	5/1/18	O
Chevron, Richmond	b	3225	Storage tank	3/1/04	—	5/1/18	O
Chevron, Richmond	b	3229	Storage tank	—	1/1/14	5/1/18	O
Chevron, Richmond	b	3230	Storage tank	—	1/1/14	5/1/18	O
Chevron, Richmond	b	4032	Heat/steam/power	5/12/09	—	5/1/18	O
Chevron, Richmond	b	4033	Heat/steam/power	5/12/09	—	5/1/18	O
Chevron, Richmond	b	4038	Heat/steam/power	5/26/09	—	5/1/18	O
Chevron, Richmond	b	4039	Heat/steam/power	5/26/09	—	5/1/18	O
Chevron, Richmond	b	4040	Heat/steam/power	5/26/09	—	5/1/18	O
Chevron, Richmond	b	4041	Heat/steam/power	5/26/09	—	5/1/18	O
Chevron, Richmond	b	4042	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4044	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4045	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4046	Heat/steam/power	5/5/09	—	5/1/18	O
Chevron, Richmond	b	4059	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4060	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4061	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4062	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4068	Heat/steam/power	5/30/09	—	5/1/18	O
Chevron, Richmond	b	4069	Heat/steam/power	5/30/09	—	5/1/18	O
Chevron, Richmond	b	4070	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4071	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4072	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4107	Heat/steam/power	5/6/09	—	5/1/18	O
Chevron, Richmond	b	4129	Heat/steam/power	1/1/36	—	5/1/18	O
Chevron, Richmond	b	4131	Heat/steam/power	1/1/36	—	5/1/18	O
Chevron, Richmond	b	4132	Heat/steam/power	1/1/41	—	5/1/18	O
Chevron, Richmond	b	4133	Heat/steam/power	1/1/41	—	5/1/18	O
Chevron, Richmond	b	4135	Heat/steam/power	1/1/53	—	5/1/18	O
Chevron, Richmond	b	4152	Heat/steam/power	5/20/09	—	5/1/18	O

Refining Facility	(notes)	Equipment Unit ID#[a]	Type	Age and Operational Data (dates) Startup	Rebuild	End-date	Status
Chevron, Richmond	b	4153	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4154	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4155	Heat/steam/power	5/20/09	1994	5/1/18	O
Chevron, Richmond	b	4156	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4157	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4158	Heat/steam/power	5/29/09	2000	5/1/18	O
Chevron, Richmond	b	4159	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4160	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4161	Heat/steam/power	5/20/09	2008	5/1/18	O
Chevron, Richmond	b	4162	Heat/steam/power	5/20/09	2008	5/1/18	O
Chevron, Richmond	b	4163	Heat/steam/power	5/20/09	2008	5/1/18	O
Chevron, Richmond	b	4164	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4165	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4166	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4167	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4168	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4169	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4170	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4171	Heat/steam/power	5/20/09	—	5/1/18	O
Chevron, Richmond	b	4188	Heat/steam/power	5/13/09	2008	5/1/18	O
Chevron, Richmond	b	4189	Heat/steam/power	5/13/09	2008	5/1/18	O
Chevron, Richmond	b	4192	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4193	Heat/steam/power	5/29/09	—	5/1/18	O
Chevron, Richmond	b	4194	Heat/steam/power	5/30/09	—	5/1/18	O
Chevron, Richmond	b	4226	Hydrotreating	12/6/05	—	5/1/18	O
Chevron, Richmond	b	4227	Sulfur recovery	1/1/75	—	5/1/18	O
Chevron, Richmond	b	4228	Sulfur recovery	1/1/75	—	5/1/18	O
Chevron, Richmond	b	4229	Sulfur recovery	1/1/76	—	5/1/18	O
Chevron, Richmond	b	4233	Hydrotreating	1/1/76	—	5/1/18	O
Chevron, Richmond	b	4234	Hydrotreating	1/1/75	—	5/1/18	O
Chevron, Richmond	b	4235	Hydrotreating	1/1/76	8/1/93	5/1/18	O
Chevron, Richmond	b	4236	Crude distillation	1/1/75	—	5/1/18	O
Chevron, Richmond	b	4237	Cat. Reforming	1/1/75	—	5/1/18	O
Chevron, Richmond	b, e	4250	Hydrogen plant	3/1/66	—	5/1/18	D
Chevron, Richmond	b	4252	Hydrocracking	2/1/66	5/1/09	5/1/18	O
Chevron, Richmond	b	4253	Hydrocracking	2/1/66	3/29/91	5/1/18	O
Chevron, Richmond	b	4283	Cat. Reforming	1/1/72	—	5/1/18	O
Chevron, Richmond	b	4285	Cat. Cracking	1/1/58	1/1/93	5/1/18	O
Chevron, Richmond	b	4291	Alkylation	1/1/59	—	5/1/18	O
Chevron, Richmond	b	4330	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4331	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4332	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4333	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4334	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4335	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4336	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4337	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4338	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4339	Heat/steam/power	6/7/09	—	5/1/18	O
Chevron, Richmond	b	4340	Hydrocracking	8/1/84	—	5/1/18	O
Chevron, Richmond	b	4341	Hydrotreating	8/1/84	—	5/1/18	O
Chevron, Richmond	b	4342	Hydrocracking	8/1/84	—	5/1/18	O
Chevron, Richmond	b	4343	Hydrotreating	8/1/84	—	5/1/18	O
Chevron, Richmond	b	4349	Heat/steam/power	6/21/09	—	5/1/18	O
Chevron, Richmond	b	4350	Heat/steam/power	9/5/93	—	5/1/18	O
Chevron, Richmond	b	4351	Heat/steam/power	9/5/93	—	5/1/18	O
Chevron, Richmond	b	4352	Heat/steam/power	9/5/93	—	5/1/18	O
Chevron, Richmond	b	4353	Heat/steam/power	9/5/93	—	5/1/18	O
Chevron, Richmond	b	6066	Storage tank	8/1/98	—	1/1/11	D
Chevron, Richmond	b	6125	Storage tank	5/27/94	—	5/1/18	O
Chevron, Richmond	b	9302	Storage tank	10/3/84	—	1/1/09	D
Chevron, Richmond	b	9303	Storage tank	10/3/84	—	1/1/09	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Chevron, Richmond	b	9321	Marine terminal	12/31/02	—	5/1/18	O
Chevron, Richmond	b	9322	Marine terminal	12/31/02	—	5/1/18	O
Chevron, Richmond	b	9323	Marine terminal	1/1/28	—	5/1/18	O
Chevron, Richmond	b	9324	Marine terminal	12/31/02	—	5/1/18	O
Chevron, Richmond	b	9325	Marine terminal	12/31/02	—	5/1/18	O
Chevron, Richmond	b	9326	Marine terminal	1/1/28	—	5/1/18	O
Chevron, Richmond	b, e	4449/50	Hydrogen plant	5/1/18	—	5/1/18	O
Marathon, Martinez	b	1	Storage tank	1/1/39	—	4/26/04	D
Marathon, Martinez	b	2	Storage tank	1/1/39	—	5/23/12	D
Marathon, Martinez	b	3	Storage tank	1/1/28	—	8/1/02	D
Marathon, Martinez	b	5	Storage tank	1/1/28	—	8/1/02	D
Marathon, Martinez	b	6	Storage tank	1/1/28	—	8/1/02	D
Marathon, Martinez	b	9	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	10	Storage tank	1/1/53	—	10/29/08	D
Marathon, Martinez	b	11	Storage tank	1/1/47	—	10/29/08	D
Marathon, Martinez	b	13	Storage tank	1/1/47	—	8/11/99	D
Marathon, Martinez	b	14	Storage tank	1/1/46	—	3/15/06	D
Marathon, Martinez	b	15	Storage tank	1/1/50	—	9/27/10	D
Marathon, Martinez	b	18	Storage tank	1/1/47	—	8/11/99	D
Marathon, Martinez	b	19	Storage tank	1/1/28	—	3/20/12	D
Marathon, Martinez	b	20	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	21	Storage tank	1/1/28	—	3/14/05	D
Marathon, Martinez	b	22	Storage tank	1/1/28	—	3/14/05	D
Marathon, Martinez	b	23	Storage tank	1/1/50	—	7/11/99	D
Marathon, Martinez	b	26	Storage tank	1/1/56	—	5/1/18	O
Marathon, Martinez	b	27	Storage tank	1/1/50	—	3/15/06	D
Marathon, Martinez	b	28	Storage tank	1/1/51	—	9/27/10	D
Marathon, Martinez	b	29	Storage tank	1/1/47	—	12/31/07	D
Marathon, Martinez	b	30	Storage tank	1/1/47	—	12/31/07	D
Marathon, Martinez	b	31	Storage tank	1/1/28	—	8/1/02	D
Marathon, Martinez	b	33	Storage tank	1/1/56	—	5/1/18	O
Marathon, Martinez	b	36	Storage tank	1/1/28	—	9/27/10	D
Marathon, Martinez	b	41	Storage tank	1/1/29	—	8/1/02	D
Marathon, Martinez	b	42	Storage tank	1/1/29	—	8/1/02	D
Marathon, Martinez	b	43	Storage tank	1/1/39	—	8/1/02	D
Marathon, Martinez	b	45	Storage tank	1/1/47	—	10/29/08	D
Marathon, Martinez	b	46	Storage tank	1/1/47	—	10/23/03	D
Marathon, Martinez	b	47	Storage tank	1/1/49	—	8/1/02	D
Marathon, Martinez	b	54	Storage tank	1/1/54	—	5/1/18	O
Marathon, Martinez	b, f	55	Marine terminal	1/1/28	—	5/1/18	O
Marathon, Martinez	b, f	55	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	56	Storage tank	1/1/54	—	12/31/07	D
Marathon, Martinez	b	58	Storage tank	1/1/28	—	8/11/99	D
Marathon, Martinez	b	59	Storage tank	1/1/28	—	3/14/05	D
Marathon, Martinez	b	60	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	61	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	62	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	63	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	64	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	65	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	66	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	67	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	68	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	69	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	70	Storage tank	1/1/28	—	9/27/10	D
Marathon, Martinez	b	71	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	76	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	77	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	78	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	79	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	80	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	81	Storage tank	1/1/28	—	10/15/03	D

