Appendix F

Health Risk Assessment (HRA)

The Proposed Amendments to the Airborne Toxic Control Measure for Chromium Electroplating and Chromic Acid Anodizing Operations

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I. Overview

California Air Resources Board (CARB) staff is proposing amendments to the Airborne Toxic Control Measure (ATCM) for Chromium Electroplating and Chromic Acid Anodizing Operations (Proposed Amendments). The Proposed Amendments to the current ATCM for Chromium Plating and Chromic Acid Anodizing Facilities (the 2007 ATCM) are the result of our reevaluation of the air quality impacts to communities located near hexavalent chromium plating facilities. This evaluation includes a look at past ambient monitoring efforts by local air pollution control districts (air districts) and CARB, which have shown elevated concentrations of hexavalent chromium near these facilities and in local communities.

In 1986, CARB's Board identified hexavalent chromium as a toxic air contaminant (TAC) under California law pursuant to Assembly Bill (AB) 1807 and Health and Safety Code (HSC) section 39657.[1,2] Exposure to hexavalent chromium has both potential cancer and noncancer chronic health impacts. Hexavalent chromium has one of the highest cancer potency factors of the identified TACs at about 500 times more toxic than diesel exhaust particular matter.

There are three types of chrome plating processes covered by the Proposed Amendments: (1) decorative chrome plating, (2) hard chrome plating, and (3) chromic acid anodizing. Hard chrome plating and chromic acid anodizing are collectively referred to as "functional plating" and decorative and functional plating are collectively referred to as "chrome plating". Each of these types of chrome plating processes operate at different production and process levels and therefore have different associated emissions. In this analysis, CARB staff analyzed the types and number of facilities for their exposure and health impacts. CARB staff analyzed the types and number of facilities where decorative or functional plating operations occur.

CARB staff conducted a health risk assessment (HRA) to model air concentrations of emissions and evaluate the health impacts from chrome plating facilities in California. This analysis evaluates present and future health impacts under the current ATCM. These health impacts are used as a baseline case and compared to the present and future health impacts under the Proposed Amendments. This comparison shows the health benefits that would be achieved with the implementation of the Proposed Amendments. Details of the analysis, example calculations, and results based on representative meteorological data are described in this document.

Transitioning to the use of trivalent chromium is a compliance option under the Proposed Amendments. To characterize the health impacts associated with the use of

[1] CARB Identified Toxic Air Contaminants

[2] AB 1807 (Tanner 1983) – Toxics Air Contaminant Identification and Control

trivalent chromium, staff also conducted a health analysis from trivalent chromium. Trivalent chromium is also a TAC but is much less toxic when compared to hexavalent chromium, and is not a known carcinogen, based on the health data of California Air Toxics Hot Spots Program.[3]

A. Approach

Chrome plating facilities that use hexavalent chromium have the potential to emit hexavalent chromium. The emitted hexavalent chromium can eventually be released into the ambient air through the stacks of emission control devices or through windows, doors, vents, or other openings.

In the chrome plating process, only about 20 percent of the total electrical energy charge applied to the parts being plated actually deposits chromium onto the surface of metallic parts. The remaining electrical energy charge forms bubbles from electrochemical reactions (hydrogen gas produced at the cathode and oxygen produced at the anode) that rise to the surface of the plating bath. As these bubbles burst, a mist carrying hexavalent chromium from the plating tank surface is emitted into the air. The hexavalent chromium in the mist can eventually be released into the ambient air through windows, doors, vents, or other openings. This type of release is referred to as fugitive emissions.

Fugitive emissions include emissions coming off uncontrolled tanks and emissions that are not captured by add-on air pollution control devices. Ambient air monitoring and sampling conducted in the South Coast Air Basin suggests that fugitive emissions could be a significant contributor to hexavalent chromium air concentrations measured near hexavalent chromium plating operations. Fugitive emissions are difficult to quantify and require further study to better identify their source and impacts. For this reason, the HRA results in Section E.10 do not include fugitive emissions and likely underestimate the potential health impacts from chrome plating operations. However, in an effort to analyze the potential impacts of fugitive emissions, staff conducted a "what if" analysis, which can be found in Section II.F. Because of the limitations surrounding the estimates of fugitive emissions, it is not advisable to combine the potential cancer risk estimates found in section II.F (fugitives) with the HRA results found in section E.10.

The general outline of the procedure used for CARB's dispersion modeling and health analyses is as follows:

- Select meteorological data that is representative of meteorological conditions throughout the State.
- Develop a facility inventory for hexavalent chromium that reflects the anticipated emissions of hexavalent chromium and trivalent chromium released annually under

[3] OEHHA Chromium, Trivalent Reference Exposure Levels

the current ATCM and the Proposed Amendments.

- Conduct air dispersion modeling to simulate the spatial distribution of ground-level concentrations of hexavalent chromium and trivalent chromium at receptors surrounding the source.
- Estimate potential health impacts from exposure to the modeled concentration at each receptor based on the OEHHA's Air Toxics Hot Spots Program Risk Assessment Guidelines, also known as the OEHHA Guidelines.[4]

For this HRA, three generic facility configurations were used to represent chrome plating facilities: (1) decorative platers that use only fume suppressants, (2) both decorative platers and small functional platers that use add-on controls, and (3) large functional platers that use add-on controls. Stack parameters and building footprints for the models were based on survey information, Google Earth® imagery, source test reports, information obtained during site visits from CARB or air district staff, and previous work CARB has conducted to model emissions of hexavalent chromium from chrome plating facilities.[5] The facilities evaluated in this appendix were grouped into two categories, decorative plating and functional plating, based on the Proposed Amendments.

The decorative plating category is comprised of:

- Decorative chrome platers that use fume suppressants to control emissions.
- Decorative chrome platers that use add-on pollution control equipment to control emissions.

The functional plating category is comprised of:

- Small functional chrome platers, including chromic acid anodizers, which have electricity usage less than 1,000,000 annual amp-hours.
- Large functional chrome platers, including chromic acid anodizers, which have electricity usage equal to or more than 1,000,000 annual amp-hours.

Under the 2007 ATCM, emission limits are based on the annual ampere-hours (amp-hour) of electricity used in the plating process at a facility and the distance between the facility and the closest sensitive receptor (e.g., schools, nursing homes, residential care facilities, daycare centers, and hospitals). Table F.1 outlines these requirements.

[4] OEHHA Risk Assessment Guidelines
[5] Chrome ATCM

Table F.1 Requirements for Existing Hexavalent Chromium Plating Facilities

Sensitive Receptor Distance [a]	Annual Permitted Amp-Hour	Emission Limitation
≤ 330 feet	≤ 20,000	0.01 milligrams/amp-hour with use of chemical fume suppressants as specified in section 93102.8 [b]
≤ 330 feet	> 20,000 and ≤ 200,000	0.0015 milligrams/amp-hour as measured after add-on air pollution control device(s)
≤ 330 feet	> 200,000	0.0015 milligrams/amp-hour as measured after add-on air pollution control device(s) [c]
> 330 feet	≤ 50,000	0.01 milligrams/amp-hour with use of chemical fume suppressants as specified in section 93102.8
> 330 feet	> 50,000 and ≤ 500,000	0.0015 milligrams/amp-hour
> 330 feet	> 500,000	0.0015 milligrams/amp-hour as measured after add-on air pollution control device(s)

[a] Distance measured as specified in section 93102.4(b)(2)(A).

[b] Alternatively, a facility may install an add-on air pollution control device(s) that controls emissions to below 0.0015 milligrams per amp-hour.

[c] When annual emissions exceed 15 grams, a site-specific risk analysis must be conducted, unless a site -specific risk analysis has already been conducted and approved by the permitting agency.

The dispersion of emissions is simulated using the U.S. EPA regulatory air dispersion model, the American Meteorological Society/EPA Regulatory Model, which is a steady state Gaussian plume dispersion model.[6] AERMOD is preferred by U.S. EPA for modeling point, area, and volume sources of continuous air emissions. To account for meteorological variability, the meteorological data used in the model are selected from five air basins (San Francisco Bay Area, San Joaquin Valley, San Diego Area, Sacramento Valley, and South Coast Air Basin). The majority of chrome plating facilities in the State are located in these five air basins. The air concentrations of target pollutants are calculated for each category of chrome plating operation by averaging the modeling runs using these five meteorological datasets. The resulting averaged concentrations are used for the health impact evaluation and presented in Section II.E.11 of this appendix.