Refining Facility	(notes)	Equipment Unit ID#[a]	Type	Age and Operational Data (dates) Startup	Rebuild	End-date	Status
Marathon, Martinez	b	100	Marine terminal	1/1/28	—	6/27/17	D
Marathon, Martinez	b	106	Marine terminal	1/1/40	—	10/1/02	D
Marathon, Martinez	b	107	Marine terminal	1/1/28	—	10/1/02	D
Marathon, Martinez	b	108	Marine terminal	1/1/41	—	6/27/17	D
Marathon, Martinez	b	114	Marine terminal	1/1/41	—	2/26/09	D
Marathon, Martinez	b	131	Storage tank	1/1/28	—	3/15/06	D
Marathon, Martinez	b	134	Storage tank	1/1/58	—	5/1/18	O
Marathon, Martinez	b	135	Storage tank	1/1/58	—	5/1/18	O
Marathon, Martinez	b	137	Storage tank	1/1/58	3/15/96	5/1/18	O
Marathon, Martinez	b	138	Storage tank	1/1/28	—	8/11/99	D
Marathon, Martinez	b	139	Storage tank	1/1/28	—	3/14/05	D
Marathon, Martinez	b	152	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	153	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	180	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	181	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	182	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	183	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	184	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	185	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	186	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	187	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	188	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	189	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	190	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	191	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	192	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	193	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	194	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	195	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	196	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	197	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	198	Storage tank	1/1/55	—	6/30/08	D
Marathon, Martinez	b	199	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	200	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	201	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	202	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	203	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	209	Storage tank	1/1/46	—	9/27/10	D
Marathon, Martinez	b	210	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	211	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	212	Storage tank	1/1/28	—	3/15/06	D
Marathon, Martinez	b	213	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	214	Storage tank	1/1/28	—	3/14/05	D
Marathon, Martinez	b	217	Storage tank	1/1/58	—	5/1/18	O
Marathon, Martinez	b	220	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	221	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	222	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	223	Storage tank	1/1/28	—	8/17/00	D
Marathon, Martinez	b	224	Storage tank	1/1/28	—	5/1/18	O
Marathon, Martinez	b	226	Storage tank	1/1/28	—	4/26/04	D
Marathon, Martinez	b	227	Storage tank	1/1/28	—	5/1/18	O
Marathon, Martinez	b	228	Storage tank	1/1/28	—	4/26/04	D
Marathon, Martinez	b	229	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	230	Storage tank	1/1/28	—	9/27/10	D
Marathon, Martinez	b	231	Storage tank	1/1/28	—	8/17/00	D
Marathon, Martinez	b	232	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	233	Storage tank	1/1/28	—	9/27/10	D
Marathon, Martinez	b	234	Storage tank	1/1/28	—	12/31/06	D
Marathon, Martinez	b	235	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	236	Storage tank	1/1/28	—	12/31/06	D
Marathon, Martinez	b	237	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	238	Storage tank	1/1/28	—	6/30/08	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Marathon, Martinez	b	239	Storage tank	1/1/28	—	8/19/87	D
Marathon, Martinez	b	240	Storage tank	1/1/28	—	8/17/00	D
Marathon, Martinez	b	241	Storage tank	1/1/28	—	10/16/03	D
Marathon, Martinez	b	242	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	243	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	244	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	245	Storage tank	1/1/28	—	6/30/08	D
Marathon, Martinez	b	246	Storage tank	1/1/28	—	6/30/08	D
Marathon, Martinez	b	247	Storage tank	1/1/28	—	6/30/08	D
Marathon, Martinez	b	248	Storage tank	1/1/28	—	3/14/05	D
Marathon, Martinez	b	259	Storage tank	1/1/28	—	11/27/91	D
Marathon, Martinez	b	269	Storage tank	1/1/28	—	5/23/12	D
Marathon, Martinez	b	271	Storage tank	1/1/28	—	5/23/12	D
Marathon, Martinez	b	273	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	275	Storage tank	1/1/28	—	8/17/00	D
Marathon, Martinez	b	276	Storage tank	1/1/28	—	8/17/00	D
Marathon, Martinez	b	278	Storage tank	1/1/28	—	9/27/10	D
Marathon, Martinez	b	279	Storage tank	1/1/28	—	10/29/08	D
Marathon, Martinez	b	280	Storage tank	1/1/28	—	3/15/06	D
Marathon, Martinez	b	281	Storage tank	1/1/28	—	11/5/03	D
Marathon, Martinez	b	282	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	283	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	284	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	285	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	286	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	287	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	288	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	289	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	290	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	291	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	292	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	293	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	294	Storage tank	1/1/28	—	8/11/99	D
Marathon, Martinez	b	295	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	296	Storage tank	1/1/28	—	10/15/03	D
Marathon, Martinez	b	300	Storage tank	1/1/53	—	10/1/02	D
Marathon, Martinez	b	302	Storage tank	1/1/41	—	7/11/01	D
Marathon, Martinez	b	311	Storage tank	1/1/28	—	3/15/06	D
Marathon, Martinez	b	312	Storage tank	1/1/28	—	4/14/03	D
Marathon, Martinez	b	313	Storage tank	1/1/28	—	9/27/10	D
Marathon, Martinez	b	314	Storage tank	1/1/28	—	12/31/07	D
Marathon, Martinez	b	315	Storage tank	1/1/28	—	5/23/12	D
Marathon, Martinez	b	316	Storage tank	1/1/28	—	9/27/10	D
Marathon, Martinez	b	317	Storage tank	1/1/28	—	5/25/05	D
Marathon, Martinez	b	318	Storage tank	1/1/28	—	5/23/12	D
Marathon, Martinez	b	319	Storage tank	1/1/51	—	8/11/99	D
Marathon, Martinez	b	323	Storage tank	1/1/45	—	5/1/18	O
Marathon, Martinez	b	324	Storage tank	1/1/28	—	12/12/03	D
Marathon, Martinez	b	325	Storage tank	1/1/28	—	12/31/07	D
Marathon, Martinez	b	327	Storage tank	1/1/53	—	5/1/18	O
Marathon, Martinez	b	329	Storage tank	1/1/54	—	8/11/99	D
Marathon, Martinez	b	345	Storage tank	1/1/28	—	3/14/05	D
Marathon, Martinez	b	356	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b	357	Storage tank	1/1/50	—	8/11/99	D
Marathon, Martinez	b	367	Storage tank	1/1/29	—	5/23/12	D
Marathon, Martinez	b	368	Storage tank	1/1/28	—	5/23/12	D
Marathon, Martinez	b	369	Storage tank	1/1/29	—	12/31/13	D
Marathon, Martinez	b	370	Storage tank	1/1/29	—	2/24/03	D
Marathon, Martinez	b	371	Storage tank	1/1/29	—	2/24/03	D
Marathon, Martinez	b	372	Storage tank	1/1/29	—	2/24/03	D
Marathon, Martinez	b	373	Storage tank	1/1/29	—	2/24/03	D
Marathon, Martinez	b	374	Storage tank	1/1/57	—	12/31/10	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Marathon, Martinez	b	375	Storage tank	1/1/29	—	2/24/03	D
Marathon, Martinez	b	376	Storage tank	1/1/29	—	2/24/03	D
Marathon, Martinez	b	377	Storage tank	1/1/28	—	5/23/12	D
Marathon, Martinez	b	378	Storage tank	1/1/28	—	5/23/12	D
Marathon, Martinez	b	384	Storage tank	1/1/30	—	2/24/03	D
Marathon, Martinez	b	385	Storage tank	1/1/30	—	4/19/91	D
Marathon, Martinez	b	387	Storage tank	1/1/30	—	2/24/03	D
Marathon, Martinez	b	388	Storage tank	1/1/30	—	2/24/03	D
Marathon, Martinez	b	389	Storage tank	1/1/30	—	2/24/03	D
Marathon, Martinez	b	390	Storage tank	1/1/30	—	2/24/03	D
Marathon, Martinez	b	391	Storage tank	1/1/31	—	3/14/05	D
Marathon, Martinez	b	392	Storage tank	1/1/30	—	8/11/99	D
Marathon, Martinez	b	393	Storage tank	1/1/31	—	8/11/99	D
Marathon, Martinez	b	403	Storage tank	1/1/31	—	9/27/10	D
Marathon, Martinez	b	405	Storage tank	1/1/31	—	9/27/10	D
Marathon, Martinez	b	406	Storage tank	1/1/31	—	12/31/13	D
Marathon, Martinez	b	411	Storage tank	1/1/31	—	8/11/99	D
Marathon, Martinez	b	427	Storage tank	1/1/32	—	8/11/99	D
Marathon, Martinez	b	428	Storage tank	1/1/31	—	9/12/07	D
Marathon, Martinez	b	430	Storage tank	1/1/33	—	9/27/10	D
Marathon, Martinez	b	431	Storage tank	1/1/33	—	10/29/08	D
Marathon, Martinez	b	432	Storage tank	1/1/55	—	5/1/18	O
Marathon, Martinez	b	433	Storage tank	1/1/33	—	8/11/99	D
Marathon, Martinez	b	434	Storage tank	1/1/33	—	7/1/03	D
Marathon, Martinez	b	435	Storage tank	1/1/33	—	7/1/03	D
Marathon, Martinez	b	446	Storage tank	1/1/34	—	8/11/99	D
Marathon, Martinez	b	448	Storage tank	1/1/34	—	2/24/03	D
Marathon, Martinez	b	452	Storage tank	1/1/34	—	4/25/06	D
Marathon, Martinez	b	453	Storage tank	1/1/34	—	3/15/06	D
Marathon, Martinez	b	456	Storage tank	1/1/34	—	7/1/03	D
Marathon, Martinez	b	457	Storage tank	1/1/34	—	5/17/04	D
Marathon, Martinez	b	458	Storage tank	1/1/35	—	8/11/99	D
Marathon, Martinez	b	459	Storage tank	1/1/35	—	8/11/99	D
Marathon, Martinez	b	460	Storage tank	1/1/35	—	8/11/99	D
Marathon, Martinez	b	461	Storage tank	1/1/35	—	8/11/99	D
Marathon, Martinez	b	462	Storage tank	1/1/35	—	10/15/03	D
Marathon, Martinez	b	463	Storage tank	1/1/35	—	10/15/03	D
Marathon, Martinez	b	464	Storage tank	1/1/35	—	10/15/03	D
Marathon, Martinez	b	465	Storage tank	1/1/35	—	10/15/03	D
Marathon, Martinez	b	485	Storage tank	1/1/35	—	10/15/03	D
Marathon, Martinez	b	486	Storage tank	1/1/36	—	7/11/01	D
Marathon, Martinez	b	487	Storage tank	1/1/36	—	2/24/93	D
Marathon, Martinez	b	489	Storage tank	1/1/37	—	9/27/10	D
Marathon, Martinez	b	490	Storage tank	1/1/37	—	12/31/07	D
Marathon, Martinez	b	491	Storage tank	1/1/37	—	7/11/01	D
Marathon, Martinez	b	493	Storage tank	1/1/37	—	3/15/06	D
Marathon, Martinez	b	496	Storage tank	1/1/37	—	10/19/09	D
Marathon, Martinez	b	499	Storage tank	1/1/37	—	12/31/07	D
Marathon, Martinez	b	503	Storage tank	1/1/38	—	5/23/12	D
Marathon, Martinez	b	504	Storage tank	1/1/38	—	3/15/06	D
Marathon, Martinez	b	505	Storage tank	1/1/29	—	8/11/99	D
Marathon, Martinez	b	506	Storage tank	1/1/39	—	9/27/10	D
Marathon, Martinez	b	507	Storage tank	1/1/39	—	2/24/03	D
Marathon, Martinez	b	508	Storage tank	1/1/39	—	8/11/99	D
Marathon, Martinez	b	510	Storage tank	1/1/39	—	9/27/10	D
Marathon, Martinez	b	513	Storage tank	1/1/40	—	12/31/16	D
Marathon, Martinez	b	527	Storage tank	1/1/40	—	3/14/05	D
Marathon, Martinez	b	529	Storage tank	1/1/40	—	5/23/12	D
Marathon, Martinez	b	530	Storage tank	1/1/40	—	5/23/12	D
Marathon, Martinez	b	531	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	535	Storage tank	1/1/41	—	6/12/92	D
Marathon, Martinez	b	539	Storage tank	1/1/41	—	2/24/03	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Marathon, Martinez	b	548	Storage tank	1/1/41	—	2/24/03	D
Marathon, Martinez	b	574	Storage tank	1/1/43	—	10/29/08	D
Marathon, Martinez	b	581	Storage tank	1/1/43	—	8/11/99	D
Marathon, Martinez	b	582	Storage tank	1/1/43	—	8/11/99	D
Marathon, Martinez	b	586	Storage tank	1/1/44	—	12/31/07	D
Marathon, Martinez	b	587	Storage tank	1/1/44	—	5/23/12	D
Marathon, Martinez	b	588	Storage tank	1/1/44	—	5/23/12	D
Marathon, Martinez	b	601	Storage tank	1/1/48	—	5/1/18	O
Marathon, Martinez	b	602	Storage tank	1/1/47	—	12/31/07	D
Marathon, Martinez	b	603	Storage tank	1/1/47	—	5/1/18	O
Marathon, Martinez	b	612	Storage tank	1/1/49	—	5/1/18	O
Marathon, Martinez	b	613	Storage tank	1/1/49	—	5/1/18	O
Marathon, Martinez	b	614	Storage tank	1/1/49	—	8/11/99	D
Marathon, Martinez	b	615	Storage tank	1/1/49	—	2/24/03	D
Marathon, Martinez	b	617	Storage tank	1/1/49	—	11/27/91	D
Marathon, Martinez	b	619	Storage tank	1/1/50	—	3/14/05	D
Marathon, Martinez	b	622	Storage tank	1/1/51	—	5/1/18	O
Marathon, Martinez	b	629	Storage tank	1/1/52	—	2/1/15	D
Marathon, Martinez	b	631	Storage tank	1/1/54	—	5/1/18	O
Marathon, Martinez	b	636	Storage tank	1/1/54	—	5/9/90	D
Marathon, Martinez	b	637	Storage tank	1/1/54	8/1/95	5/1/18	O
Marathon, Martinez	b	638	Storage tank	1/1/54	—	5/1/18	O
Marathon, Martinez	b	639	Storage tank	1/1/54	8/1/95	5/1/18	O
Marathon, Martinez	b	640	Storage tank	1/1/54	—	5/1/18	O
Marathon, Martinez	b	641	Storage tank	1/1/54	—	5/1/18	O
Marathon, Martinez	b	642	Storage tank	1/1/54	—	5/1/18	O
Marathon, Martinez	b	643	Storage tank	1/1/54	—	3/14/05	D
Marathon, Martinez	b	650	Storage tank	1/1/56	—	5/1/18	O
Marathon, Martinez	b	651	Storage tank	1/1/56	—	5/1/18	O
Marathon, Martinez	b	654	Storage tank	1/1/56	—	3/14/05	D
Marathon, Martinez	b	655	Storage tank	1/1/56	—	12/31/07	D
Marathon, Martinez	b	657	Storage tank	1/1/56	—	12/31/07	D
Marathon, Martinez	b	659	Storage tank	1/1/55	—	5/23/12	D
Marathon, Martinez	b	660	Storage tank	1/1/55	—	5/23/12	D
Marathon, Martinez	b	663	Storage tank	1/1/56	—	5/25/05	D
Marathon, Martinez	b	664	Storage tank	1/1/57	8/1/95	5/1/18	O
Marathon, Martinez	b	672	Storage tank	1/1/57	—	9/24/09	D
Marathon, Martinez	b	682	Storage tank	1/1/63	—	8/11/99	D
Marathon, Martinez	b	683	Storage tank	1/1/63	—	8/11/99	D
Marathon, Martinez	b	684	Storage tank	1/1/63	—	8/11/99	D
Marathon, Martinez	b	685	Storage tank	1/1/63	—	8/11/99	D
Marathon, Martinez	b	686	Storage tank	1/1/63	—	8/17/93	D
Marathon, Martinez	b	687	Storage tank	1/1/63	—	9/15/87	D
Marathon, Martinez	b	688	Storage tank	1/1/63	—	9/15/87	D
Marathon, Martinez	b	692	Storage tank	1/1/65	—	5/1/18	O
Marathon, Martinez	b	694	Storage tank	1/1/69	8/1/95	5/1/18	O
Marathon, Martinez	b	696	Storage tank	1/1/69	—	5/1/18	O
Marathon, Martinez	b	697	Storage tank	1/1/69	—	7/23/09	D
Marathon, Martinez	b	698	Storage tank	1/1/69	—	7/23/09	D
Marathon, Martinez	b	699	Storage tank	1/1/70	8/1/89	5/1/18	O
Marathon, Martinez	b	700	Storage tank	1/1/70	—	5/1/18	O
Marathon, Martinez	b	701	Storage tank	1/1/73	—	5/1/18	O
Marathon, Martinez	b	702	Storage tank	1/1/74	8/1/95	5/1/18	O
Marathon, Martinez	b	705	Storage tank	3/27/78	—	5/1/18	O
Marathon, Martinez	b	706	Storage tank	1/1/79	—	5/1/18	O
Marathon, Martinez	b	707	Storage tank	1/1/79	—	5/1/18	O
Marathon, Martinez	b	708	Storage tank	1/1/79	—	5/1/18	O
Marathon, Martinez	b	709	Storage tank	1/1/79	—	5/1/18	O
Marathon, Martinez	b	710	Storage tank	1/1/79	—	5/1/18	O
Marathon, Martinez	b	711	Storage tank	1/1/79	—	5/1/18	O
Marathon, Martinez	b	715	Storage tank	1/1/50	—	1/16/91	D
Marathon, Martinez	b	716	Storage tank	1/1/50	—	1/16/91	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Marathon, Martinez	b	717	Storage tank	1/1/50	—	1/16/91	D
Marathon, Martinez	b	718	Storage tank	1/1/51	—	5/17/04	D
Marathon, Martinez	b	719	Storage tank	1/1/51	—	1/16/91	D
Marathon, Martinez	b	720	Storage tank	1/1/55	—	1/30/91	D
Marathon, Martinez	b	721	Storage tank	1/1/55	—	1/30/91	D
Marathon, Martinez	b	722	Storage tank	1/1/55	—	1/30/91	D
Marathon, Martinez	b	723	Storage tank	1/1/55	—	1/30/91	D
Marathon, Martinez	b	724	Storage tank	1/1/55	—	1/30/91	D
Marathon, Martinez	b	725	Storage tank	1/1/55	—	1/30/91	D
Marathon, Martinez	b	727	Storage tank	1/1/55	—	2/3/88	D
Marathon, Martinez	b	728	Storage tank	1/1/55	—	2/3/88	D
Marathon, Martinez	b	731	Storage tank	1/1/70	—	1/16/91	D
Marathon, Martinez	b	732	Storage tank	1/1/70	—	1/16/91	D
Marathon, Martinez	b	733	Storage tank	1/1/70	—	1/16/91	D
Marathon, Martinez	b	734	Storage tank	1/1/70	—	1/16/91	D
Marathon, Martinez	b	735	Storage tank	1/1/74	—	1/16/91	D
Marathon, Martinez	b	736	Storage tank	1/1/70	—	1/16/91	D
Marathon, Martinez	b	739	Storage tank	1/1/54	—	2/26/09	D
Marathon, Martinez	b	741	Storage tank	1/1/77	—	7/23/09	D
Marathon, Martinez	b	743	Storage tank	1/1/30	—	7/23/09	D
Marathon, Martinez	b	744	Storage tank	1/1/65	—	10/1/90	D
Marathon, Martinez	b	746	Storage tank	1/1/50	—	7/23/09	D
Marathon, Martinez	b	749	Storage tank	1/1/60	—	6/14/12	D
Marathon, Martinez	b	750	Storage tank	1/1/60	—	3/13/91	D
Marathon, Martinez	b	755	Storage tank	1/1/40	—	6/21/06	D
Marathon, Martinez	b	756	Storage tank	1/1/40	—	6/21/06	D
Marathon, Martinez	b	758	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	759	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	760	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	761	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	762	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	763	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	764	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	765	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	766	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	767	Storage tank	1/1/40	—	10/15/03	D
Marathon, Martinez	b	768	Storage tank	1/1/40	—	6/21/06	D
Marathon, Martinez	b	770	Storage tank	1/1/60	—	8/5/93	D
Marathon, Martinez	b	802	Cat. Cracking	1/1/45	—	5/1/18	O
Marathon, Martinez	b	806	Coking	1/1/55	—	11/13/08	D
Marathon, Martinez	b	808	Storage tank	1/1/55	—	11/13/08	D
Marathon, Martinez	b	817	Crude distillation	1/1/65	8/1/94	5/1/18	O
Marathon, Martinez	b	850	Hydrotreating	1/1/83	—	5/1/18	O
Marathon, Martinez	b	871	Storage tank	12/21/06	—	5/1/18	O
Marathon, Martinez	b	901	Heat/steam/power	1/1/69	—	5/1/18	O
Marathon, Martinez	b	902	Heat/steam/power	4/29/09	—	5/1/18	O
Marathon, Martinez	b	903	Heat/steam/power	1/1/56	—	11/13/08	D
Marathon, Martinez	b	904	Heat/steam/power	1/1/56	—	5/1/18	O
Marathon, Martinez	b	905	Heat/steam/power	5/10/09	—	7/2/09	D
Marathon, Martinez	b	906	Heat/steam/power	4/19/09	—	6/26/09	D
Marathon, Martinez	b	907	Heat/steam/power	4/21/09	—	6/26/09	D
Marathon, Martinez	b	908	Heat/steam/power	4/21/09	—	5/1/18	O
Marathon, Martinez	b	909	Heat/steam/power	4/28/09	—	5/1/18	O
Marathon, Martinez	b	910	Heat/steam/power	4/28/09	—	6/8/09	D
Marathon, Martinez	b	911	Heat/steam/power	5/6/09	—	6/22/09	D
Marathon, Martinez	b	912	Heat/steam/power	5/7/09	—	5/1/18	O
Marathon, Martinez	b	913	Heat/steam/power	5/7/09	—	5/1/18	O
Marathon, Martinez	b	914	Heat/steam/power	5/8/09	—	6/22/09	D
Marathon, Martinez	b	915	Heat/steam/power	5/8/09	—	5/1/18	O
Marathon, Martinez	b	916	Heat/steam/power	5/8/09	—	5/1/18	O
Marathon, Martinez	b	917	Heat/steam/power	5/8/09	1990	5/1/18	O
Marathon, Martinez	b	918	Heat/steam/power	5/10/09	—	6/22/09	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Marathon, Martinez	b	919	Heat/steam/power	5/10/09	—	5/1/18	O
Marathon, Martinez	b	920	Heat/steam/power	5/10/09	—	5/1/18	O
Marathon, Martinez	b	921	Heat/steam/power	5/10/09	—	5/1/18	O
Marathon, Martinez	b	923	Heat/steam/power	5/10/09	—	7/1/09	D
Marathon, Martinez	b	924	Heat/steam/power	5/10/09	—	7/1/09	D
Marathon, Martinez	b	925	Heat/steam/power	5/10/09	—	7/1/09	D
Marathon, Martinez	b	926	Heat/steam/power	5/11/09	—	5/1/18	O
Marathon, Martinez	b	927	Heat/steam/power	5/11/09	—	5/1/18	O
Marathon, Martinez	b	928	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	929	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	930	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	931	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	932	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	933	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	934	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	935	Heat/steam/power	5/16/09	—	5/1/18	O
Marathon, Martinez	b	936	Heat/steam/power	5/16/09	—	6/30/09	D
Marathon, Martinez	b	937	Heat/steam/power	5/16/09	2003	5/1/18	O
Marathon, Martinez	b	938	Heat/steam/power	5/16/09	—	6/30/09	D
Marathon, Martinez	b	939	Heat/steam/power	5/18/09	—	7/1/09	D
Marathon, Martinez	b	940	Heat/steam/power	1/1/43	—	10/11/00	D
Marathon, Martinez	b	941	Heat/steam/power	1/1/43	—	7/1/03	D
Marathon, Martinez	b	942	Heat/steam/power	1/1/45	—	7/1/03	D
Marathon, Martinez	b	943	Storage tank	1/1/64	—	5/1/18	O
Marathon, Martinez	b	950	Heat/steam/power	4/30/09	—	5/1/18	O
Marathon, Martinez	b	951	Heat/steam/power	5/31/09	—	5/1/18	O
Marathon, Martinez	b	971	Heat/steam/power	6/4/09	2015	5/1/18	O
Marathon, Martinez	b	972	Heat/steam/power	6/4/09	2015	5/1/18	O
Marathon, Martinez	b	973	Heat/steam/power	6/6/09	—	5/1/18	O
Marathon, Martinez	b	974	Heat/steam/power	6/6/09	—	5/1/18	O
Marathon, Martinez	b	991	Heat/steam/power	6/6/09	—	6/30/09	D
Marathon, Martinez	b	1001	Crude distillation	1/1/47	1/9/91	5/1/18	O
Marathon, Martinez	b	1002	Hydrotreating	1/1/54	5/24/85	5/1/18	O
Marathon, Martinez	b	1003	Hydrotreating	1/1/56	—	5/1/18	O
Marathon, Martinez	b	1004	Cat. Reforming	1/1/56	—	5/1/18	O
Marathon, Martinez	b	1005	Hydrogen plant	1/1/63	—	5/1/18	O
Marathon, Martinez	b	1006	Hydrotreating	1/1/54	—	5/1/18	O
Marathon, Martinez	b	1007	Hydrocracking	1/1/63	—	5/1/18	O
Marathon, Martinez	b	1009	Alkylation	1/1/66	5/5/95	5/1/18	O
Marathon, Martinez	b	1020	Cat. Reforming	1/1/81	3/31/15	5/1/18	O
Marathon, Martinez	b	1105	Hydrotreating	7/27/05	—	5/1/18	O
Marathon, Martinez	b	1106	Heat/steam/power	6/28/09	—	5/1/18	O
Marathon, Martinez	b	1401	Sulfur recovery	1/1/63	2/15/84	5/1/18	O
Marathon, Martinez	b	1407	Storage tank	1/1/76	—	6/29/87	D
Marathon, Martinez	b	1408	Storage tank	1/1/76	—	6/29/87	D
Marathon, Martinez	b	1409	Storage tank	1/1/76	—	5/1/18	O
Marathon, Martinez	b	1410	Storage tank	1/1/76	—	5/1/18	O
Marathon, Martinez	b	1415	Marine terminal	1/1/72	—	5/1/18	O
Marathon, Martinez	b	1416	Storage tank	1/1/53	—	5/1/18	O
Marathon, Martinez	b	1417	Storage tank	1/1/53	—	12/19/05	D
Marathon, Martinez	b	1419	Storage tank	11/1/85	—	12/26/95	D
Marathon, Martinez	b	1422	Storage tank	8/1/05	—	5/1/18	O
Marathon, Martinez	b	1439	Storage tank	1/1/60	—	4/19/91	D
Marathon, Martinez	b	1459	Storage tank	8/3/00	—	9/15/10	D
Marathon, Martinez	b	1460	Storage tank	8/3/00	—	9/15/10	D
Marathon, Martinez	b	1461	Storage tank	5/21/01	—	5/1/18	O
Marathon, Martinez	b	1463	Storage tank	8/15/01	—	5/1/18	O
Marathon, Martinez	b	1464	Storage tank	10/21/01	—	5/1/18	O
Marathon, Martinez	b	1465	Storage tank	10/21/01	—	5/1/18	O
Marathon, Martinez	b	1466	Storage tank	8/3/00	—	10/15/03	D
Marathon, Martinez	b	1467	Storage tank	8/3/00	—	10/15/03	D
Marathon, Martinez	b	1470	Heat/steam/power	6/25/09	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Marathon, Martinez	b	1485	Storage tank	7/7/04	—	5/1/18	O
Marathon, Martinez	b	1496	Storage tank	1/24/05	—	5/1/18	O
Marathon, Martinez	b	1506	Storage tank	7/20/07	—	5/1/18	O
Marathon, Martinez	b	1507	Storage tank	7/16/07	—	5/1/18	O
Marathon, Martinez	b	1508	Storage tank	10/1/06	—	6/27/17	D
Marathon, Martinez	b	1509	Storage tank	12/4/08	—	6/27/17	D
Marathon, Martinez	b	1510	Coking	6/2/09	—	5/1/18	O
Marathon, Martinez	b	1511	Heat/steam/power	7/2/09	—	5/1/18	O
Marathon, Martinez	b	1512	Heat/steam/power	7/2/09	—	5/1/18	O
Marathon, Martinez	b	1521	Storage tank	12/2/08	—	5/1/18	O
Marathon, Martinez	b	1549	Storage tank	5/4/10	—	5/1/18	O
Marathon, Martinez	b	1550	Heat/steam/power	11/5/09	—	5/1/18	O
Marathon, Martinez	b	1551	Heat/steam/power	11/5/09	—	5/1/18	O
Marathon, Martinez	b	1553	Heat/steam/power	8/3/10	—	5/1/18	O
Marathon, Martinez	b	1554	Storage tank	9/23/11	—	5/1/18	O
Marathon, Martinez	b	1560	Marine terminal	—	2/16/17	5/1/18	O
Marathon, Martinez	b, f	48	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b, f	48	Storage tank	1/1/49	—	8/1/02	D
Marathon, Martinez	b, f	49	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b, f	49	Storage tank	1/1/54	—	3/20/12	D
Marathon, Martinez	b, f	50	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b, f	50	Storage tank	1/1/55	—	3/20/12	D
Marathon, Martinez	b, f	51	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b, f	51	Storage tank	8/10/78	—	8/1/02	D
Marathon, Martinez	b, f	52	Heat/steam/power	5/9/09	—	6/25/09	D
Marathon, Martinez	b, f	52	Storage tank	1/1/28	—	7/11/01	D
Marathon, Martinez	b, f	53	Marine terminal	1/1/28	—	8/1/02	D
Marathon, Martinez	b, f	53	Storage tank	1/1/28	—	7/11/01	D
Martinez Cogen, LLC	b	10	Heat/steam/power	1/1/88	—	5/1/18	O
Martinez Cogen, LLC	b	11	Heat/steam/power	1/1/88	—	5/1/18	O
PBF, Torrance	c	Proc. 3	Cat. Cracking	1/1/67	6/1/16	5/1/18	O
Phillips 66, Rodeo	b	1	Heat/steam/power	5/3/09	—	6/10/09	D
Phillips 66, Rodeo	b	2	Heat/steam/power	5/9/09	—	5/1/18	O
Phillips 66, Rodeo	b	3	Heat/steam/power	5/9/09	—	5/1/18	O
Phillips 66, Rodeo	b	4	Heat/steam/power	5/9/09	1999	5/1/18	O
Phillips 66, Rodeo	b	5	Heat/steam/power	6/2/09	1999	5/1/18	O
Phillips 66, Rodeo	b	7	Heat/steam/power	5/9/09	—	5/1/18	O
Phillips 66, Rodeo	b	8	Heat/steam/power	1/1/71	—	3/9/09	D
Phillips 66, Rodeo	b	9	Heat/steam/power	1/1/71	—	5/1/18	O
Phillips 66, Rodeo	b	10	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	11	Heat/steam/power	5/25/09	2000	5/1/18	O
Phillips 66, Rodeo	b	12	Heat/steam/power	5/25/09	2001	5/1/18	O
Phillips 66, Rodeo	b	13	Heat/steam/power	5/25/09	2000	5/1/18	O
Phillips 66, Rodeo	b	14	Heat/steam/power	5/25/09	—	7/6/09	D
Phillips 66, Rodeo	b	15	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	16	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	17	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	18	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	19	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	20	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	21	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	22	Heat/steam/power	5/25/09	—	5/1/18	O
Phillips 66, Rodeo	b	23	Heat/steam/power	4/20/09	—	6/10/09	D
Phillips 66, Rodeo	b	25	Heat/steam/power	4/18/09	—	6/21/09	D
Phillips 66, Rodeo	b	26	Heat/steam/power	4/26/09	—	6/21/09	D
Phillips 66, Rodeo	b	27	Heat/steam/power	5/19/09	—	6/10/09	D
Phillips 66, Rodeo	b	28	Heat/steam/power	5/21/09	—	6/9/09	D
Phillips 66, Rodeo	b	29	Heat/steam/power	5/22/09	1999	5/1/18	O
Phillips 66, Rodeo	b	30	Heat/steam/power	5/1/09	1999	5/1/18	O
Phillips 66, Rodeo	b	31	Heat/steam/power	5/11/09	1999	5/1/18	O
Phillips 66, Rodeo	b	32	Heat/steam/power	5/2/09	—	6/21/09	D
Phillips 66, Rodeo	b	33	Heat/steam/power	5/2/09	—	6/21/09	D

Refining Facility	(notes)	Equipment Unit ID#[a]	Type	Age and Operational Data (dates) Startup	Rebuild	End-date	Status
Phillips 66, Rodeo	b	34	Heat/steam/power	5/22/09	—	6/21/09	D
Phillips 66, Rodeo	b	35	Heat/steam/power	5/3/09	—	6/21/09	D
Phillips 66, Rodeo	b	39	Heat/steam/power	5/3/09	—	6/21/09	D
Phillips 66, Rodeo	b	40	Heat/steam/power	5/15/09	—	6/21/09	D
Phillips 66, Rodeo	b	41	Heat/steam/power	4/29/09	—	6/11/09	D
Phillips 66, Rodeo	b	42	Heat/steam/power	5/8/09	—	6/12/09	D
Phillips 66, Rodeo	b	43	Heat/steam/power	6/8/09	1999	5/1/18	O
Phillips 66, Rodeo	b	44	Heat/steam/power	6/8/09	—	5/1/18	O
Phillips 66, Rodeo	b	45	Heat/steam/power	7/2/09	—	5/1/18	O
Phillips 66, Rodeo	b	85	Storage tank	1/1/73	—	7/21/99	D
Phillips 66, Rodeo	b	88	Storage tank	1/1/28	—	5/1/18	O
Phillips 66, Rodeo	b	89	Storage tank	1/1/28	—	5/1/18	O
Phillips 66, Rodeo	b	95	Storage tank	1/1/28	—	12/31/85	D
Phillips 66, Rodeo	b	96	Storage tank	1/1/28	—	7/9/93	D
Phillips 66, Rodeo	b	97	Storage tank	1/1/69	—	5/1/18	O
Phillips 66, Rodeo	b	100	Storage tank	1/1/72	—	5/1/18	O
Phillips 66, Rodeo	b	104	Storage tank	1/1/50	—	7/9/93	D
Phillips 66, Rodeo	b	107	Storage tank	1/1/52	—	5/1/18	O
Phillips 66, Rodeo	b	110	Storage tank	1/1/55	—	5/1/18	O
Phillips 66, Rodeo	b	111	Storage tank	1/1/55	—	5/1/18	O
Phillips 66, Rodeo	b	112	Storage tank	1/1/57	—	5/1/18	O
Phillips 66, Rodeo	b	113	Storage tank	1/1/57	—	5/1/18	O
Phillips 66, Rodeo	b	114	Storage tank	1/1/57	—	5/1/18	O
Phillips 66, Rodeo	b	115	Storage tank	1/1/55	—	5/1/18	O
Phillips 66, Rodeo	b	116	Storage tank	1/1/55	—	5/14/91	D
Phillips 66, Rodeo	b	117	Storage tank	1/1/55	—	9/22/14	D
Phillips 66, Rodeo	b	118	Storage tank	1/1/55	—	5/24/16	D
Phillips 66, Rodeo	b	119	Storage tank	1/1/55	—	12/31/86	D
Phillips 66, Rodeo	b	121	Storage tank	1/1/77	—	9/22/14	D
Phillips 66, Rodeo	b	122	Storage tank	1/1/56	—	5/1/18	O
Phillips 66, Rodeo	b	123	Storage tank	1/1/56	—	5/1/18	O
Phillips 66, Rodeo	b	124	Storage tank	1/1/56	—	5/1/18	O
Phillips 66, Rodeo	b	125	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	126	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	128	Storage tank	1/1/60	—	5/1/18	O
Phillips 66, Rodeo	b	129	Storage tank	1/1/57	1/5/93	5/1/18	O
Phillips 66, Rodeo	b	133	Storage tank	1/1/57	1/16/91	5/1/18	O
Phillips 66, Rodeo	b	134	Storage tank	1/1/57	—	5/1/18	O
Phillips 66, Rodeo	b	135	Storage tank	3/15/05	—	5/1/18	O
Phillips 66, Rodeo	b	137	Storage tank	1/1/41	—	5/1/18	O
Phillips 66, Rodeo	b	139	Storage tank	1/1/74	—	5/1/18	O
Phillips 66, Rodeo	b	146	Storage tank	1/1/41	—	7/21/99	D
Phillips 66, Rodeo	b	150	Storage tank	1/1/42	—	5/1/18	O
Phillips 66, Rodeo	b	151	Storage tank	1/1/42	—	5/1/18	O
Phillips 66, Rodeo	b	152	Storage tank	1/1/42	—	10/18/91	D
Phillips 66, Rodeo	b	153	Storage tank	1/1/42	—	7/9/93	D
Phillips 66, Rodeo	b	154	Storage tank	1/1/42	—	10/13/94	D
Phillips 66, Rodeo	b	155	Storage tank	1/1/42	—	7/9/93	D
Phillips 66, Rodeo	b	156	Storage tank	1/1/42	—	7/9/93	D
Phillips 66, Rodeo	b	161	Storage tank	1/1/28	—	7/13/92	D
Phillips 66, Rodeo	b	163	Storage tank	1/1/45	—	7/21/99	D
Phillips 66, Rodeo	b	170	Storage tank	1/1/52	—	11/7/90	D
Phillips 66, Rodeo	b	176	Storage tank	1/1/49	—	6/2/94	D
Phillips 66, Rodeo	b	177	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	178	Storage tank	1/1/59	—	5/1/18	O
Phillips 66, Rodeo	b	181	Storage tank	1/1/54	—	10/1/90	D
Phillips 66, Rodeo	b	182	Storage tank	1/1/54	11/1/13	5/1/18	O
Phillips 66, Rodeo	b	183	Storage tank	1/1/54	—	5/1/18	O
Phillips 66, Rodeo	b	184	Storage tank	1/1/54	12/22/92	5/1/18	O
Phillips 66, Rodeo	b	185	Storage tank	1/1/54	—	10/1/90	D
Phillips 66, Rodeo	b	193	Storage tank	1/1/68	—	9/22/14	D
Phillips 66, Rodeo	b	194	Storage tank	1/1/68	—	5/1/18	O