The concentrations predicted by AERMOD are directly proportional to the source emission rates. Because of this, source emission rates can be entered into the model in one of two ways: (1) the modeler can enter the actual emission rates, or (2) the modeler can use a unit emission rate, which results in concentrations from which actual concentrations can be scaled after the modeling is complete. This analysis is based on a unit emission rate of one gram per second (1 g/sec). To calculate the final annual average ground level concentration of hexavalent chromium at each receptor, the model results are multiplied by the actual emission rate from each source.

Finally, the concentrations are combined with the pollutant specific cancer potency factor (CPF) and reference exposure level (REL) values determined under the

[6] USEPA AERMOD

dose-response assessment by OEHHA.[7] This step integrates the information used to quantify the potential cancer and noncancer risks.

B. Years Evaluated

For the HRA, staff evaluated four calendar years according to the implementation schedule of the Proposed Amendments:

Year 2019:

- 2019 serves as the Baseline year. This year was chosen to represent the normal operating conditions of the chrome plating industry (not impacted by the COVID-19 pandemic) prior to implementation of the Proposed Amendments.

Year 2026:

- Beginning January 1, 2026, functional chrome plating facilities must:
    - Meet a new hexavalent chromium emission limit of 0.00075 mg/amp-hour. This is half of the current ATCM limit.
    - Implement building enclosures; install add-on controls on all qualifying hexavalent chromium containing tanks (see Section I.Q.2).
    - Conduct a source test at operating facilities.

Year 2027:

- Beginning January 1, 2027, decorative chrome plating facilities may no longer use hexavalent chromium for chrome plating in California.

Year 2039:

- Beginning January 1, 2039, functional chrome plating facilities may no longer use hexavalent chromium for chrome plating in California.
- Prior to January 1, 2039, CARB will conduct two technology reviews to analyze progress in developing alternatives to replace hexavalent chromium for functional chrome plating.

[7] Consolidated Table of OEHHA/CARB approved health values

II. Health Risk Assessment for Chrome Plating and Chromic Acid Anodizing Operations

A.Health Risk Assessment Overview

Health risk assessment is a multi-step process that requires the analysis of many variables to simulate real-world situations and integration of health values to quantify the health impacts from the target pollutant. The standard approach used for this HRA involves four steps: (1) hazard identification, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

1. Hazard Identification

Hazard identification is a process of determining the substances that can cause adverse health effects (i.e., cancer, reproductive, developmental, etc.) and their likely impacts to humans. For this assessment, the target pollutant is hexavalent chromium from chrome plating and chromic anodizing operations. In 1986, under the AB 1807 Toxic Air Contaminant Identification and Control Program, CARB identified hexavalent chromium as a toxic air contaminant (TAC) based on its potential to cause cancer and other health impacts with no known safe level of exposure. As previously stated, transitioning to the use of trivalent chromium is a compliance option under the Proposed Amendments. To characterize the health impacts associated with the use of trivalent chrome, staff also conducted a health analysis from trivalent chromium. Trivalent chromium is also a TAC but is much less toxic when compared to hexavalent chromium based on the health data of California Air Toxics Hot Spots Program.

2. Exposure Assessment

Exposure assessment is an estimate of the level, duration, and frequency of exposures of an individual or population to a substance. This involves emissions quantification, estimation of air concentrations from dispersion modeling, evaluation of environmental fate, identification of exposure pathways and exposed populations, and estimation of exposure levels. Near chrome plating facilities, the receptors that are most likely to be exposed include residents and off-site workers. On-site workers could also be impacted by the emissions; however, they are not included in this HRA because the California Department of Industrial Relations, Division of Occupational Safety and Health (Cal/OSHA) has jurisdiction over on-site exposure to workers who are employed at the facilities. OEHHA has determined that hexavalent chromium is carcinogenic through the inhalation and oral pathways. The magnitude of exposure to the target pollutant is based on the air dispersion modeling concentration of the target pollutant for each of the specified receptors.

3. Dose-Response Assessment

Dose-response describes the amount of exposure (the dose) to a substance and its relation to the likelihood and severity of adverse health effect (i.e., the response). The assessment characterizes the relationship between exposure to a pollutant and the incidence or occurrence of an adverse health effect. In this step, CARB staff used the health values developed by OEHHA. These dose-response relationships come in the form of cancer potency factors (CPF) for carcinogenic effects and reference exposure levels (REL) for non-carcinogenic effects (see Table F.8(a) in Section II.E.2). For detailed information, see the OEHHA Guidelines for a list of health factors.

Hexavalent chromium is one of the most toxic TACs. Table F.2 provides a comparison of the unit risk factor for hexavalent chromium to those of other TACs. As shown in Table F.2, only one other chemical, dioxin, has a higher potential to cause cancer than hexavalent chromium.

Table F.2 Cancer Potencies of Common Carcinogens Relative to Hexavalent Chromium

Compound	OEHHA Unit Risk Factors $(\mu g/m^3)^{-1}$	Relative Potency to Hexavalent Chromium
Dioxin	3.8E+01	253
Hexavalent Chromium	**1.5E-01**	**1**
Cadmium	4.2E-03	0.028
Arsenic (inorganic)	3.3E-03	0.022
Diesel Exhaust	3.0E-04	0.002
Nickel	2.6E-04	0.0017
Ethylene Oxide	8.8E-05[a]	0.00059
Benzene	2.9E-05	0.00019
Ethylene Dichloride	2.1E-05	0.00014
Lead	1.2E-05	0.00008

[a] U.S. EPA Integrated Risk Information System (IRIS) inhalation unit risk factor is 5.0E-03 per $\mu g/m^3$ for lifetime exposure and 3.0E-03 for adult exposure (https://iris.epa.gov/static/pdfs/1025_summary.pdf).

4. Risk Characterization

Finally, risk characterization communicates the results of the evaluation of risks as well as the assumptions and uncertainties inherent in the assessment. Air concentrations, which are estimated through air dispersion modeling, are combined with the OEHHA CPF and REL values. This step integrates all necessary information used to quantify the potential cancer and noncancer risks.

B. Selection of Facilities

There are three types of facilities covered by the Proposed Amendments: (1) decorative chrome plating facilities, (2) hard chrome plating facilities, and (3) chromic acid anodizing facilities. As previously stated, hard chrome plating and chromic acid anodizing are collectively referred to as "functional plating." All three types of facilities use hexavalent chromium in chemical solution for plating operations.

For this HRA, three generic model configurations were used to represent decorative plating or functional plating facilities: (1) decorative platers that use only fume suppressants, (2) both decorative platers that use add-on controls and small functional platers, and (3) large functional platers.

C. Emission Inventory

HRAs require information about the type of operation associated with the target pollutant and the amount of target pollutant emitted. Under the 2007 ATCM, chrome plating facilities have different emission limits to comply with based on activity levels (i.e., amp-hours) and the distance between the facility and any identified sensitive receptors. These limits are summarized in Table F.1. The 2007 ATCM requirements that apply to existing, modified, and new hexavalent chromium plating facilities include, but are not limited to:

- Use of add-on air pollution control device(s) meeting an emission rate of 0.0015 milligrams per amp-hour or less as measured after the add-on air pollution control device or unless the facility is operating under an approved alternative method as provided in section 93102.4(b)(3) of the 2007 ATCM and Health and Safety Code section 39666(f).
- Environmental compliance and recordkeeping must be conducted only by persons who completed a CARB Compliance Assistance Training Course and renew the training every two years.
- Housekeeping practices must be implemented to reduce potential fugitive emissions of hexavalent chromium.

For further details of the 2007 ATCM, see Section L.

Table F.3 shows the hexavalent chromium emission factors by emission control type for the 2019 Baseline and Proposed Amendment years 2026, 2027, and 2039.

Table F.3 Hexavalent Chromium Emission Factors Used for Health Risk Assessment

Year	In-Tank Fume Suppressant (Baseline)	In-Tank Fume Suppressant (Proposed)	Add-On Pollution Control (Baseline)	Add-On Pollution Control (Proposed)
2019	0.01	-	0.0015	-
2026	0.01	0.01	0.0015	0.00075
2027	0.01	0	0.0015	0.00075
2039	0.01	0	0.0015	0

Note: Emission factors listed are in milligrams per ampere-hour (mg/amp-hour)

D. Air Dispersion Model

Staff used the AERMOD air dispersion model to estimate air concentrations of hexavalent chromium from chrome plating operations at receptors. This section describes the rationale and methodology for the model selection, modeling parameters, meteorological data selection, and the model receptor locations.