	Equipment Unit			Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Phillips 66, Rodeo	b	196	Storage tank	1/1/70	—	5/24/16	D
Phillips 66, Rodeo	b	197	Storage tank	1/1/28	—	7/21/99	D
Phillips 66, Rodeo	b	198	Storage tank	1/1/28	—	7/21/99	D
Phillips 66, Rodeo	b	199	Storage tank	1/1/70	—	3/21/98	D
Phillips 66, Rodeo	b	200	Storage tank	1/1/54	—	2/3/88	D
Phillips 66, Rodeo	b	201	Storage tank	1/1/28	—	7/21/99	D
Phillips 66, Rodeo	b	203	Storage tank	1/1/46	—	7/21/99	D
Phillips 66, Rodeo	b	210	Storage tank	1/1/37	—	7/30/98	D
Phillips 66, Rodeo	b	211	Storage tank	1/1/37	—	7/10/92	D
Phillips 66, Rodeo	b	212	Storage tank	1/1/37	—	9/30/98	D
Phillips 66, Rodeo	b	213	Storage tank	1/1/42	—	7/21/99	D
Phillips 66, Rodeo	b	215	Storage tank	1/1/48	—	7/30/98	D
Phillips 66, Rodeo	b	216	Storage tank	1/1/28	—	5/1/18	O
Phillips 66, Rodeo	b	218	Storage tank	1/1/50	—	7/21/99	D
Phillips 66, Rodeo	b	219	Storage tank	1/1/50	—	7/21/99	D
Phillips 66, Rodeo	b	220	Storage tank	1/1/50	—	7/21/99	D
Phillips 66, Rodeo	b	221	Storage tank	1/1/50	—	7/21/99	D
Phillips 66, Rodeo	b	222	Storage tank	1/1/58	—	7/21/99	D
Phillips 66, Rodeo	b	223	Storage tank	1/1/58	—	7/21/99	D
Phillips 66, Rodeo	b	232	Storage tank	1/1/41	—	7/21/99	D
Phillips 66, Rodeo	b	233	Storage tank	1/1/41	—	7/21/99	D
Phillips 66, Rodeo	b	235	Storage tank	1/1/41	—	12/31/86	D
Phillips 66, Rodeo	b	238	Storage tank	1/1/41	—	9/22/14	D
Phillips 66, Rodeo	b	242	Storage tank	1/1/46	—	7/9/93	D
Phillips 66, Rodeo	b	243	Storage tank	1/1/32	—	9/30/88	D
Phillips 66, Rodeo	b	244	Storage tank	1/1/32	—	9/30/88	D
Phillips 66, Rodeo	b	245	Storage tank	1/1/32	—	9/30/88	D
Phillips 66, Rodeo	b	246	Storage tank	1/1/32	—	9/30/88	D
Phillips 66, Rodeo	b	247	Storage tank	1/1/32	—	9/30/88	D
Phillips 66, Rodeo	b	248	Storage tank	1/1/32	—	1/6/87	D
Phillips 66, Rodeo	b	249	Storage tank	1/1/32	—	12/31/86	D
Phillips 66, Rodeo	b	250	Storage tank	1/1/34	—	7/21/99	D
Phillips 66, Rodeo	b	251	Storage tank	1/1/34	—	7/21/99	D
Phillips 66, Rodeo	b	252	Storage tank	1/1/34	—	7/21/99	D
Phillips 66, Rodeo	b	254	Storage tank	1/1/57	—	5/1/18	O
Phillips 66, Rodeo	b	255	Storage tank	1/1/57	—	5/1/18	O
Phillips 66, Rodeo	b	256	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	257	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	258	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	259	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	261	Storage tank	1/1/58	—	5/1/18	O
Phillips 66, Rodeo	b	264	Storage tank	1/1/49	—	7/21/99	D
Phillips 66, Rodeo	b	265	Storage tank	1/1/49	—	7/21/99	D
Phillips 66, Rodeo	b	269	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	270	Storage tank	1/1/28	—	5/6/88	D
Phillips 66, Rodeo	b	271	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	272	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	273	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	274	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	275	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	276	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	277	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	278	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	279	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	280	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	281	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	282	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	283	Storage tank	1/1/28	—	4/7/89	D
Phillips 66, Rodeo	b	284	Storage tank	1/1/45	—	4/7/89	D
Phillips 66, Rodeo	b	288	Storage tank	1/1/49	—	7/21/99	D
Phillips 66, Rodeo	b, f	300	Coking	1/1/48	6/1/04	5/1/18	O
Phillips 66, Rodeo	b, f	300	Crude distillation	1/1/48	6/1/04	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Phillips 66, Rodeo	b	304	Hydrotreating	1/1/61	6/1/04	5/1/18	O
Phillips 66, Rodeo	b	305	Hydrotreating	1/1/55	—	5/1/18	O
Phillips 66, Rodeo	b	306	Cat. Reforming	1/1/55	—	5/1/18	O
Phillips 66, Rodeo	b	307	Hydrocracking	1/1/71	—	5/1/18	O
Phillips 66, Rodeo	b	308	Cat. Reforming	1/1/71	—	5/1/18	O
Phillips 66, Rodeo	b	309	Hydrotreating	1/1/71	—	5/1/18	O
Phillips 66, Rodeo	b	310	Crude distillation	1/1/37	—	9/9/88	D
Phillips 66, Rodeo	b	326	Heat/steam/power	5/31/09	—	6/12/09	D
Phillips 66, Rodeo	b	327	Heat/steam/power	5/31/09	—	6/12/09	D
Phillips 66, Rodeo	b	329	Storage tank	4/1/77	—	8/8/89	D
Phillips 66, Rodeo	b	334	Storage tank	1/1/78	—	5/1/18	O
Phillips 66, Rodeo	b	335	Marine terminal	1/1/53	—	7/10/90	D
Phillips 66, Rodeo	b	336	Heat/steam/power	6/2/09	1999	5/1/18	O
Phillips 66, Rodeo	b	337	Heat/steam/power	6/2/09	1999	5/1/18	O
Phillips 66, Rodeo	b	340	Storage tank	6/1/81	—	5/1/18	O
Phillips 66, Rodeo	b	341	Storage tank	10/1/82	—	5/1/18	O
Phillips 66, Rodeo	b	342	Storage tank	9/1/82	—	5/1/18	O
Phillips 66, Rodeo	b	343	Storage tank	8/1/82	—	5/1/18	O
Phillips 66, Rodeo	b	350	Crude distillation	3/12/87	—	5/1/18	O
Phillips 66, Rodeo	b	351	Heat/steam/power	6/11/09	—	5/1/18	O
Phillips 66, Rodeo	b	352	Heat/steam/power	9/29/87	—	5/1/18	O
Phillips 66, Rodeo	b	353	Heat/steam/power	9/29/87	—	5/1/18	O
Phillips 66, Rodeo	b	354	Heat/steam/power	9/29/87	—	5/1/18	O
Phillips 66, Rodeo	b	355	Heat/steam/power	9/29/87	—	5/1/18	O
Phillips 66, Rodeo	b	356	Heat/steam/power	9/29/87	—	5/1/18	O
Phillips 66, Rodeo	b	357	Heat/steam/power	9/29/87	—	5/1/18	O
Phillips 66, Rodeo	b	360	Storage tank	3/16/89	—	5/1/18	O
Phillips 66, Rodeo	b	371	Heat/steam/power	6/11/09	—	5/1/18	O
Phillips 66, Rodeo	b	372	Heat/steam/power	6/11/09	—	5/1/18	O
Phillips 66, Rodeo	b	381	Storage tank	3/29/90	—	5/1/18	O
Phillips 66, Rodeo	b	382	Storage tank	3/29/90	—	5/1/18	O
Phillips 66, Rodeo	b	385	Heat/steam/power	6/13/09	—	5/1/18	O
Phillips 66, Rodeo	b	390	Heat/steam/power	6/13/09	—	5/1/18	O
Phillips 66, Rodeo	b	425	Marine terminal	1/1/55	8/1/96	5/1/18	O
Phillips 66, Rodeo	b	426	Marine terminal	1/1/55	8/1/96	5/1/18	O
Phillips 66, Rodeo	b	430	Storage tank	4/1/91	—	7/21/99	D
Phillips 66, Rodeo	b	431	Storage tank	4/1/91	—	7/21/99	D
Phillips 66, Rodeo	b	433	Storage tank	6/23/92	—	5/1/18	O
Phillips 66, Rodeo	b	434	Hydrocracking	10/14/09	—	5/1/18	O
Phillips 66, Rodeo	b	437	Hydrogen plant	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	438	Heat/steam/power	6/21/09	—	5/1/18	O
Phillips 66, Rodeo	b	439	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	440	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	442	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	444	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	445	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	446	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	447	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	448	Storage tank	10/1/98	—	5/1/18	O
Phillips 66, Rodeo	b	449	Storage tank	5/8/95	—	5/1/18	O
Phillips 66, Rodeo	b	451	Storage tank	6/19/02	—	5/1/18	O
Phillips 66, Rodeo	b	460	Hydrotreating	3/12/05	—	5/1/18	O
Phillips 66, Rodeo	b	461	Heat/steam/power	6/28/09	—	5/1/18	O
Phillips 66, Rodeo	b	464	Hydrogen plant	1/1/71	—	6/10/14	D
Phillips 66, Rodeo	b	506	Storage tank	1/28/08	—	5/1/18	O
Phillips 66, Rodeo	b	1001	Sulfur recovery	1/1/55	—	11/30/11	D
Phillips 66, Rodeo	b	1002	Sulfur recovery	1/1/71	—	5/1/18	O
Phillips 66, Rodeo	b	1003	Sulfur recovery	1/1/75	—	5/1/18	O
Phillips 66, Rodeo	b	1005	Storage tank	1/1/80	—	7/21/99	D
Phillips 66, Rodeo	b	1006	Storage tank	1/1/80	—	7/21/99	D
Phillips 66, Rodeo	b	1010	Sulfur recovery	6/24/10	—	5/1/18	O
Phillips 66, Nipomo	d	B-1	Coking	12/31/55	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Phillips 66, Nipomo	d	C	Coking	12/31/55	—	5/1/18	O
Phillips 66, Nipomo	d	D-1	Crude distillation	12/31/55	—	5/1/18	O
Shell, Martinez	b	3	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	4	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	9	Storage tank	1/1/28	—	5/15/89	D
Shell, Martinez	b	13	Storage tank	1/1/28	9/16/96	5/1/18	O
Shell, Martinez	b	14	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	19	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	20	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	21	Storage tank	1/1/28	6/24/91	5/1/18	O
Shell, Martinez	b	22	Storage tank	1/1/28	6/24/91	5/1/18	O
Shell, Martinez	b	23	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	24	Storage tank	6/24/91	—	5/1/18	O
Shell, Martinez	b	25	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	26	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	30	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	31	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	32	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	34	Storage tank	1/1/28	6/24/91	5/1/18	O
Shell, Martinez	b	35	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	36	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	38	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	42	Storage tank	1/1/28	—	10/18/00	D
Shell, Martinez	b	43	Storage tank	1/1/28	—	6/27/00	D
Shell, Martinez	b	46	Storage tank	1/1/28	—	10/18/00	D
Shell, Martinez	b	56	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	58	Storage tank	1/1/28	—	10/18/00	D
Shell, Martinez	b	59	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	61	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	63	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	64	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	74	Storage tank	1/1/28	—	7/28/95	D
Shell, Martinez	b	84	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	90	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	91	Storage tank	1/1/28	—	6/22/95	D
Shell, Martinez	b	92	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	93	Storage tank	1/1/28	—	6/22/95	D
Shell, Martinez	b	94	Storage tank	1/1/28	—	6/22/95	D
Shell, Martinez	b	95	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	96	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	98	Storage tank	1/1/28	—	6/22/95	D
Shell, Martinez	b	99	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	100	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	101	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	102	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	103	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	104	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	105	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	106	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	107	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	108	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	109	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	110	Storage tank	1/1/28	—	6/22/95	D
Shell, Martinez	b	111	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	112	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	113	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	124	Storage tank	1/1/28	—	7/28/95	D
Shell, Martinez	b	125	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	126	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	127	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	129	Storage tank	1/1/28	—	4/28/06	D
Shell, Martinez	b	158	Storage tank	1/1/28	—	2/15/00	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	159	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	178	Storage tank	1/1/28	—	8/13/01	D
Shell, Martinez	b	179	Storage tank	1/1/28	—	8/13/01	D
Shell, Martinez	b	185	Storage tank	1/1/28	—	3/6/86	D
Shell, Martinez	b	191	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	197	Storage tank	1/1/28	—	8/10/92	D
Shell, Martinez	b	198	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	206	Storage tank	1/1/61	—	9/25/86	D
Shell, Martinez	b	210	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	211	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	212	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	213	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	220	Storage tank	1/1/28	—	8/4/87	D
Shell, Martinez	b	224	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	226	Storage tank	1/1/28	—	7/17/01	D
Shell, Martinez	b	227	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	253	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	254	Storage tank	1/1/28	—	7/18/90	D
Shell, Martinez	b	257	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	259	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	260	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	261	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	262	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	264	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	265	Storage tank	1/1/28	—	6/27/00	D
Shell, Martinez	b	268	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	269	Storage tank	1/1/28	—	8/8/94	D
Shell, Martinez	b	299	Storage tank	1/1/28	—	8/10/92	D
Shell, Martinez	b	300	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	331	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	340	Storage tank	1/1/28	—	6/27/00	D
Shell, Martinez	b	341	Storage tank	1/1/28	—	6/27/00	D
Shell, Martinez	b	342	Storage tank	1/1/28	—	8/8/94	D
Shell, Martinez	b	343	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	344	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	355	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	364	Storage tank	1/1/28	—	8/13/01	D
Shell, Martinez	b	365	Storage tank	1/1/28	—	8/13/01	D
Shell, Martinez	b	366	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	368	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	369	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	370	Storage tank	1/1/28	—	8/8/94	D
Shell, Martinez	b	372	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	382	Storage tank	1/1/28	—	8/10/92	D
Shell, Martinez	b	383	Storage tank	1/1/28	—	9/25/86	D
Shell, Martinez	b	384	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	385	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	386	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	387	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	388	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	389	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	390	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	391	Storage tank	1/1/28	—	8/10/92	D
Shell, Martinez	b	396	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	397	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	398	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	419	Storage tank	1/1/28	—	4/27/04	D
Shell, Martinez	b	421	Storage tank	1/1/29	—	12/3/91	D
Shell, Martinez	b	422	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	423	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	424	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	425	Storage tank	1/1/28	—	8/22/97	D

Refining Facility	(notes)	Equipment Unit ID#[a]	Type	Age and Operational Data (dates) Startup	Rebuild	End-date	Status
Shell, Martinez	b	426	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	427	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	428	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	431	Storage tank	1/1/28	—	6/12/02	D
Shell, Martinez	b	432	Storage tank	1/1/28	6/24/91	5/1/18	O
Shell, Martinez	b	436	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	437	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	438	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	439	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	440	Storage tank	1/1/28	—	2/15/00	D
Shell, Martinez	b	441	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	442	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	443	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	444	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	446	Storage tank	1/1/28	—	7/14/86	D
Shell, Martinez	b	447	Storage tank	9/1/82	—	12/3/91	D
Shell, Martinez	b	448	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	456	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	457	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	458	Storage tank	1/1/28	—	7/28/95	D
Shell, Martinez	b	459	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	460	Storage tank	1/1/28	—	7/17/01	D
Shell, Martinez	b	462	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	463	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	464	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	465	Storage tank	1/1/28	—	3/6/86	D
Shell, Martinez	b	467	Storage tank	1/1/28	—	4/27/04	D
Shell, Martinez	b	468	Storage tank	1/1/28	—	4/27/04	D
Shell, Martinez	b	473	Storage tank	1/1/28	—	6/22/95	D
Shell, Martinez	b	480	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	483	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	484	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	491	Storage tank	1/1/28	—	12/3/91	D
Shell, Martinez	b	492	Storage tank	1/1/28	—	4/25/01	D
Shell, Martinez	b	493	Storage tank	1/1/28	—	4/25/01	D
Shell, Martinez	b	497	Storage tank	1/1/28	6/24/91	5/1/18	O
Shell, Martinez	b	498	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	505	Storage tank	1/1/28	—	8/22/97	D
Shell, Martinez	b	509	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	514	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	520	Storage tank	1/1/28	—	10/18/00	D
Shell, Martinez	b	522	Storage tank	1/1/28	—	8/13/01	D
Shell, Martinez	b	523	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	524	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	525	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	526	Storage tank	1/1/28	—	8/24/04	D
Shell, Martinez	b	527	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	528	Storage tank	1/1/28	—	12/19/96	D
Shell, Martinez	b	529	Storage tank	1/1/29	—	6/27/00	D
Shell, Martinez	b	530	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	531	Storage tank	1/1/28	—	8/8/94	D
Shell, Martinez	b	532	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	533	Storage tank	1/1/28	—	4/28/89	D
Shell, Martinez	b	534	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	538	Storage tank	1/1/28	—	8/8/94	D
Shell, Martinez	b	539	Storage tank	1/1/28	—	8/8/94	D
Shell, Martinez	b	540	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	541	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	544	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	545	Storage tank	1/1/29	—	5/1/18	O
Shell, Martinez	b	548	Storage tank	1/1/29	—	5/1/18	O
Shell, Martinez	b	549	Storage tank	1/1/29	—	4/27/04	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	552	Storage tank	1/1/29	3/26/91	5/1/18	O
Shell, Martinez	b	553	Storage tank	1/1/29	3/26/91	5/1/18	O
Shell, Martinez	b	554	Storage tank	1/1/29	3/26/91	5/1/18	O
Shell, Martinez	b	555	Storage tank	1/1/29	3/26/91	5/1/18	O
Shell, Martinez	b	556	Storage tank	1/1/29	6/24/91	5/1/18	O
Shell, Martinez	b	557	Storage tank	1/1/29	6/24/91	5/1/18	O
Shell, Martinez	b	558	Storage tank	1/1/29	3/26/91	5/1/18	O
Shell, Martinez	b	559	Storage tank	1/1/29	6/24/91	5/1/18	O
Shell, Martinez	b	560	Storage tank	1/1/29	3/26/91	5/1/18	O
Shell, Martinez	b	561	Storage tank	1/1/29	3/26/91	5/1/18	O
Shell, Martinez	b	563	Storage tank	1/1/29	—	8/13/01	D
Shell, Martinez	b	567	Storage tank	1/1/29	6/24/91	5/1/18	O
Shell, Martinez	b	568	Storage tank	1/1/30	6/24/91	5/1/18	O
Shell, Martinez	b	571	Storage tank	1/1/30	6/24/91	5/1/18	O
Shell, Martinez	b	572	Storage tank	1/1/30	6/24/91	5/1/18	O
Shell, Martinez	b	573	Storage tank	1/1/30	6/24/91	5/1/18	O
Shell, Martinez	b	598	Storage tank	1/1/30	6/24/91	5/1/18	O
Shell, Martinez	b	610	Storage tank	1/1/28	—	5/1/18	O
Shell, Martinez	b	611	Storage tank	1/1/29	—	5/1/18	O
Shell, Martinez	b	612	Storage tank	1/1/29	—	5/1/18	O
Shell, Martinez	b	613	Storage tank	1/1/29	—	5/1/18	O
Shell, Martinez	b	715	Storage tank	1/1/32	—	7/14/86	D
Shell, Martinez	b	750	Storage tank	1/1/34	—	12/3/91	D
Shell, Martinez	b	751	Storage tank	1/1/34	—	12/3/91	D
Shell, Martinez	b	786	Storage tank	1/1/35	—	8/24/04	D
Shell, Martinez	b	787	Storage tank	1/1/37	—	8/24/04	D
Shell, Martinez	b	788	Storage tank	1/1/35	—	8/24/04	D
Shell, Martinez	b	803	Storage tank	1/1/35	—	7/14/86	D
Shell, Martinez	b	804	Storage tank	1/1/35	—	8/24/04	D
Shell, Martinez	b	807	Storage tank	1/1/36	—	7/14/86	D
Shell, Martinez	b	808	Storage tank	1/1/36	—	7/14/86	D
Shell, Martinez	b	815	Storage tank	1/1/37	3/26/91	5/1/18	O
Shell, Martinez	b	816	Storage tank	1/1/37	—	10/3/02	D
Shell, Martinez	b	817	Storage tank	1/1/37	—	2/15/00	D
Shell, Martinez	b	818	Storage tank	1/1/37	—	12/3/91	D
Shell, Martinez	b	819	Storage tank	1/1/37	—	8/22/97	D
Shell, Martinez	b	820	Storage tank	1/1/37	—	6/27/00	D
Shell, Martinez	b	822	Storage tank	1/1/37	—	8/24/04	D
Shell, Martinez	b	824	Storage tank	1/1/37	—	6/20/94	D
Shell, Martinez	b	825	Storage tank	1/1/37	—	6/20/94	D
Shell, Martinez	b	826	Storage tank	1/1/37	—	4/25/01	D
Shell, Martinez	b	827	Storage tank	9/1/82	—	7/18/90	D
Shell, Martinez	b	832	Storage tank	1/1/37	—	2/15/00	D
Shell, Martinez	b	836	Storage tank	1/1/38	—	2/15/00	D
Shell, Martinez	b	837	Storage tank	1/1/38	—	8/24/01	D
Shell, Martinez	b	838	Storage tank	1/1/38	—	2/15/00	D
Shell, Martinez	b	847	Storage tank	1/1/38	—	8/13/01	D
Shell, Martinez	b	849	Storage tank	1/1/39	—	8/13/01	D
Shell, Martinez	b	856	Storage tank	1/1/39	—	5/1/18	O
Shell, Martinez	b	858	Storage tank	1/1/39	—	8/24/04	D
Shell, Martinez	b	859	Storage tank	1/1/39	—	4/7/89	D
Shell, Martinez	b	860	Storage tank	1/1/54	—	8/24/04	D
Shell, Martinez	b	861	Storage tank	1/1/55	—	8/24/04	D
Shell, Martinez	b	864	Storage tank	1/1/39	—	8/13/01	D
Shell, Martinez	b	866	Storage tank	1/1/39	—	12/3/91	D
Shell, Martinez	b	867	Storage tank	1/1/39	6/24/91	5/1/18	O
Shell, Martinez	b	868	Storage tank	1/1/39	6/24/91	5/1/18	O
Shell, Martinez	b	870	Storage tank	1/1/39	—	12/3/91	D
Shell, Martinez	b	871	Storage tank	1/1/39	—	9/25/86	D
Shell, Martinez	b	876	Storage tank	1/1/40	6/24/91	5/1/18	O
Shell, Martinez	b	877	Storage tank	1/1/40	—	8/24/04	D
Shell, Martinez	b	880	Storage tank	1/1/41	—	8/24/04	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	886	Storage tank	1/1/41	—	12/19/96	D
Shell, Martinez	b	887	Storage tank	1/1/41	—	12/3/91	D
Shell, Martinez	b	892	Storage tank	1/1/42	—	6/27/00	D
Shell, Martinez	b	900	Storage tank	1/1/44	—	2/15/00	D
Shell, Martinez	b	904	Storage tank	1/1/44	—	6/22/95	D
Shell, Martinez	b	905	Storage tank	1/1/44	—	2/15/00	D
Shell, Martinez	b	916	Storage tank	1/1/44	—	5/15/89	D
Shell, Martinez	b	917	Storage tank	1/1/44	—	5/15/89	D
Shell, Martinez	b	919	Storage tank	1/1/44	—	5/15/89	D
Shell, Martinez	b	923	Storage tank	1/1/45	—	12/13/94	D
Shell, Martinez	b	924	Storage tank	1/1/46	—	6/27/00	D
Shell, Martinez	b	926	Storage tank	1/1/45	—	8/24/04	D
Shell, Martinez	b	927	Storage tank	1/1/45	—	8/24/04	D
Shell, Martinez	b	942	Storage tank	1/1/46	—	8/24/04	D
Shell, Martinez	b	947	Storage tank	1/1/46	—	12/19/96	D
Shell, Martinez	b	949	Storage tank	1/1/47	—	8/22/97	D
Shell, Martinez	b	950	Storage tank	1/1/47	—	12/19/96	D
Shell, Martinez	b	951	Storage tank	1/1/47	—	12/19/96	D
Shell, Martinez	b	952	Storage tank	1/1/47	—	5/1/18	O
Shell, Martinez	b	957	Storage tank	1/1/47	—	8/24/04	D
Shell, Martinez	b	958	Storage tank	1/1/47	—	8/24/04	D
Shell, Martinez	b	961	Storage tank	1/1/47	6/24/91	5/1/18	O
Shell, Martinez	b	963	Storage tank	1/1/47	—	12/19/96	D
Shell, Martinez	b	969	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	970	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	971	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	972	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	973	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	974	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	978	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	979	Storage tank	1/1/48	—	7/14/86	D
Shell, Martinez	b	982	Storage tank	1/1/48	—	6/27/00	D
Shell, Martinez	b	984	Storage tank	1/1/48	—	8/10/92	D
Shell, Martinez	b	985	Storage tank	1/1/48	6/24/91	5/1/18	O
Shell, Martinez	b	989	Storage tank	1/1/49	—	6/27/00	D
Shell, Martinez	b	991	Storage tank	1/1/49	—	12/3/91	D
Shell, Martinez	b	992	Storage tank	1/1/50	—	5/1/18	O
Shell, Martinez	b	993	Storage tank	1/1/49	—	8/24/04	D
Shell, Martinez	b	994	Storage tank	1/1/50	—	8/8/94	D
Shell, Martinez	b	995	Storage tank	1/1/50	—	4/7/89	D
Shell, Martinez	b	1000	Storage tank	1/1/50	—	8/24/04	D
Shell, Martinez	b	1001	Storage tank	1/1/51	—	4/27/04	D
Shell, Martinez	b	1002	Storage tank	1/1/51	—	4/19/89	D
Shell, Martinez	b	1003	Storage tank	1/1/51	—	4/27/04	D
Shell, Martinez	b	1004	Storage tank	1/1/52	—	8/24/04	D
Shell, Martinez	b	1005	Storage tank	1/1/51	—	4/27/04	D
Shell, Martinez	b	1006	Storage tank	1/1/51	8/1/91	5/1/18	O
Shell, Martinez	b	1007	Storage tank	1/1/51	—	8/8/94	D
Shell, Martinez	b	1008	Storage tank	1/1/51	—	12/3/91	D
Shell, Martinez	b	1009	Storage tank	1/1/51	—	4/27/04	D
Shell, Martinez	b	1010	Storage tank	1/1/51	—	6/22/95	D
Shell, Martinez	b	1011	Storage tank	1/1/51	—	12/19/96	D
Shell, Martinez	b	1013	Storage tank	1/1/51	—	4/27/04	D
Shell, Martinez	b	1014	Storage tank	1/1/52	—	7/18/90	D
Shell, Martinez	b	1016	Storage tank	1/1/53	—	12/19/96	D
Shell, Martinez	b	1017	Storage tank	1/1/53	6/24/91	5/1/18	O
Shell, Martinez	b	1018	Storage tank	1/1/53	6/24/91	5/1/18	O
Shell, Martinez	b	1023	Storage tank	1/1/54	—	8/24/04	D
Shell, Martinez	b	1024	Storage tank	1/1/54	—	8/24/04	D
Shell, Martinez	b	1025	Storage tank	1/1/54	—	12/19/96	D
Shell, Martinez	b	1026	Storage tank	1/1/54	—	8/24/04	D
Shell, Martinez	b	1031	Storage tank	1/1/56	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	1038	Storage tank	1/1/56	—	12/3/91	D
Shell, Martinez	b	1041	Storage tank	1/1/56	6/24/91	5/1/18	O
Shell, Martinez	b	1042	Storage tank	1/1/56	—	6/27/00	D
Shell, Martinez	b	1043	Storage tank	1/1/56	—	5/1/18	O
Shell, Martinez	b	1044	Storage tank	1/1/56	3/26/91	5/1/18	O
Shell, Martinez	b	1045	Storage tank	1/1/56	3/26/91	5/1/18	O
Shell, Martinez	b	1046	Storage tank	1/1/56	—	5/1/18	O
Shell, Martinez	b	1048	Storage tank	1/1/59	3/26/91	5/1/18	O
Shell, Martinez	b	1050	Storage tank	1/1/60	—	8/24/04	D
Shell, Martinez	b	1051	Storage tank	1/1/60	—	5/1/18	O
Shell, Martinez	b	1063	Storage tank	1/1/62	—	5/1/18	O
Shell, Martinez	b	1064	Storage tank	1/1/62	—	8/22/97	D
Shell, Martinez	b	1065	Storage tank	1/1/63	—	12/16/91	D
Shell, Martinez	b	1067	Storage tank	1/1/63	—	5/1/18	O
Shell, Martinez	b	1070	Storage tank	1/1/63	—	5/1/18	O
Shell, Martinez	b	1071	Storage tank	1/1/63	—	8/24/04	D
Shell, Martinez	b	1072	Storage tank	1/1/64	—	5/1/18	O
Shell, Martinez	b	1076	Storage tank	1/1/68	—	5/1/18	O
Shell, Martinez	b	1077	Storage tank	4/7/88	—	5/1/18	O
Shell, Martinez	b	1101	Storage tank	1/1/65	—	10/9/87	D
Shell, Martinez	b	1102	Storage tank	1/1/65	—	8/22/97	D
Shell, Martinez	b	1108	Storage tank	1/1/65	—	7/14/86	D
Shell, Martinez	b	1114	Storage tank	6/26/92	—	5/1/18	O
Shell, Martinez	b	1115	Storage tank	6/26/92	—	5/1/18	O
Shell, Martinez	b	1116	Storage tank	7/20/92	—	5/1/18	O
Shell, Martinez	b	1117	Storage tank	3/9/95	—	5/1/18	O
Shell, Martinez	b	1127	Storage tank	1/1/64	—	1/4/95	D
Shell, Martinez	b	1128	Storage tank	8/1/15	—	5/1/18	O
Shell, Martinez	b	1129	Storage tank	10/1/82	—	5/1/18	O
Shell, Martinez	b	1130	Storage tank	12/1/82	—	5/1/18	O
Shell, Martinez	b	1131	Storage tank	9/1/82	—	5/1/18	O
Shell, Martinez	b	1133	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1134	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1136	Storage tank	1/1/65	—	8/13/01	D
Shell, Martinez	b	1137	Storage tank	1/1/65	—	8/13/01	D
Shell, Martinez	b	1139	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1140	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1141	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1146	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1147	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1157	Storage tank	1/1/66	—	8/22/97	D
Shell, Martinez	b	1158	Storage tank	1/1/66	—	8/8/94	D
Shell, Martinez	b	1159	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1160	Storage tank	1/1/65	6/24/91	5/1/18	O
Shell, Martinez	b	1161	Storage tank	1/1/65	—	5/1/18	O
Shell, Martinez	b	1176	Storage tank	1/1/71	—	7/14/86	D
Shell, Martinez	b	1185	Storage tank	1/1/71	—	8/24/04	D
Shell, Martinez	b	1186	Storage tank	1/1/71	—	5/1/18	O
Shell, Martinez	b	1188	Storage tank	1/1/71	—	7/14/86	D
Shell, Martinez	b	1191	Storage tank	10/4/84	—	5/1/18	O
Shell, Martinez	b	1192	Storage tank	10/4/84	—	5/1/18	O
Shell, Martinez	b	1204	Storage tank	1/1/58	—	7/14/86	D
Shell, Martinez	b	1205	Storage tank	1/1/63	—	5/1/18	O
Shell, Martinez	b	1206	Storage tank	1/1/30	—	5/1/18	O
Shell, Martinez	b	1207	Storage tank	1/1/30	—	5/1/18	O
Shell, Martinez	b	1208	Storage tank	1/1/47	—	7/14/86	D
Shell, Martinez	b	1225	Storage tank	1/1/66	—	5/1/18	O
Shell, Martinez	b	1226	Storage tank	1/1/66	—	5/1/18	O
Shell, Martinez	b	1227	Storage tank	1/1/30	—	5/1/18	O
Shell, Martinez	b	1228	Storage tank	1/1/56	—	5/1/18	O
Shell, Martinez	b	1229	Storage tank	1/1/63	—	5/1/18	O
Shell, Martinez	b	1230	Storage tank	1/1/49	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	1232	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1233	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1234	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1235	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1236	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1237	Storage tank	1/1/44	—	5/1/18	O
Shell, Martinez	b	1238	Storage tank	1/1/44	—	5/1/18	O
Shell, Martinez	b	1239	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1240	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1241	Storage tank	1/1/57	—	5/1/18	O
Shell, Martinez	b	1242	Storage tank	1/1/35	—	5/1/18	O
Shell, Martinez	b	1243	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1244	Storage tank	1/1/35	—	9/25/86	D
Shell, Martinez	b	1245	Storage tank	1/1/35	—	9/25/86	D
Shell, Martinez	b	1246	Storage tank	1/1/35	—	5/1/18	O
Shell, Martinez	b	1247	Storage tank	1/1/35	—	5/1/18	O
Shell, Martinez	b	1248	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1249	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1250	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1251	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1252	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1253	Storage tank	1/1/35	—	5/1/18	O
Shell, Martinez	b	1254	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1255	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1256	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1257	Storage tank	1/1/58	—	5/1/18	O
Shell, Martinez	b	1258	Storage tank	1/1/66	—	5/1/18	O
Shell, Martinez	b	1259	Storage tank	1/1/46	—	5/1/08	O
Shell, Martinez	b	1260	Storage tank	1/1/46	—	5/1/08	O
Shell, Martinez	b	1261	Storage tank	1/1/34	—	7/14/86	D
Shell, Martinez	b	1262	Storage tank	1/1/34	—	8/22/97	D
Shell, Martinez	b	1263	Storage tank	1/1/54	—	9/25/86	D
Shell, Martinez	b	1264	Storage tank	1/1/55	—	9/25/86	D
Shell, Martinez	b	1265	Storage tank	1/1/55	—	9/25/86	D
Shell, Martinez	b	1266	Storage tank	1/1/55	—	5/1/18	O
Shell, Martinez	b	1267	Storage tank	1/1/56	—	7/14/86	D
Shell, Martinez	b	1268	Storage tank	1/1/56	—	7/14/86	D
Shell, Martinez	b	1269	Storage tank	1/1/56	—	7/14/86	D
Shell, Martinez	b	1270	Storage tank	1/1/66	—	8/8/94	D
Shell, Martinez	b	1271	Storage tank	1/1/57	—	9/25/86	D
Shell, Martinez	b	1272	Storage tank	1/1/65	—	8/8/94	D
Shell, Martinez	b	1273	Storage tank	1/1/65	—	9/25/86	D
Shell, Martinez	b	1274	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1275	Storage tank	1/1/33	—	7/14/86	D
Shell, Martinez	b	1276	Storage tank	1/1/55	—	8/8/94	D
Shell, Martinez	b	1277	Storage tank	1/1/57	—	8/8/94	D
Shell, Martinez	b	1278	Storage tank	1/1/57	—	8/8/94	D
Shell, Martinez	b	1279	Storage tank	1/1/52	—	5/1/18	O
Shell, Martinez	b	1280	Storage tank	1/1/50	—	5/1/18	O
Shell, Martinez	b	1281	Storage tank	1/1/50	—	5/1/18	O
Shell, Martinez	b	1282	Storage tank	1/1/50	—	5/1/18	O
Shell, Martinez	b	1283	Storage tank	1/1/50	—	5/1/18	O
Shell, Martinez	b	1285	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1286	Storage tank	1/1/55	—	5/1/18	O
Shell, Martinez	b	1287	Storage tank	1/1/63	—	5/1/18	O
Shell, Martinez	b	1288	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1289	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1290	Storage tank	1/1/46	—	5/1/08	O
Shell, Martinez	b	1291	Storage tank	1/1/46	—	5/1/08	O
Shell, Martinez	b	1292	Storage tank	1/1/46	—	5/1/08	O
Shell, Martinez	b	1293	Storage tank	1/1/46	—	5/1/08	O
Shell, Martinez	b	1294	Storage tank	1/1/52	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	1295	Storage tank	1/1/52	—	7/14/86	D
Shell, Martinez	b	1296	Storage tank	1/1/49	—	5/1/18	O
Shell, Martinez	b	1297	Storage tank	1/1/49	—	5/1/18	O
Shell, Martinez	b	1298	Storage tank	1/1/48	—	5/1/08	O
Shell, Martinez	b	1299	Storage tank	1/1/49	—	5/1/18	O
Shell, Martinez	b	1300	Storage tank	1/1/54	—	5/1/18	O
Shell, Martinez	b	1301	Storage tank	1/1/54	—	5/1/18	O
Shell, Martinez	b	1302	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1303	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1304	Storage tank	1/1/48	—	5/1/08	O
Shell, Martinez	b	1305	Storage tank	1/1/67	—	5/1/18	O
Shell, Martinez	b	1306	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1307	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1308	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1309	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1310	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1311	Storage tank	1/1/48	—	9/25/86	D
Shell, Martinez	b	1312	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1313	Storage tank	1/1/51	—	5/1/18	O
Shell, Martinez	b	1314	Storage tank	1/1/48	—	5/1/08	O
Shell, Martinez	b	1315	Storage tank	1/1/48	—	5/1/08	O
Shell, Martinez	b	1316	Storage tank	1/1/48	—	5/1/08	O
Shell, Martinez	b	1317	Storage tank	1/1/49	—	9/25/86	D
Shell, Martinez	b	1318	Storage tank	1/1/52	—	9/25/86	D
Shell, Martinez	b	1319	Storage tank	1/1/49	—	9/25/86	D
Shell, Martinez	b	1320	Storage tank	1/1/52	—	5/1/18	O
Shell, Martinez	b	1321	Storage tank	1/1/54	—	9/25/86	D
Shell, Martinez	b	1322	Storage tank	1/1/51	—	7/14/86	D
Shell, Martinez	b	1323	Storage tank	1/1/51	—	9/25/86	D
Shell, Martinez	b	1324	Storage tank	1/1/51	—	9/25/86	D
Shell, Martinez	b	1325	Storage tank	1/1/55	—	9/25/86	D
Shell, Martinez	b	1326	Storage tank	1/1/56	—	5/1/18	O
Shell, Martinez	b	1327	Storage tank	1/1/56	—	5/1/18	O
Shell, Martinez	b	1328	Storage tank	1/1/56	—	5/1/18	O
Shell, Martinez	b	1329	Storage tank	1/1/57	—	5/1/18	O
Shell, Martinez	b	1330	Storage tank	1/1/53	—	5/1/18	O
Shell, Martinez	b	1331	Storage tank	1/1/66	—	8/22/97	D
Shell, Martinez	b	1365	Storage tank	1/1/56	—	5/1/18	O
Shell, Martinez	b	1373	Storage tank	1/1/64	—	7/18/90	D
Shell, Martinez	b	1374	Storage tank	1/1/63	—	5/1/18	O
Shell, Martinez	b	1375	Storage tank	1/1/34	—	5/1/18	O
Shell, Martinez	b	1377	Storage tank	1/1/34	—	7/14/86	D
Shell, Martinez	b	1378	Storage tank	1/1/34	—	7/14/86	D
Shell, Martinez	b	1379	Storage tank	1/1/53	—	7/14/86	D
Shell, Martinez	b	1380	Storage tank	1/1/53	—	7/14/86	D
Shell, Martinez	b	1381	Storage tank	1/1/47	—	7/14/86	D
Shell, Martinez	b	1382	Storage tank	1/1/66	—	7/14/86	D
Shell, Martinez	b	1383	Storage tank	1/1/55	—	7/14/86	D
Shell, Martinez	b	1384	Storage tank	1/1/57	—	5/1/18	O
Shell, Martinez	b	1385	Storage tank	1/1/57	—	7/14/86	D
Shell, Martinez	b	1386	Storage tank	1/1/63	—	5/1/18	O
Shell, Martinez	b	1387	Storage tank	1/1/64	—	7/14/86	D
Shell, Martinez	b	1388	Storage tank	1/1/66	—	5/1/18	O
Shell, Martinez	b	1389	Storage tank	1/1/56	—	7/14/86	D
Shell, Martinez	b	1390	Storage tank	1/1/51	—	8/8/94	D
Shell, Martinez	b	1391	Storage tank	1/1/53	—	10/4/94	D
Shell, Martinez	b	1392	Storage tank	1/1/49	—	7/14/86	D
Shell, Martinez	b	1393	Storage tank	1/1/34	—	7/14/86	D
Shell, Martinez	b	1394	Heat/steam/power	5/8/09	—	6/7/09	D
Shell, Martinez	b	1395	Heat/steam/power	5/10/09	—	6/7/09	D
Shell, Martinez	b	1400	Heat/steam/power	5/25/09	—	6/17/09	D
Shell, Martinez	b	1411	Crude distillation	1/1/38	—	7/8/05	D