1. Air Dispersion Model Selection

Air dispersion models simulate physical process that affect air pollutants as they disperse in the atmosphere. The selection of an air dispersion model depends on many factors, such as characteristics of emission sources (e.g., point, area, volume, or line), the type of terrain (e.g., flat or complex) at the emission source locations, and the relationship between sources and receptors. For this HRA, CARB staff selected U.S. EPA's AERMOD Dispersion Model to simulate the air concentration of hexavalent chromium emissions at nearby receptors. AERMOD is a steady-state plume model that incorporates air dispersion based on a planetary boundary layer turbulence structure and parameterization concepts, including treatment of both surface and elevated sources and dispersion distance up to 50 kilometers (km) in both flat and complex terrain.

2. Modeled Source Type and Parameters

Since chrome plating facilities are able to control emissions of hexavalent chromium with either chemical fume suppressants or add-on pollution controls, CARB staff modeled hexavalent chromium emissions using a volume source to represent facilities that use fume suppressants or a set of point sources to represent facilities that use add-on control devices. The parameters used to define these sources in AERMOD include emission rates (grams per second or g/sec), stack heights and release heights (m), initial vertical dimensions (m), and initial lateral dimensions (m).

3. Meteorological Data

AERMOD requires hourly meteorological data as inputs to the model. Meteorological parameters include, but are not limited to, wind speed, wind direction, ambient temperature, and vertical temperature profile. These parameters are recorded at surface meteorological stations and by upper atmospheric sounding data.

Five meteorological stations were chosen to represent a range of terrain and meteorological conditions throughout the state. These meteorological stations are (1) Miramar Marine Air Station (San Diego), (2) Fresno/Yosemite International Airport Station (Fresno), (3) Ontario International Airport Station (Ontario), (4) Sacramento International Airport Station (Sacramento), and (5) San Jose International Airport Station (San Jose). These meteorological datasets were pre-processed in a model-ready format by local air districts.

Table F.4 summarizes the wind speed conditions (average wind speeds and percent calm wind) from the most recent consecutive five years of processed meteorological data, as recommended by the User's Guide for the AMS/EPA Regulatory Model.[8] The daily operating schedule for decorative chrome platers is assumed to be 6 am to 3 pm.

Table F.4 Meteorological Data Summary

Station		Miramar	Fresno	Ontario	Sacramento	San Jose
Avg. Period	Met Condition	2009-2013	2013-2017	2012-2016	2014-2018	2013-2017
24 Hours	Avg. Speed (m/s)	2.53	2.95	2.88	3.64	3.19
24 Hours	Calm %	20.7	4.3	2.9	1.0	1.2
6 AM – 3 PM	Avg. Speed (m/s)	3.01	2.65	2.82	3.50	3.11
6 AM – 3 PM	Calm %	16.4	3.5	2.7	1.0	1.3

These meteorological datasets include various wind patterns and conditions and are representative of the meteorological conditions in different air basins. The wind direction of each dataset was rotated so that the prevailing wind is aligned with the source layout and building configuration (used in the point source model) to provide health-protective cancer risk estimates. Figures F.1 – F.5 display wind roses for the five meteorological stations. Wind roses display the wind speed and wind direction at a specific location over a period of time. The length of the wind rose petals indicate how frequently the wind blows from a given direction and how frequently the wind blows at a specified speed.

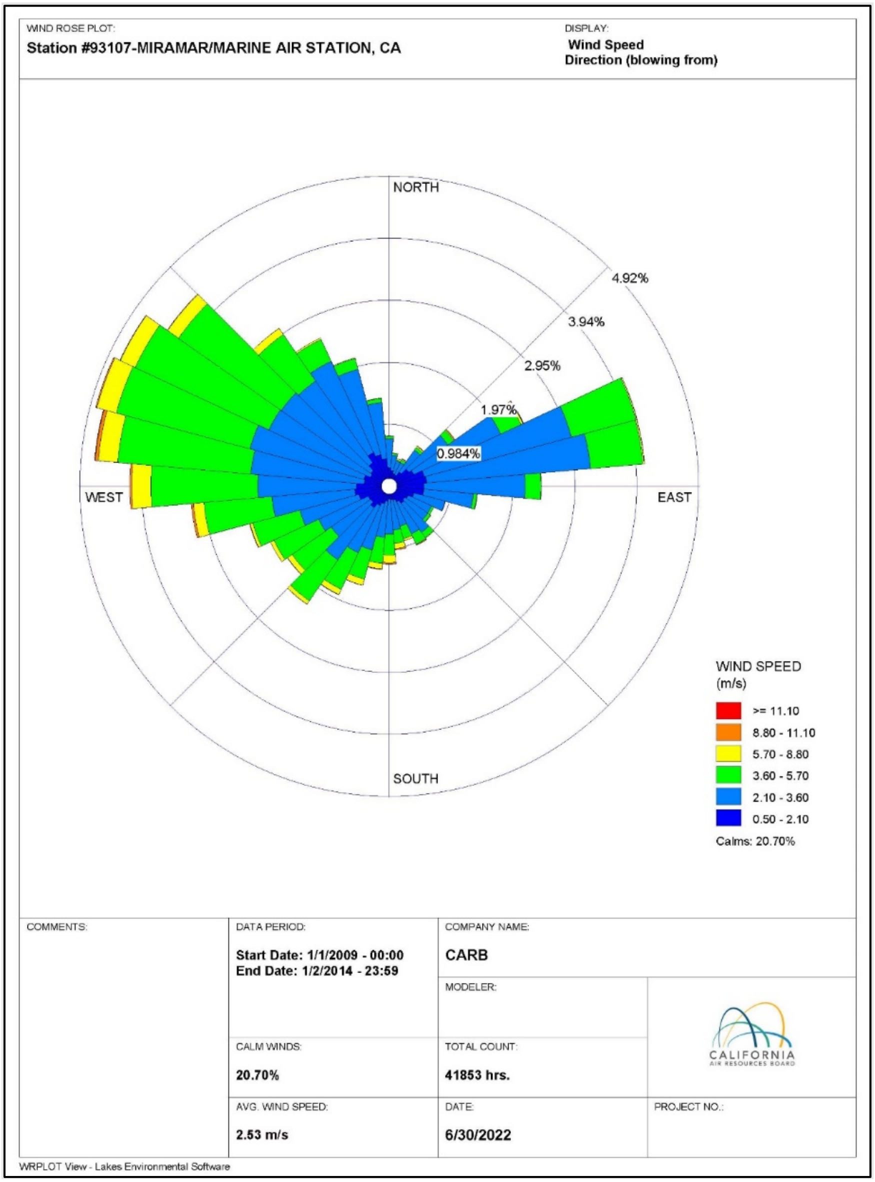
[8] User's Guide for the AMS/EPA Regulatory Model

Miramar Marine Corps Air Station (San Diego)

The meteorological data at Miramar Marine Corps Air Station was processed by San Diego County Air Pollution Control District for calendar years 2009-2013.

In AERMOD, the wind direction rotation adjustment option was selected for the Miramar Marine Corps Air Station with an input of +32.0 degrees. Miramar's wind rose is shown in Figure F.1.

Figure F.1 Wind Rose Plot at Miramar Marine Corps Air Station

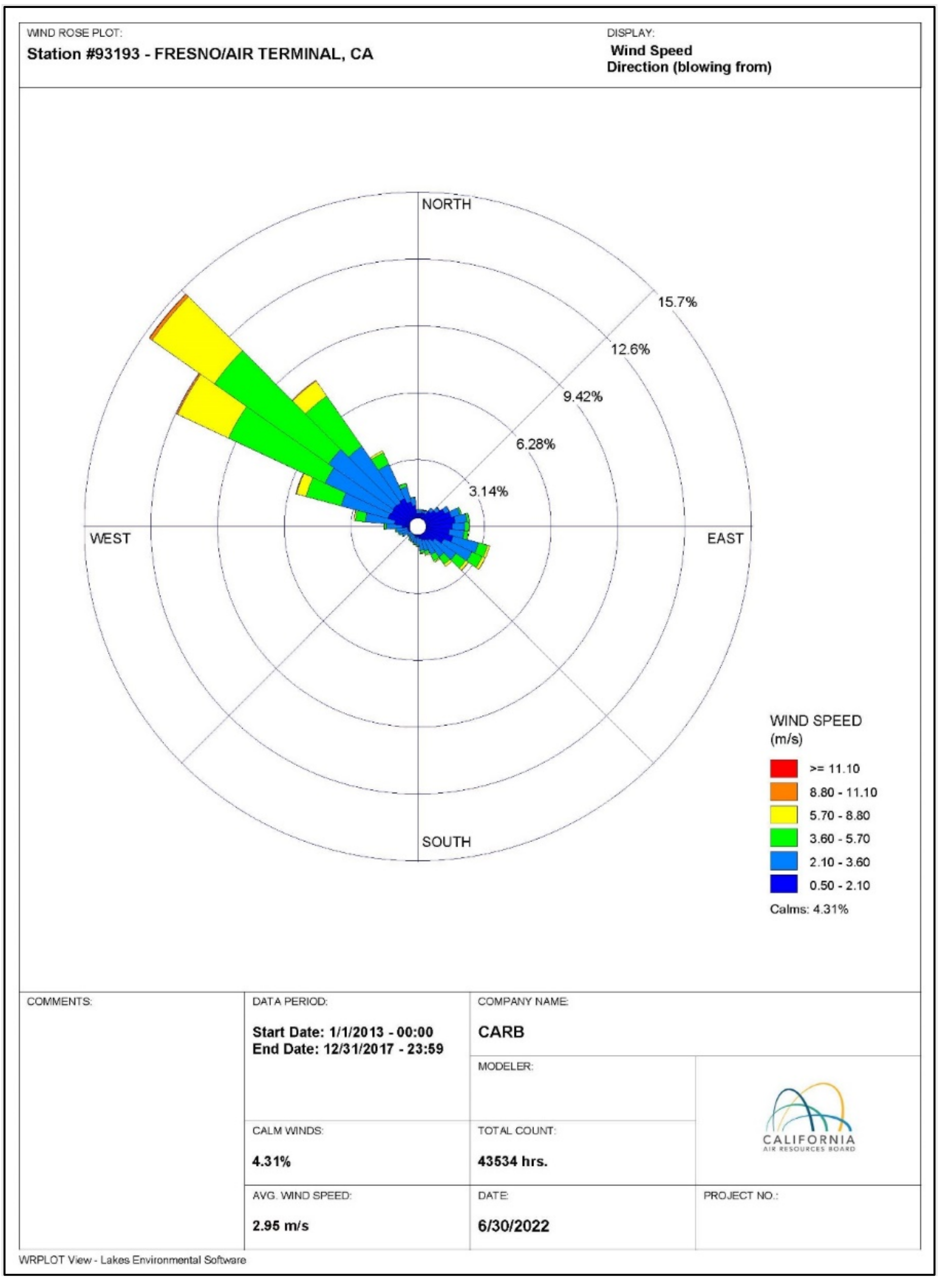


Fresno/Yosemite International Airport Station (Fresno)

Fresno Yosemite International Airport Station's AERMOD-ready meteorological data files were processed by the San Joaquin Valley Air Pollution Control District staff for years 2013-2017.

In AERMOD, the wind direction rotation adjustment option was selected for Fresno with an input of +38.0 degrees. Fresno's wind rose is shown in Figure F.2.

Figure F.2 Wind Rose Plot at Fresno/Yosemite International Airport Station

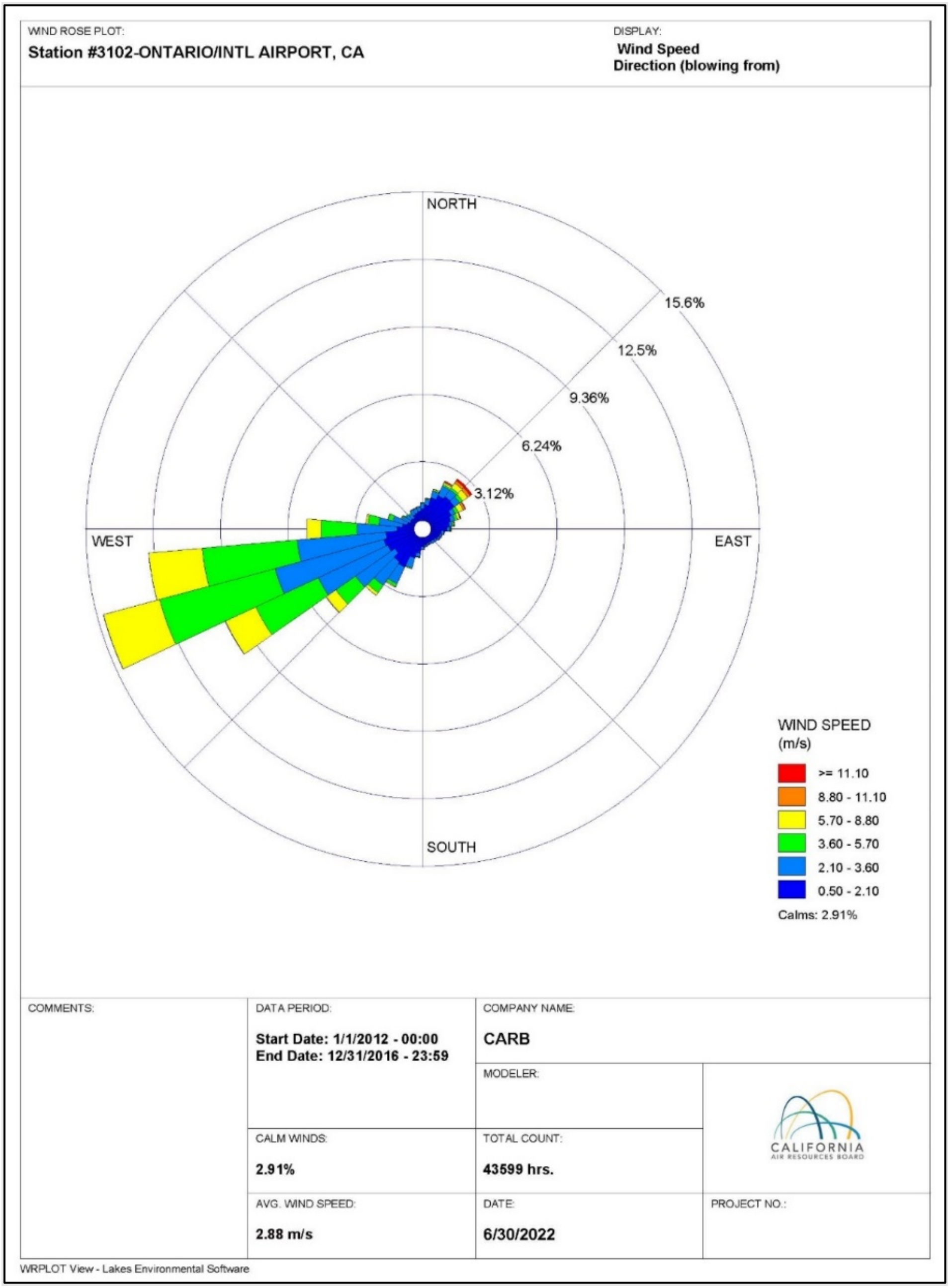


Ontario International Airport Station (Ontario)

Ontario International Airport Station's AERMOD-ready meteorological data files were processed by the South Coast Air Quality Management District for years 2012-2016.

In AERMOD, the wind direction rotation adjustment option was selected for Ontario with an input of –18.0 degrees. Ontario's wind rose is shown in Figure F.3.