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	1412	Crude distillation	1/1/37	—	7/8/05	D
Shell, Martinez	b	1416	Hydrotreating	1/1/61	—	7/25/06	D
Shell, Martinez	b	1417	Hydrotreating	1/1/72	—	5/1/18	O
Shell, Martinez	b	1420	Crude distillation	1/1/66	—	5/1/18	O
Shell, Martinez	b	1421	Crude distillation	1/1/66	—	5/1/18	O
Shell, Martinez	b	1423	Hydrotreating	1/1/66	—	5/1/18	O
Shell, Martinez	b	1424	Hydrotreating	1/1/66	—	5/1/18	O
Shell, Martinez	b	1425	Cat. Reforming	1/1/66	—	5/1/18	O
Shell, Martinez	b	1426	Cat. Cracking	1/1/66	—	5/1/18	O
Shell, Martinez	b	1428	Hydrotreating	1/1/66	—	5/1/18	O
Shell, Martinez	b	1429	Hydrotreating	1/1/66	—	5/1/18	O
Shell, Martinez	b	1430	Alkylation	1/1/66	—	5/1/18	O
Shell, Martinez	b	1431	Sulfur recovery	1/1/66	10/30/81	5/1/18	O
Shell, Martinez	b	1432	Sulfur recovery	1/1/74	10/29/81	5/1/18	O
Shell, Martinez	b	1433	Hydrotreating	1/1/66	—	5/1/18	O
Shell, Martinez	b	1445	Hydrogen plant	1/1/66	—	5/1/18	O
Shell, Martinez	b	1449	Hydrocracking	1/1/66	—	5/1/18	O
Shell, Martinez	b	1473	Heat/steam/power	4/30/09	—	6/7/09	D
Shell, Martinez	b	1474	Heat/steam/power	4/26/09	—	6/9/09	D
Shell, Martinez	b	1475	Heat/steam/power	4/12/09	—	6/7/09	D
Shell, Martinez	b	1476	Heat/steam/power	4/22/09	—	6/28/09	D
Shell, Martinez	b	1477	Heat/steam/power	4/19/09	—	6/28/09	D
Shell, Martinez	b	1478	Heat/steam/power	4/22/09	—	6/27/09	D
Shell, Martinez	b	1479	Heat/steam/power	4/22/09	—	6/27/09	D
Shell, Martinez	b	1480	Heat/steam/power	4/13/09	—	5/1/18	O
Shell, Martinez	b	1481	Heat/steam/power	5/8/09	—	5/1/18	O
Shell, Martinez	b	1483	Heat/steam/power	5/13/09	—	5/1/18	O
Shell, Martinez	b	1484	Heat/steam/power	5/15/09	—	6/29/09	D
Shell, Martinez	b	1485	Heat/steam/power	5/20/09	—	6/12/09	D
Shell, Martinez	b	1486	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1487	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1488	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1489	Heat/steam/power	5/20/09	—	6/16/09	D
Shell, Martinez	b	1490	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1491	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1492	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1493	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1494	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1495	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1496	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1497	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1498	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1499	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1500	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1502	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1503	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1504	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1505	Heat/steam/power	5/20/09	1988	5/1/18	O
Shell, Martinez	b	1506	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1507	Heat/steam/power	1/1/66	1/21/80	5/1/18	O
Shell, Martinez	b	1508	Heat/steam/power	5/20/09	1994	5/1/18	O
Shell, Martinez	b	1509	Heat/steam/power	1/1/66	—	5/1/18	O
Shell, Martinez	b	1510	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1511	Heat/steam/power	5/20/09	—	5/1/18	O
Shell, Martinez	b	1512	Heat/steam/power	1/1/66	1/21/80	5/1/18	O
Shell, Martinez	b	1513	Heat/steam/power	5/20/09	—	6/8/09	D
Shell, Martinez	b	1514	Heat/steam/power	1/1/70	—	5/1/18	O
Shell, Martinez	b	1515	Heat/steam/power	5/25/09	—	5/1/18	O
Shell, Martinez	b	1516	Heat/steam/power	5/24/09	—	6/7/09	D
Shell, Martinez	b	1705	Storage tank	1/1/80	—	8/4/87	D
Shell, Martinez	b	1751	Storage tank	2/1/82	—	5/1/18	O
Shell, Martinez	b	1752	Storage tank	2/1/82	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Shell, Martinez	b	1759	Coking	1/1/83	—	5/1/18	O
Shell, Martinez	b	1760	Heat/steam/power	5/15/09	2003	5/1/18	O
Shell, Martinez	b	1761	Heat/steam/power	5/15/09	—	5/1/18	O
Shell, Martinez	b	1762	Heat/steam/power	5/15/09	1994	5/1/18	O
Shell, Martinez	b	1763	Heat/steam/power	5/15/09	—	5/1/18	O
Shell, Martinez	b	1765	Sulfur recovery	1/1/83	8/1/91	5/1/18	O
Shell, Martinez	b	1774	Hydrogen plant	1/1/82	—	5/1/18	O
Shell, Martinez	b	1800	Heat/steam/power	6/1/85	—	5/1/18	O
Shell, Martinez	b	2001	Marine terminal	1/1/65	—	5/1/18	O
Shell, Martinez	b	2002	Marine terminal	1/1/65	—	5/1/18	O
Shell, Martinez	b	2003	Marine terminal	1/1/65	—	5/1/18	O
Shell, Martinez	b	2004	Marine terminal	1/1/65	—	5/1/18	O
Shell, Martinez	b	2013	Storage tank	12/3/93	—	5/1/18	O
Shell, Martinez	b	2116	Storage tank	4/12/94	—	4/4/95	D
Shell, Martinez	b	2445	Storage tank	1/27/93	—	5/1/18	O
Shell, Martinez	b	2446	Storage tank	1/27/93	—	5/1/18	O
Shell, Martinez	b	4001	Coking	11/26/96	—	5/1/18	O
Shell, Martinez	b	4002	Heat/steam/power	6/19/09	—	5/1/18	O
Shell, Martinez	b	4003	Heat/steam/power	6/19/09	—	5/1/18	O
Shell, Martinez	b	4020	Hydrotreating	10/22/96	—	5/1/18	O
Shell, Martinez	b	4021	Heat/steam/power	6/18/09	2000	5/1/18	O
Shell, Martinez	b	4031	Heat/steam/power	6/18/09	—	5/1/18	O
Shell, Martinez	b	4140	Hydrotreating	7/1/96	9/10/02	5/1/18	O
Shell, Martinez	b	4141	Heat/steam/power	6/18/09	—	5/1/18	O
Shell, Martinez	b	4160	Hydrogen plant	6/1/95	—	5/1/18	O
Shell, Martinez	b	4161	Heat/steam/power	6/18/09	—	5/1/18	O
Shell, Martinez	b	4170	Hydrotreating	12/1/95	—	7/25/06	D
Shell, Martinez	b	4171	Heat/steam/power	6/19/09	—	6/29/09	D
Shell, Martinez	b	4180	Sulfur recovery	8/1/96	—	5/1/18	O
Shell, Martinez	b	4190	Heat/steam/power	8/1/96	—	5/1/18	O
Shell, Martinez	b	4192	Heat/steam/power	8/1/96	—	5/1/18	O
Shell, Martinez	b	4310	Storage tank	9/27/96	—	5/1/18	O
Shell, Martinez	b	4319	Storage tank	11/8/95	—	5/1/18	O
Shell, Martinez	b	4322	Storage tank	9/16/96	—	5/1/18	O
Shell, Martinez	b	4329	Storage tank	7/12/95	—	5/1/18	O
Shell, Martinez	b	4330	Storage tank	7/12/95	—	5/1/18	O
Shell, Martinez	b	4334	Storage tank	2/16/92	—	5/1/18	O
Shell, Martinez	b	4349	Storage tank	7/12/95	—	5/1/18	O
Shell, Martinez	b	6062	Storage tank	5/1/06	—	5/1/18	O
Shell, Martinez	b	6068	Storage tank	10/30/07	—	5/1/18	O
Shell, Martinez	b	6069	Storage tank	8/1/15	—	5/1/18	O
Shell, Martinez	b	6070	Storage tank	4/10/17	—	5/1/18	O
Shell, Martinez	b	6072	Storage tank	6/9/14	—	5/1/18	O
Shell, Martinez	b	17095	Storage tank	1/21/04	—	5/1/18	O
Valero, Benicia	b	1	Sulfur recovery	1/1/69	—	5/1/18	O
Valero, Benicia	b	2	Sulfur recovery	1/1/69	—	5/1/18	O
Valero, Benicia	b	3	Heat/steam/power	5/23/09	—	7/4/09	D
Valero, Benicia	b	4	Heat/steam/power	5/23/09	—	7/4/09	D
Valero, Benicia	b	5	Cat. Cracking	1/1/68	—	5/1/18	O
Valero, Benicia	b	6	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	7	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	8	Storage tank	1/1/86	—	5/1/18	O
Valero, Benicia	b	13	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	20	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	21	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	23	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	24	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	25	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	26	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	30	Heat/steam/power	5/24/09	—	5/1/18	O
Valero, Benicia	b	31	Heat/steam/power	5/24/09	—	5/1/18	O
Valero, Benicia	b	32	Heat/steam/power	5/24/09	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Valero, Benicia	b	33	Heat/steam/power	5/24/09	—	5/1/18	O
Valero, Benicia	b	34	Heat/steam/power	5/24/09	—	5/1/18	O
Valero, Benicia	b	35	Heat/steam/power	5/24/09	—	5/1/18	O
Valero, Benicia	b	36	Heat/steam/power	1/1/69	—	5/1/18	O
Valero, Benicia	b	37	Heat/steam/power	1/1/69	—	5/1/18	O
Valero, Benicia	b	40	Heat/steam/power	1/1/75	9/1/94	5/1/18	O
Valero, Benicia	b	42	Heat/steam/power	5/24/09	—	7/4/09	D
Valero, Benicia	b	43	Heat/steam/power	1/1/59	—	5/1/18	O
Valero, Benicia	b	44	Heat/steam/power	1/1/69	—	5/1/18	O
Valero, Benicia	b	45	Heat/steam/power	1/1/69	—	5/1/18	O
Valero, Benicia	b	46	Heat/steam/power	1/1/69	7/1/96	5/1/18	O
Valero, Benicia	b	48	Heat/steam/power	1/1/69	—	5/1/18	O
Valero, Benicia	b	50	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	51	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	52	Heat/steam/power	5/23/09	—	5/1/18	O
Valero, Benicia	b	54	Storage tank	1/1/68	—	5/1/18	O
Valero, Benicia	b	55	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	56	Heat/steam/power	1/1/69	—	5/1/18	O
Valero, Benicia	b	57	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	58	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	59	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	60	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	61	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	62	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	63	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	67	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	68	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	70	Storage tank	1/1/68	—	5/25/04	D
Valero, Benicia	b	71	Storage tank	1/1/72	—	5/25/04	D
Valero, Benicia	b	72	Storage tank	1/1/72	—	5/25/04	D
Valero, Benicia	b	73	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	74	Storage tank	1/1/69	—	5/25/04	D
Valero, Benicia	b	75	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	76	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	77	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	78	Storage tank	1/1/71	—	5/1/18	O
Valero, Benicia	b	79	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	80	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	81	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	82	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	83	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	84	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	85	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	86	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	87	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	88	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	89	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	90	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	91	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	92	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	97	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	102	Storage tank	1/1/68	—	4/29/02	D
Valero, Benicia	b	103	Storage tank	1/1/68	—	5/1/18	O
Valero, Benicia	b	104	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	105	Storage tank	3/1/90	—	5/1/18	O
Valero, Benicia	b	106	Storage tank	1/1/71	—	5/1/18	O
Valero, Benicia	b	108	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	110	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	111	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	112	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	113	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	114	Storage tank	1/1/69	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Valero, Benicia	b	115	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	117	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	120	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	122	Storage tank	1/1/68	—	5/1/18	O
Valero, Benicia	b	123	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	124	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	129	Marine terminal	1/1/69	6/6/84	5/1/18	O
Valero, Benicia	b	130	Storage tank	1/1/69	—	4/29/02	D
Valero, Benicia	b	132	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	133	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	134	Storage tank	1/1/69	—	5/1/18	O
Valero, Benicia	b	141	Storage tank	1/1/78	—	6/30/88	D
Valero, Benicia	b	144	Storage tank	1/1/78	—	5/14/15	D
Valero, Benicia	b	147	Storage tank	1/1/76	—	7/9/98	D
Valero, Benicia	b	152	Storage tank	1/1/70	—	7/13/92	D
Valero, Benicia	b	153	Storage tank	1/1/70	—	7/13/92	D
Valero, Benicia	b	158	Storage tank	1/1/80	—	5/1/18	O
Valero, Benicia	b	162	Marine terminal	6/6/84	—	8/1/86	D
Valero, Benicia	b	163	Storage tank	4/1/79	—	5/1/18	O
Valero, Benicia	b	169	Storage tank	11/4/83	—	5/1/18	O
Valero, Benicia	b	170	Storage tank	11/12/84	—	12/31/12	D
Valero, Benicia	b	173	Heat/steam/power	6/8/09	—	5/1/18	O
Valero, Benicia	b	174	Storage tank	10/22/087	—	5/1/18	O
Valero, Benicia	b	175	Storage tank	3/1/87	—	5/1/18	O
Valero, Benicia	b	176	Storage tank	9/1/76	—	5/1/18	O
Valero, Benicia	b	180	Storage tank	1/1/87	—	9/10/14	D
Valero, Benicia	b	186	Storage tank	9/25/90	—	11/9/94	D
Valero, Benicia	b	187	Storage tank	9/25/90	—	11/9/94	D
Valero, Benicia	b	190	Storage tank	9/25/90	—	11/9/94	D
Valero, Benicia	b	191	Storage tank	9/25/90	—	11/9/94	D
Valero, Benicia	b	193	Storage tank	8/28/91	—	5/1/18	O
Valero, Benicia	b	196	Storage tank	8/28/92	—	5/1/18	O
Valero, Benicia	b	207	Storage tank	8/1/93	—	5/1/18	O
Valero, Benicia	b	220	Heat/steam/power	6/23/09	—	5/1/18	O
Valero, Benicia	b	234	Storage tank	6/19/00	—	12/31/07	D
Valero, Benicia	b	235	Storage tank	6/19/00	—	12/31/07	D
Valero, Benicia	b	237	Heat/steam/power	1/17/00	—	5/1/18	O
Valero, Benicia	b	247	Heat/steam/power	7/1/09	—	5/1/18	O
Valero, Benicia	b	1002	Hydrotreating	1/1/69	—	5/1/18	O
Valero, Benicia	b	1003	Hydrocracking	1/1/69	—	5/1/18	O
Valero, Benicia	b	1004	Cat. Reforming	1/1/69	—	5/1/18	O
Valero, Benicia	b	1005	Hydrotreating	1/1/69	—	5/1/18	O
Valero, Benicia	b	1006	Crude distillation	1/1/69	1/1/69	5/1/18	O
Valero, Benicia	b	1007	Alkylation	1/1/69	8/1/92	5/1/18	O
Valero, Benicia	b	1008	Hydrotreating	1/1/69	—	5/1/18	O
Valero, Benicia	b	1009	Hydrotreating	1/1/69	—	5/1/18	O
Valero, Benicia	b	1011	Hydrotreating	1/1/68	—	5/1/18	O
Valero, Benicia	b	1024	Hydrotreating	1/8/96	—	5/1/18	O
Valero, Benicia	b	1030	Heat/steam/power	12/18/02	—	5/1/18	O
Valero, Benicia	b	1031	Heat/steam/power	12/18/02	—	5/1/18	O
Valero, Benicia	b	1047	Storage tank	1/6/09	—	5/1/18	O
Valero, Benicia	b	1048	Storage tank	1/6/09	—	5/1/18	O
Valero, Benicia	b	1052	Hydrotreating	8/5/08	—	5/1/18	O
Valero, Benicia	b	1059	Heat/steam/power	7/4/09	—	5/1/18	O
Valero, Benicia	b	1060	Heat/steam/power	7/4/09	—	5/1/18	O
Valero, Benicia	b	1066	Heat/steam/power	10/22/15	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	1	Storage tank	1/1/82	—	5/25/04	D
Valero, Benicia Asph. Plt.	b	2	Storage tank	1/1/82	—	5/25/04	D
Valero, Benicia Asph. Plt.	b	4	Storage tank	4/19/82	—	5/25/04	D
Valero, Benicia Asph. Plt.	b	5	Storage tank	4/17/82	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	6	Storage tank	4/17/82	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	7	Storage tank	4/17/82	—	5/1/18	O