Figure F.3 Wind Rose Plot at Ontario International Airport Station

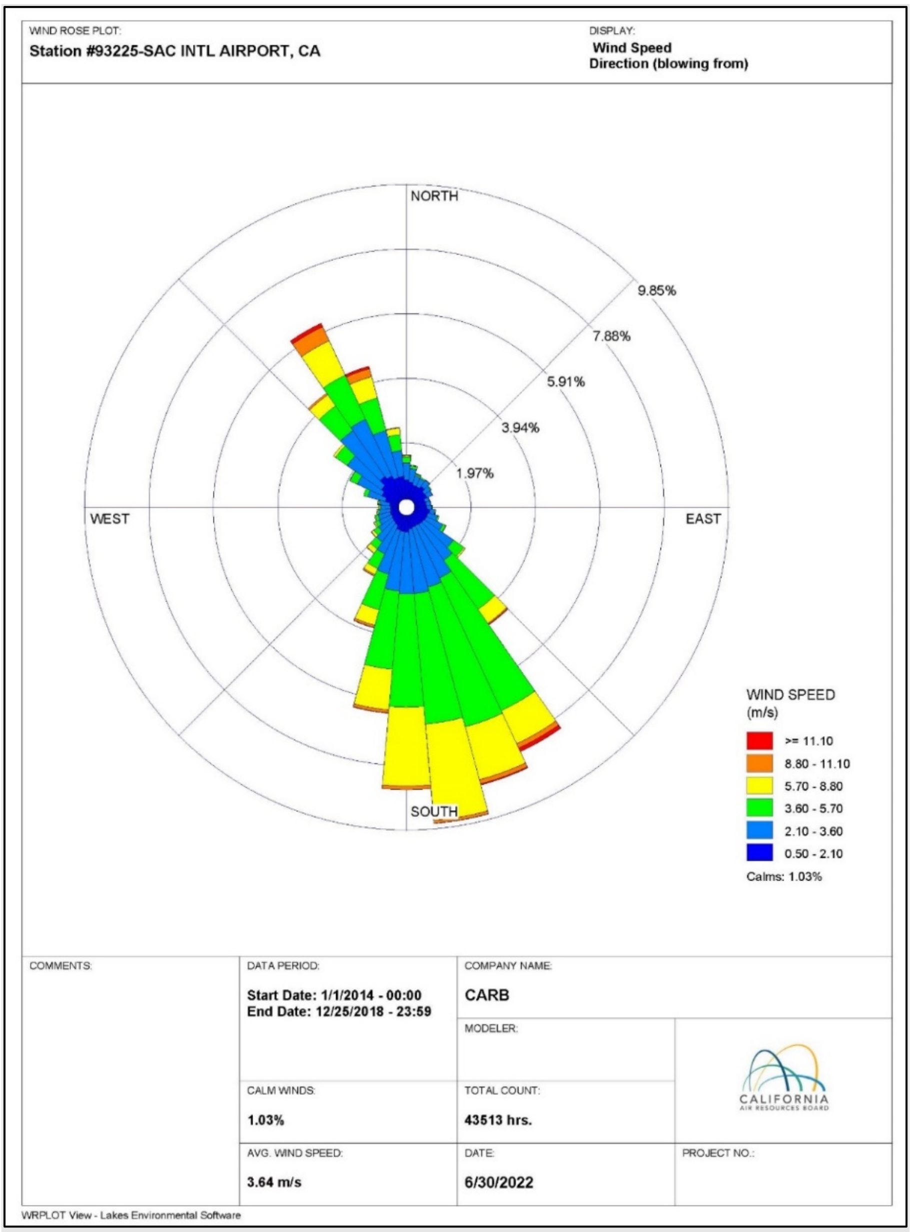


Sacramento International Airport Station (Sacramento)

Sacramento International Airport Station's AERMOD-ready meteorological data files were processed by the Sacramento Metropolitan Air Quality Management District for years 2014-2018.

In AERMOD, the wind direction rotation adjustment option was selected for Sacramento with an input of –10.0 degrees. Sacramento's wind rose is shown in Figure F.4.

Figure F.4 Wind Rose Plot at Sacramento International Airport Station

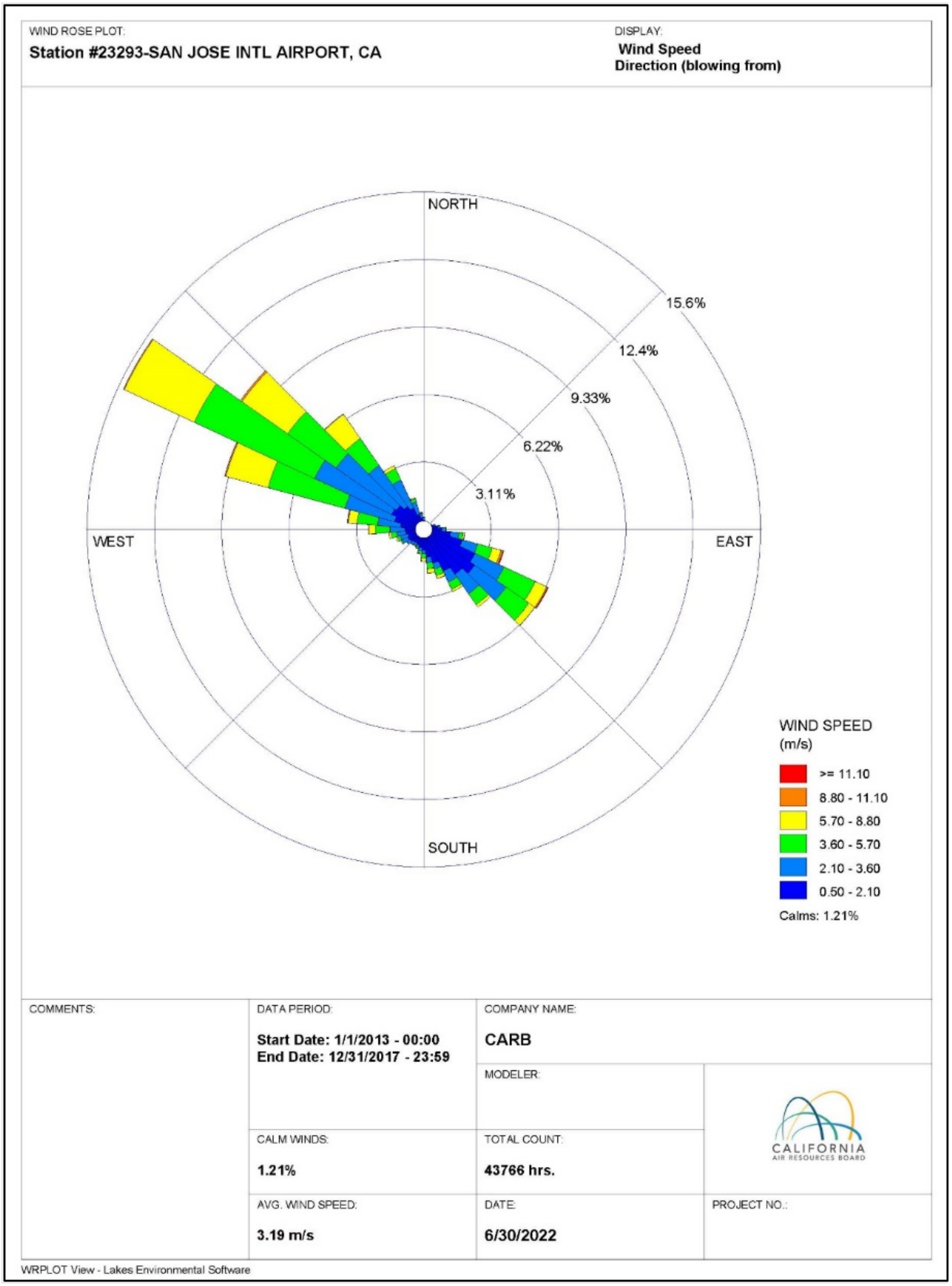


San Jose International Airport Station (San Jose)

San Jose International Airport Station's AERMOD-ready meteorological data files were processed by the Bay Area Air Quality Management District for years 2013-2017.

In AERMOD, the wind direction rotation adjustment option was selected for San Jose with an input of +32.0 degrees. San Jose's wind rose is shown in Figure F.5.

Figure F.5 Wind Rose Plot at San Jose International Airport Station



E. Risk Exposure Scenarios

To analyze the health impacts from chrome plating facilities, staff evaluated exposure scenarios for inhalation and oral cancer risk and noncancer chronic and acute risk. Staff calculated the health impacts using the methodology consistent with the OEHHA Guidelines. Health impacts were evaluated for the 2019 Baseline, and Proposed Amendment years 2026, 2027, and 2039. The description of the exposure scenarios and assumptions are presented below.

1. Exposure Scenarios for Cancer Risk

The OEHHA Guidelines provide a description of the risk algorithms, recommended exposure variates, and health values for calculating potential cancer risk. Potential cancer risk is calculated by converting an annual average concentration to a dose and then comparing it to a pollutant-specific value.

Staff calculated potential cancer risk values for two exposure scenarios, individual resident exposure and off-site worker exposure.

1. 30-Year Individual Resident Cancer Risk: An individual resident cancer risk evaluation assumes that a resident is exposed to the emission source for 30 years. This assumes an individual will live at a single location for that timeframe.
2. Off-Site Worker Cancer Risk: An off-site worker cancer risk evaluation assumes that an individual who works at a facility near chrome plating operations is exposed to the emission source for 25 years, 8 hours per day, and 250 days per year.

For individual resident exposure, staff applied the CARB and the California Air Pollution Control Officers Association (CAPCOA) risk management policy (RMP) for the multipathway-based cancer risk. The policy recommends using the 95th percentile daily breathing rates (DBR) for age bins less than 2 years old and the 80th percentile breathing rates for age bins greater than or equal to 2 years old. Because people have different breathing rates and different levels of sensitivity to carcinogens at different ages, potential cancer risk is calculated by age ranges (bins). These age bins include third trimester of pregnancy, 0<2, 2<16, and 16<30 for the 30-year individual resident cancer risk or 16-70 for off-site worker potential cancer risk. Staff also used the OEHHA Guidelines recommended eight-hour worker breathing rate for moderate intensity activities. Table F.5 summarizes the exposure assumptions for each scenario.

Table F.5 Summary of Exposure Parameters

Risk Scenario	Exposure Duration: Hours per Day	Exposure Duration: Days per Year	Exposure Duration: Years	Daily Breathing Rate (DBR)	Fraction of Time at Home (FAH)	Pathway Evaluated
Individual Resident (30-year Individual Resident Cancer Risk)	24	350	30	RMP (95th percentile DBRs for age bins less than 2 years and 80th percentile DBRs for age bins greater than 2 years)	1 for age bins less than 16 0.73 for age bins greater than 16 years	Inhalation Soil Dermal Mother's Milk
Off-site Worker	8	250	25	8-hour moderate intensity BRs for ages 16 to 70.	Not applied (all age bins use 1)	Inhalation Soil Dermal

The bins allow for the use of age-specific exposure rates. Exposure variates include breathing rates, age sensitive factors, fraction of time at home, and exposure duration. For example, age sensitivity factors will multiply the risk by a factor of 10 for age bins less than 2 years of age and by a factor of 3 for age bins between 2 and 16. Age sensitivity factors, presented in Table F.6, were developed by OEHHA and account for the increased sensitivity to carcinogens, like hexavalent chromium, during early-in-life exposure.

Table F.6 Age Sensitivity Factors by Age Group for Cancer Risk Assessment

Age Group	Age Sensitivity Factors (unitless)
3rd Trimester	10
0 < 2	10
2 < 16	3
16 < 30	1
16 < 70	1

Table F.7 summarizes exposure duration by age bin for individual residents and off-site workers. After the potential cancer risk is calculated for each applicable age bin, the results are summed for the exposure duration of interest (e.g., 30 years for this evaluation) to yield a total individual potential cancer risk.

Table F.7 Exposure Duration by Age Bin for Individual Residents and Off-Site Workers

Risk Scenario	3rd Trimester	0<2	2<16	16<30	16 -70	Total
Individual Resident (30-year Individual Resident Cancer Risk)	0.25 years	2 years	14 years	14 years	-	30 years
Off-site Worker	-	-	-		25 years	25 years

2. Exposure Scenarios for Noncancer Chronic Risk

A Reference Exposure Level (REL) is used as an indicator of potential noncancer adverse health effects and is defined as a concentration level at or below which no adverse health effects are expected. RELs are designed to protect the most sensitive persons in the population by including safety factors and can be created for acute, 8-hour, and chronic exposures.

Chronic exposure is defined as long-term exposure, which is equal to about 12 percent of a lifetime, or 8 or more years. An acute exposure is defined as one or a series of short-term exposures generally lasting less than 24 hours. An 8-hour REL is for repeated 8-hour exposures that can occur for a significant fraction of a lifetime such as exposures that an off-site worker may experience.

The chronic, acute, and 8-hour health Hazard Indices (HI) are calculated by dividing the annual average concentrations of hexavalent or trivalent chromium by the inhalation REL for hexavalent or trivalent chromium. Tables F.8(a) and F.8(b) contain noncancer inhalation and oral RELs and toxicological endpoints for hexavalent chromium and trivalent chromium.

Table F.8(a) Hexavalent Chromium Reference Exposure Levels and Toxicological Endpoints Used in Noncancer Health Risk Assessment

Health Effect	Noncancer Reference Exposure Levels (RELs) or Dose[a]	Toxicological Endpoints
Chronic – Inhalation	0.20 (μg/m^3)	Respiratory System
Chronic – Oral	0.02 (mg/kg-day)	Hematologic

[a] mg/kg-day

Table F.8(b) Trivalent Chromium Reference Exposure Levels and Toxicological Endpoints Used in Noncancer Health Risk Assessment

Health Effect	Noncancer Reference Exposure Levels (RELs)	Toxicological Endpoints
Acute - Inhalation	0.48 (μg/m^3)	Respiratory System
8-Hour - Inhalation	0.12 (μg/m^3)	Respiratory System
Chronic - Inhalation	0.06 (μg/m^3)	Respiratory System

Only noncancer chronic RELs have been determined for hexavalent chromium. There is no noncancer acute REL for hexavalent chromium. Noncancer impacts linked to hexavalent chromium exposure include respiratory irritation, severe nasal and skin ulcerations and lesions, perforation in the nasal septum, liver and kidney failure, and birth defects.

F. Methodology and HRA Results

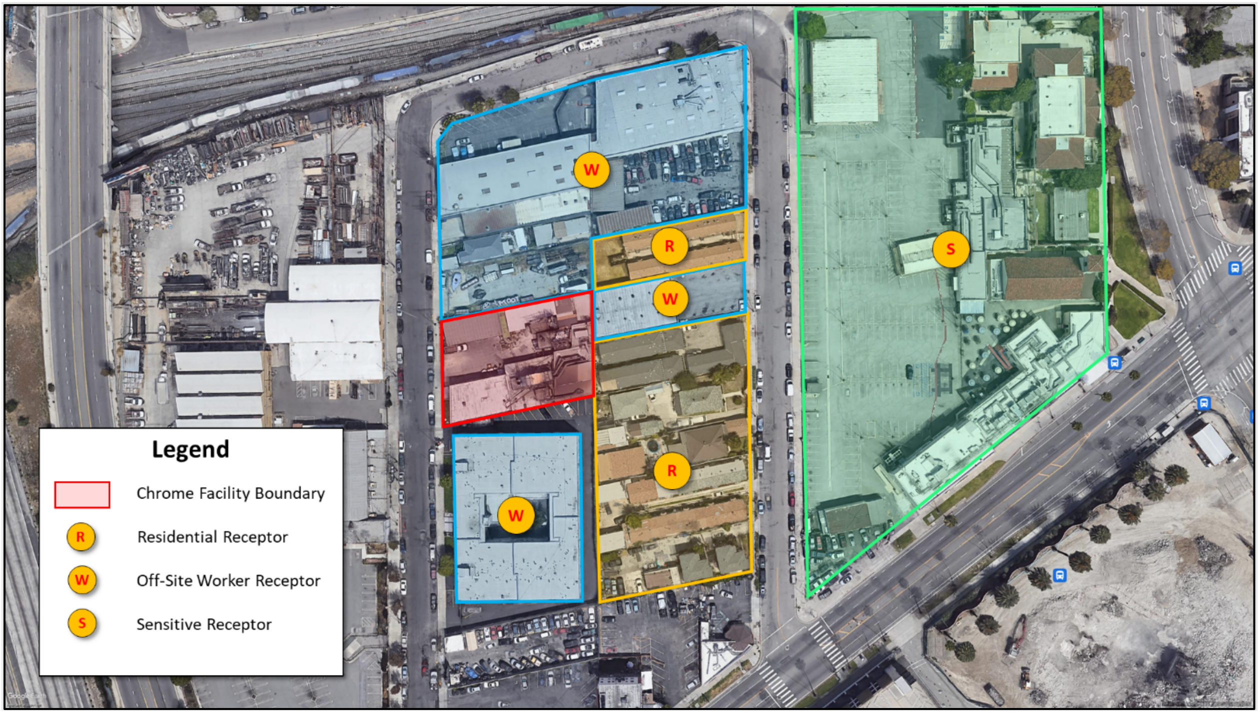
1. Source Description

Chrome plating facilities range in size depending on the type of operation. The Proposed Amendments will eliminate hexavalent chromium emissions from the chrome plating industry in California following the phase out of hexavalent chromium from chrome plating operations. Because of the variability in size and operation, CARB staff elected to model generic chrome plating facilities that could accommodate a range of operations and activity from 5,000 annual amp-hours, representing a small decorative plater, to 120 million annual amp-hours, representing a large functional plater.

a) Facility Layout

The chrome plating facility footprints are treated as buildings with a range in sizes. As discussed previously, CARB staff analyzed the type and number of facilities where decorative or functional plating operations occur. As part of this analysis, staff used Google Earth® images to estimate the footprints (e.g., length, width, and height) of these facilities and their property boundaries. Figure F.6 is an example of this facility layout analysis and includes individual resident, off-site worker receptors, and sensitive receptors around a chrome plating facility. CARB staff cross-referenced these facility footprints, based on their plating category, with their reported annual amp-hour throughput in 2019. Finally, staff averaged the building dimensions based on the annual amp-hour ranges. The averaged building dimensions are presented in Tables F.10(a) and F.10(b).