		Equipment Unit		Age and Operational Data (dates)			
Refining Facility	(notes)	ID#[a]	Type	Startup	Rebuild	End-date	Status
Valero, Benicia Asph. Plt.	b	8	Storage tank	4/17/82	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	9	Storage tank	4/19/82	6/16/92	5/1/18	O
Valero, Benicia Asph. Plt.	b	11	Heat/steam/power	6/6/09	—	6/13/09	D
Valero, Benicia Asph. Plt.	b	12	Storage tank	2/23/98	12/1/11	5/1/18	O
Valero, Benicia Asph. Plt.	b	13	Storage tank	2/23/98	2/23/98	5/1/18	O
Valero, Benicia Asph. Plt.	b	18	Crude distillation	4/19/82	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	20	Heat/steam/power	4/19/82	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	21	Heat/steam/power	4/19/82	5/1/96	5/1/18	O
Valero, Benicia Asph. Plt.	b	23	Storage tank	1/1/82	—	5/25/04	D
Valero, Benicia Asph. Plt.	b	24	Heat/steam/power	6/5/09	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	25	Storage tank	4/17/82	—	3/9/09	D
Valero, Benicia Asph. Plt.	b	26	Storage tank	4/17/82	12/1/11	5/1/18	O
Valero, Benicia Asph. Plt.	b	27	Storage tank	4/17/82	—	3/7/13	D
Valero, Benicia Asph. Plt.	b	28	Storage tank	4/17/82	12/1/11	5/1/18	O
Valero, Benicia Asph. Plt.	b	30	Marine terminal	4/8/82	—	5/27/05	D
Valero, Benicia Asph. Plt.	b	34	Storage tank	6/8/98	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	59	Storage tank	2/23/98	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	60	Storage tank	9/29/98	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	61	Storage tank	4/6/98	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	62	Storage tank	4/6/98	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	63	Storage tank	6/24/99	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	65	Storage tank	4/5/01	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	67	Storage tank	1/1/81	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	70	Storage tank	1/1/82	—	5/1/18	O
Valero, Benicia Asph. Plt.	b	1010	Hydrogen plant	1/1/68	—	5/1/18	O