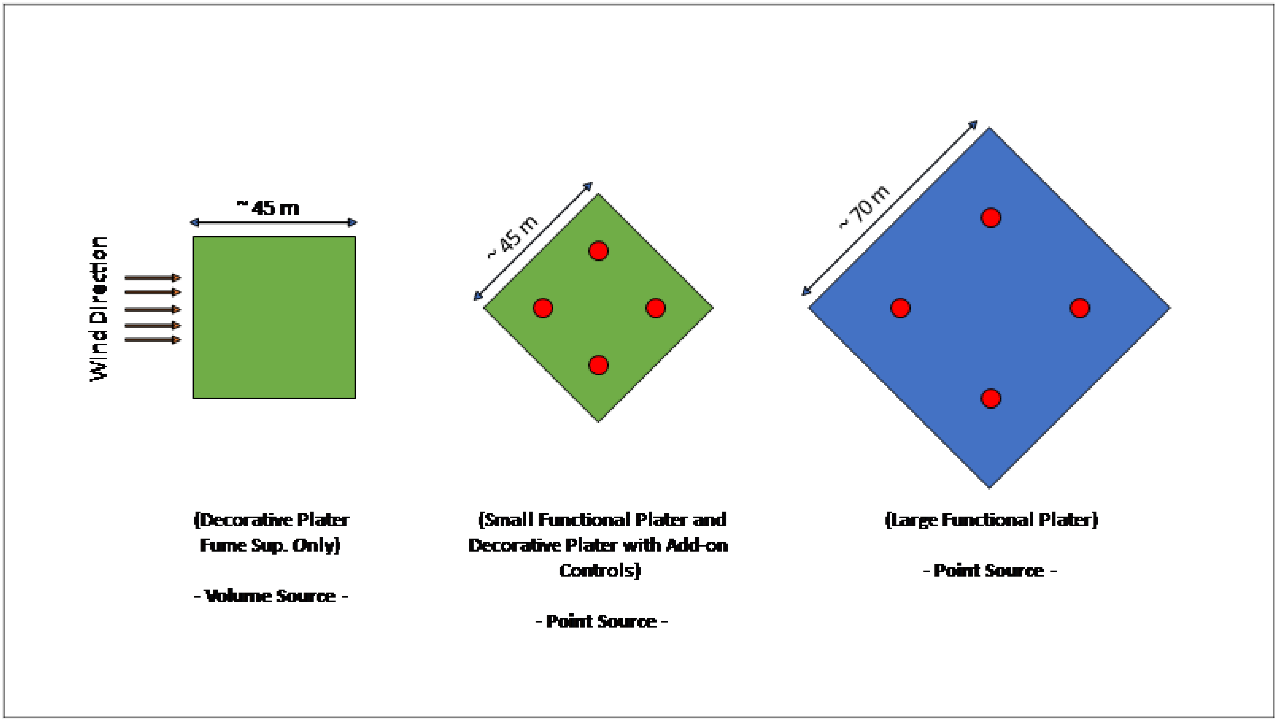
Figure F.6 Aerial Image and Spatial Analysis of a Chrome Plating Facility in California



Map Data: Google, Digital Globe

Based on this analysis, as well as survey information, source information, and observations during site visits from CARB or local air district staff, generic facility configurations were created (shown in Figure F.7), including (1) decorative platers that use only fume suppressants, (2) both decorative platers that use add-on controls and small functional platers, and (3) large functional platers.

Figure F.7 Schematic of Facility Layouts in Model



Note: Figure not to scale.

Stack emissions are characterized as point sources in the model to represent the hexavalent chromium exhaust from add-on pollution control device with forced ventilation systems in chrome plating facilities. Google Earth® imagery of various facilities suggests that facilities could have more than one exhaust stack, often near the edge of the building. For this modeling work, four stacks were placed equidistant from the center of the facility building to represent a range of facility configurations statewide.

Some facilities use only in-tank controls, such as chemical fume suppressants, to reduce hexavalent chromium emissions. Volume sources are used to represent the nature of the non-stack emissions from these facilities. This emission characterization represents most decorative plating facilities. In this case, the source of emissions (the tank) is assumed to be in the center of the building and the air concentrations are modeled from that point.

2. Emission Inventory

Hexavalent chromium emissions are based on a facility's chrome plating activity, estimated in total annual electricity usage of ampere-hours (amp-hours). CARB staff developed a facility and activity profile to represent chrome plating amp-hours ranging from 5,000 to 120 million amp-hours per year. For this HRA, staff established a range of amp-hour activity for each facility type based on 2019 facility throughput data collected from local air districts. The emission factors used for facility emissions were based on the current ATCM limits and Proposed Amendments limits (see Section I.B). The annual emissions rates were calculated by multiplying the amp-hours by the respective emission factors.

Finally, using the equation shown below, the emission rates, in grams per second (g/sec), were calculated and applied to the modeled concentrations, which were modeled using a unit emission rate of 1 g/sec, to determine actual concentrations of hexavalent chromium at each receptor point. Tables F.9(a), F.9(b), F.9(c), and F.9(d) summarize the range of annual amp-hours, emission limits, and emission rates applied to the modeled concentrations by facility plating type.

$$Facility\ Emission\left(\frac{g}{year}\right) = Electricity\ Usage\left(\frac{amp \cdot hours}{year}\right) \times \frac{Emission\ Factor\left(\frac{mg}{amp \cdot hours}\right)}{1000\left(\frac{mg}{g}\right)}$$

Table F.9(a) Current and Proposed Hexavalent Chromium Emission Limits and Emission Rates for Decorative Platers with Fume Suppressant Only

	ATCM Emission Limit (mg/amp-hour)				Emission Rate (g/sec)			
Annual Activity (amp-hour)[a]	2019	2026	2027	2039	2019	2026	2027	2039
5,000	0.01	0.01	0	0	1.59E-09	1.59E-09	0	0
10,000	0.01	0.01	0	0	3.17E-09	3.17E-09	0	0
20,000	0.01	0.01	0	0	6.34E-09	6.34E-09	0	0
50,000	0.01	0.01	0	0	1.59E-08	1.59E-08	0	0
250,000	0.0015	0.0015	0	0	1.19E-08	1.19E-08	0	0
500,000	0.0015	0.0015	0	0	2.38E-08	2.38E-08	0	0
1,000,000	0.0015	0.0015	0	0	4.76E-08	4.76E-08	0	0

[a] Under the 2007 ATCM, a decorative plater with annual activity greater than 50,000 amp-hours can operate with chemical fume suppressants to control emissions, provided that they can achieve an emission limit of 0.0015 mg/amp-hour.