Table S24. Bay Area refinery hydrogen production emissions, 2015–2017

Mt: Megaton; 1 million metric tons **CO_2e:** carbon dioxide equivalents (100-year GWP)

Emission source	Period	Emissions of CO_2e Mass (Mt)	Emissions of CO_2e (% of total)
Refiner-owned hydrogen plants [a]			
	2015	5.2404	
	2016	4.2013	
	2017	4.1687	
	2015–2017	13.6104	28 %
Third party hydrogen plants for refining [b]			
	2015	1.0166	
	2016	1.0374	
	2017	1.0715	
	2015–2017	3.1255	6.4 %
Refinery hydrogen production sum [c]	2015–2017	16.7359	34 %
Total refining emissions including refiner-owned and third party hydrogen plants [b]	2015–2017	48.9213	100 %

a. This estimate includes only emissions from San Francisco Bay Area plants, because refiner-owned hydrogen plant emissions were not broken out separately for other in-state refineries in the publicly reported data as of December 2018. Data were reported for hydrogen production from the Chevron Richmond refinery (Site A0010) sources 4156, 4157, 4158, 4170, 4171, 4250 and 4348; Shell Martinez refinery (Site A0011) sources 1445, 1774, 4160 and 4161; Phillips 66 San Francisco Refinery (Site A0016) sources 437 and 438; Valero Benicia refinery (Site B2626) sources 21 and 1010; and "Tesoro" Martinez refinery now owned by Marathon (Site B2758) sources 937 and 1005. These data were taken from the Bay Area Air Quality Management District source emission inventory (*RS43*).

b. Data were taken from the Air Resources Board public emission reports (*RS2*). Emissions from third party hydrogen plants dedicated to supplying Bay Area refineries (Air Liquide, Rodeo and Air Products, Martinez) and from the Chevron Richmond, Phillips 66 San Francisco (Rodeo and Santa Maria facilities), Shell Martinez, Tesoro (now Marathon) Martinez (including the Martinez Cogen facility), and Valero Benicia refineries were included in the estimates shown.

c. The estimated percentage shown (34%) is taken from data for the S.F. Bay Area refineries and may not represent the statewide percentage precisely. However, given the relatively similar weighted average crude feed densities (*RS18–RS20*) and usage of hydrogen production (*RS2, RS34*) observed statewide as compared with those in the Bay Area, this estimate is probably reasonably close to the as-yet unreported statewide percentage.

References

RS1. *Crude Average Carbon Intensity Value;* Low Carbon Fuel Standard program data documentation. California Air Resources Board: Sacramento, CA. Data reports for annual crude average CI value documentation. *See*: www.arb.ca.gov/fuels/lcfs/crude-oil/2016_crude_average_ci_value_final.pdf.

RS2. *Annual Summary of Greenhouse Gas Emissions Data Reported to the California Air Resources Board;* Mandatory Reporting Regulation public data reports for 2013 through 2017. California Air Resources Board: Sacramento, CA. www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm.

RS3. *California's Greenhouse Gas Inventory by IPCC Category;* California Air Resources Board: Sacramento, CA. 12 August 2019. 11th edition. www.arb.ca.gov/cc/inventory/data/data.htm.

RS4. *Disaggregation of Industrial Cogeneration Categories in California's Greenhouse Gas Inventory;* California Air Resources Board: Sacramento, CA. 9 June 2019. 12th edition. www.arb.ca.gov/cc/inventory/data/data.htm.

RS5. *Fuel Activity for California's Greenhouse Gas Inventory by Sector & Activity;* California Air Resources Board: Sacramento, CA. 12 Aug. 2019. 12th ed. www.arb.ca.gov/cc/inventory/data/data.htm.

RS6. *Fuels Watch Reports;* 2013–2017. California Energy Commission: Sacramento, CA. Download Reports; Weekly Fuels Watch reports. http://energy.ca.gov/almanac/petroleum_data/fuels_watch/.

RS7. *PADD 5 Refinery Net Production;* EIA database updated 30 April 2018. U.S. Energy Information Administration: Washington, D.C. http://www.eia.gov/dnav/pet/pet_pnp_refp2_dc_r50_mbbl_a.htm.

RS8. *OGJ surveys downloads;* PennWell: Tulsa, OK. 2018. 2018 Worldwide Refining Survey, *Oil & Gas Journal.* Web site: https://www.ogj.com/ogj-survey-downloads (accessed 9 September 2019.)

RS9. *Total Hydroelectricity Production (Annual Totals; Excludes Imports);* Cal. Energy Commission: Sacramento, CA. www.energy.ca.gov/almanac/renewables_data/hydro/. Accessed June 2018.

RS10. U.S. Chemical Safety and Hazard Investigation Board, 2017. *Investigation Report: ExxonMobil Torrance Refinery Electrostatic Precipitator Explosion, Torrance, California;* 2015-02-I-CA. May 2017.

RS11. Brelsford, R., 2016. ExxonMobil restarts Torrance refinery. *Oil & Gas Journal* 11 May 2016. https://www.ogj.com/articles/2016/05/exxonmobil-restarts-torrance-refinery.html.

RS12. *Taxable Fuel Statistics;* California Department of Tax and Fee Administration: Sacramento, CA. *Net Taxable Gasoline Gallons (Including Aviation Gasoline)–Ten Year Report; Taxable Diesel Gallons 10 Year Report–Net of Refunds;* and *Net Taxable Jet Fuel Gallons 10 Year Report.* Accessed June 2018 from www.cdtfa.ca.gov/taxes-and-fess/spftrpts.htm.

RS13. *2016 SIP Emission Projection Data: 2015 Estimated Annual Average Emissions Statewide;* State Clean Air Act Implementation Plan data for 2015; California Air Resources Board: Sacramento, CA. www.arb.ca.gov/app/emsinv/2017/emssumcat_query.php?F_YR=2015&F_DIV=0&F_SEASON=A&SP=SIP105ADJ&F_AREA=CA.

RS14. *2017 Clean Air Plan;* State Clean Air Act Implementation Plan for the San Francisco Bay Area air basin. Includes *Multi-Pollutant Evaluation Method* (MPEM) documentation. Adopted 19 April 2017. Bay Area Air Quality Management District: San Francisco, CA. Available online at www.baaqmd.gov.

RS15. Kuiper, H., Broome, C. V., Brunner, W., Gould, R. M., Heller, J., Jackson, R. L., Kirsch, J. L., Neutra, R., Newman, T. B., Ostro, B., Rudolph, L., Shonkoff, S. BC., and Sutton, P., 2017. *Health Assessment of Draft EIR for BAAQMD Rule 12-16;* Includes "Impact of Rule 12-16 on mortality associated with exposure to $PM_{2.5}$ from processing heavier oil in Bay Area refineries." Analysis provided in commentary to the Bay Area Air Quality Management District, San Francisco, CA, on 8 May 2017.

References *continued*

RS16. Rogelj et al. (13 authors). Mitigation Pathways Compatible with 1.5ºC in the Context of Sustainable Development. In: *Global Warming of 1.5ºC. An IPCC Special Report on the impacts of global warming of 1.5ºC above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte et al. (eds.)]. In Press. Intergovernmental Panel on Climate Change (IPCC). 2018. www.ipcc.ch; *See* esp. Table 2.2, pp. 104–108.

RS17. United States Bureau of the Census. California population in 2017 from *Vintage 2017 Population Estimates;* worldwide population on 22 May 2018 from *World Population Clock* (https://www.census.gov/popclock/world).

RS18. Karras, G., 2016. *Combustion Emissions from Refining Lower Quality Oil, Part 2: How much could a switch to 'tar sands' oil increase direct emissions of $PM_{2.5}$ and CO_2 from northern California refineries?* CBE Technical Report provided to the Bay Area Air Quality Management District in San Francisco, CA as commentary regarding proposed Rule 12-16 on 2 December 2016. Communities for a Better Environment: Richmond, CA.

RS19. Karras, G., 2010. Combustion emissions from refining lower quality oil: What is the global warming potential? *Environmental Science & Technology* 44(24): 9584–9589. Includes Supporting Information. DOI: 10.1021/es1019965.

RS20. Karras, G., 2011. *Oil Refinery CO_2 Performance Measurement;* report peer reviewed and published by the Union of Concerned Scientists (UCS). Technical analysis prepared by Communities for a Better Environment (CBE) for UCS. Union of Concerned Scientists: Berkeley, CA. Includes Supporting Information data tables.

RS21. Abella, J. P., and Bergerson, J. A., 2012. Model to investigate energy and greenhouse gas emissions implications of refining petroleum: Impacts of crude quality and refinery configuration. *Environmental Science & Technology* 46: 13037–13047. DOI: 10.1021/es3018682.

RS22. Gordon, D., Brandt, A., Bergerson, J. and Koomey, J., 2015. *Know Your Oil: Creating a Global Oil-Climate Index;* Carnegie Endowment for International Peace: Washington, D.C. Available to be downloaded at no cost at CarnegieEndowment.org/publications.

RS23. Gordon, D., Brandt, A., Bergerson, J. and Koomey, J., 2016. Oil-Climate Index, http://oci.carnegieendowment.org/, created 2015 and updated 2016.

RS24. Meyer, R. F., Attanasi, E. D., and Freeman, P. A., 2007. *Heavy Oil and Natural Bitumen Resources in Geologic Basins of the World;* USGS Open-File Report 2007-1084. U.S. Geological Survey: Washington, D.C. Available at http://pubs.usgs.gov/of/2007/1084/.

RS25. *The 2017 Climate Change Scoping Plan Update;* California Air Resources Board: Sacramento, CA. 20 Jan 2017 accessed June 2018; https://www.arb.ca.gov/cc/scopingplan/meetings/meetings.htm. *See* esp. pages 49, 52, 58.

RS26. *U.S. Refinery Crude Oil Input Qualities;* U.S. Energy Information Administration: Washington, D.C. Update released 30 March 2018. http://www.eia.gov/dnav/pet/pet_pnp_crq_dcu_nus_m.htm.

RS27. *U.S. Refinery Yield;* U.S. Energy Information Administration: Washington, D.C. Update released 31 May 2018. http://www.eia.gov/dnav/pet/pet_pnp_pct_dc_nus_pct_a.htm.

RS28. Davis, S. J., Caldeira, K., and Matthews, H. D. 2010. Future CO_2 emissions and climate change from existing energy infrastructure. *Science* 329: 1330–1333. 10 September 2010. DOI: 10.1126/science.1188566.

References *continued*

RS29. Rosenberg, J., Davis, S. J., Narloch, U., and Hallegatte, S. 2015. Climate constraints on the carbon intensity of economic growth. *Environmental Research Letters* 10(2015)095006. DOI: 10.1088/1748-9326/10/9/095006.

RS30. Ha-Duong, M., Grubb, M. J., and Hourcade, J–C. 1997. Influence of socioeconomic inertia and uncertainty on optimal CO_2-emission abatement. *Nature* 390: 270–273. 20 November 1997.

RS31. Johnston, D. 1996. Refining report complexity index indicates refinery capability, value. *Oil & Gas Journal* vol. 94 (12). March 18, 1996.

RS32. ARB, 2014. *Proposed Re-Adoption of the Low Carbon Fuel Standard Staff Report: Initial Statement of Reasons for Proposed Rulemaking;* California Air Resources Board: Sacramento, CA. December 2014. *See* Table II-7, modified Nelson Complexity indices, page III-49.

RS33. Meyer, D. W., and Taylor, C. T. 2015. *The Determinants of Plant Exit: The Evolution of the U.S. Refining Industry;* Working Paper No. 328. Bureau of Economics, Federal Trade Commission: Washington, DC. November 2015.

RS34. *Refinery Capacity Data by individual refinery;* U.S. Energy Information Administration: Washington, D.C. Capacity data by refining site, refining process type, and year. Previous Issues; Refinery Capacity Report Archives; https://www.eia.gov/petroleum/refinerycapacity/.

RS35. *Chevron Products Company El Segundo Refinery Coke Drum Reliability Project: Final Environmental Impact Report;* SCH No. 2011101026. South Coast Air Quality Management District: Diamond Bar, CA. November 2012. *See* esp. pp. 1-6, 2-7.

RS36. Avidan, A. A., and Edwards, M. 1990. Innovative improvements highlight FCC's past and future. *Oil & Gas Journal* 88(2) 2 January 1990. https://www.ogj.com/articles/print/volume-88/issue-2/in-this-issue/general-interest/innovative-improvements-highlight-fcc39s-past-and-future.html.

RS37. Ramos, L. 2018. Correspondence to G. Karras, Communities for a Better Environment, regarding response to request for review of records pursuant to the California Public Records Act. Control No. 93343. South Coast Air Quality Management District: Diamond Bar, CA. 12 April 2018.

RS38. *California Refining Facilities;* Phillips 66, Santa Maria Refinery (Operational). California Energy Commission: Sacramento, CA. www.energy.ca.gov/almanac/petroleum_data/refinery_history.html. Accessed 9 March 2018.

RS39. Carlson, D. 2018. Correspondence to G. Karras, Communities for a Better Environment, regarding response to request for review of records pursuant to the California Public Records Act. San Luis Obispo County Air Pollution Control District: San Luis Obispo, CA. 1 February 2018.

RS40. San Luis Obispo County Air Pollution Control District, 2012. Phillips 66 Santa Maria Refinery Throughput Increase Project. EIR SCH# 20081010111. San Luis Obispo County Air Pollution Control District: San Luis Obispo, CA *See* Figure 2-6.

RS41. City of Richmond, 2014. Chevron Refinery Modernization Project Environmental Impact Report. EIR SCH# 2011062042. City of Richmond: Richmond, CA. *See* esp. project objectives, page 3-12.

RS42. *Filing of Notice of Exemption Pursuant to CEQA §21152(b) and CEQA Guidelines §§ 15062: Chevron Richmond Refinery, Issuance of an Authority to Construct to Install A-4413 Flameless Thermal Oxidizer, Associated Piping, and Fugitive Components (Application 28492):* Bay Area Air Quality Management District: San Francisco, CA. Leong, P., Director of Engineering. 25 April 2018. *See* esp. Project Description (issuance of permit for related equipment "in preparation of the impending startup of [Chevron's] new hydrogen plant").

RS43. *Criteria and CO_2 Source Emissions for Site Nos. A0010, A0011, A0016, A1820, B0295, B2626, B2758, B2759, B4628 and B7419;* includes emissions from refinery-owned hydrogen production at S.F. Bay Area refineries that were compared with total refinery emissions and third-party hydrogen plant emissions from reference *RS2.* Data from response to CBE Public Records Request No. 2018-08-0099. Bay Area Air Quality Management District: San Francisco, CA.

RS44. Diaz et al. (29 authors), **2019**. *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services;* Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Available at https://www.ipbes.net/global-assessment-report-biodiversity-ecosystem-services.

RS45. Tong, D., Zhang, Q. Zheng, Y., Caldeira, K., Shearer, C., Hong, C., Qin, Y., Davis, S. J. Committed emissions from existing energy infrastructure jeopardize 1.5ºC climate target. *Nature* **2019** DOI: 10.1038/s41586-019-1364-3.