Table F.9(b) Current and Proposed Hexavalent Chromium Emission Limits and Emission Rates for Decorative Platers with Add-on Pollution Controls

	ATCM Emission Limit (mg/amp-hour)				Emission Rate (g/sec)			
Annual Activity (amp-hour)	2019	2026	2027	2039	2019	2026	2027	2039
25,000	0.0015	0.0015	0	0	1.19E-09	1.19E-09	0	0
50,000	0.0015	0.0015	0	0	2.38E-09	2.38E-09	0	0
100,000	0.0015	0.0015	0	0	4.76E-09	4.76E-09	0	0
250,000	0.0015	0.0015	0	0	1.19E-08	1.19E-08	0	0
500,000	0.0015	0.0015	0	0	2.38E-08	2.38E-08	0	0
750,000	0.0015	0.0015	0	0	3.57E-08	3.57E-08	0	0
1,000,000	0.0015	0.0015	0	0	4.76E-08	4.76E-08	0	0
3,000,000	0.0015	0.0015	0	0	1.43E-07	1.43E-07	0	0

Table F.9(c) Current and Proposed Hexavalent Chromium Emission Limits and Emission Rates for Small Functional Platers

	ATCM Emission Limit (mg/amp-hour)				Emission Rate (g/sec)			
Annual Activity (amp-hour)	2019	2026	2027	2039	2019	2026	2027	2039
10,000	0.0015	0.0075	0.00075	0	4.76E-10	2.38E-10	2.38E-10	0
25,000	0.0015	0.0075	0.00075	0	1.19E-09	5.95E-10	5.95E-10	0
50,000	0.0015	0.0075	0.00075	0	2.38E-09	1.19E-09	1.19E-09	0
100,000	0.0015	0.0075	0.00075	0	4.76E-09	2.38E-09	2.38E-09	0
500,000	0.0015	0.0075	0.00075	0	2.38E-08	1.19E-08	1.19E-08	0
750,000	0.0015	0.0075	0.00075	0	3.57E-08	1.78E-08	1.78E-08	0

Table F.9(d) Current and Proposed Hexavalent Chromium Emission Limits and Emission Rates for Large Functional Platers

	ATCM Emission Limit (mg/amp-hour)				Emission Rate (g/sec)			
Annual Activity (amp-hour)	2019	2026	2027	2039	2019	2026	2027	2039
1,000,000	0.0015	0.0075	0.00075	0	4.76E-08	2.38E-08	2.38E-08	0
5,000,000	0.0015	0.0075	0.00075	0	2.38E-07	1.19E-07	1.19E-07	0
10,000,000	0.0015	0.0075	0.00075	0	4.76E-07	2.38E-07	2.38E-07	0
30,000,000	0.0015	0.0075	0.00075	0	1.43E-06	7.13E-07	7.13E-07	0
60,000,000	0.0015	0.0075	0.00075	0	2.85E-06	1.43E-06	1.43E-06	0
120,000,000	0.0015	0.0075	0.00075	0	5.71E-06	2.85E-06	2.85E-06	0

3. Air Dispersion Modeling

To run AERMOD, modelers are required to define and setup the project and emissions sources, select meteorological data files, and specify the receptor locations. These are specified in the model's input file as the control pathway, source pathway, meteorology pathway, and receptor pathway. These input pathways, with exception of the meteorological pathway, are described below.

a) Control Pathway

The control pathway contains input control file parameters used to specify the overall model run, such as dispersion coefficient options, terrain options, etc. Table F.10 presents the control parameters used in the model input.

Table F.8 AERMOD Control Inputs for Chrome Plating Facilities

Control Parameter	Model Input
Dispersion Coefficients	Rural
Terrain Option	Flat

b) Source Pathway

The source pathway identifies the source type (e.g., point, area, volume, or open pit) and defines the source type emission parameters. For example, point sources are defined by emission rate, release height, exit velocity, and exit temperature. Tables F.11(a) and F.11(b) present the source parameters used to characterize hexavalent chromium sources from chrome plating facilities.

Table F.11(a) Generic Facility Point Source Emission Parameters for AERMOD Air Dispersion Modeling

Parameters	Decorative with add-on Controls, Small Functional Platers	Large Functional Platers
Stack Diameter (m)	0.66	0.92
Stack Height (m)	9.1	12.8
Stack Temperature (°K)	297.15	297.15
Stack Exhaust Velocity (m/s)	12.2	8.5

Table F.11(b) Generic Facility Volume Source Emission Parameters for AERMOD Air Dispersion Modeling

Parameters	Decorative Platers with Fume Suppressants
Release Height (m)	4.4
Lateral Dimension (m)	10.4
Vertical Dimension (m)	4.1

c) Receptor Pathway

The receptor pathway specifies the locations of receptors. Receptors are points, defined in the model, where the concentrations of target pollutant are calculated. A polar receptor grid was used for this HRA. Depending on the facility type being modeled, receptors were adjusted so that the nearest receptors were about five meters away from the edge of the building. Table F.12 presents the receptor grid parameters used in the model input.

Table F.9 Uniform Polar Receptor Grid Inputs

Facility Type	No. of Radials	No. of Receptor Rings	Modeled Distance (m)[a]	Receptor Height (m)
Dec. Platers with Fume Suppressants	72	34	1,020	1.2
Dec. Platers with Add-on Controls and Small Functional Platers	72	34	1,030	1.2
Large Functional Platers	72	34	1,050	1.2

[a] Distances reflect the first receptor placed at five meters away from the building envelope. Total modeled distance is 1,000 meters from the building.

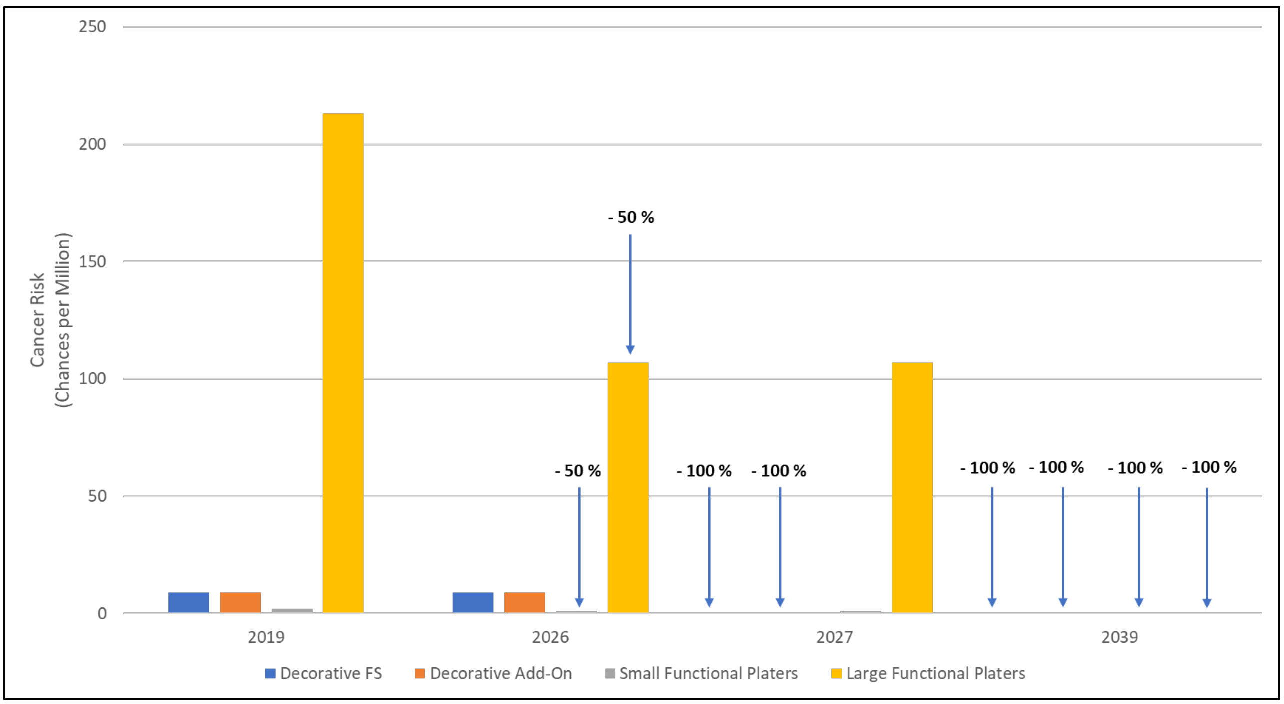
4. Health Risk Assessment – Summary of Cancer Risk

For functional plating facilities, CARB staff evaluated the potential cancer risk at nearby receptors under the Baseline and the Proposed Amendments. The Proposed Amendments provide reductions in potential cancer risk to individual residents and off-site workers when compared to the Baseline.

a) Potential Individual Resident Cancer Risk

Figure F.8 summarizes the progressive reductions of potential individual resident cancer risks from 2019 Baseline to year 2039 under the Proposed Amendments (not including the impacts from fugitive emissions). The figure also highlights the maximum reduction in potential individual resident cancer risk in the year 2039 after full implementation of the Proposed Amendments. The potential individual resident cancer risk is reduced by 50 percent for functional platers in 2026 and 100 percent for decorative platers in 2027. In 2039, potential individual resident cancer risk is reduced by 100 percent for all plating types when compared to the 2019 Baseline. This is due to the different requirements and implementation schedules for decorative and functional platers under the Proposed Amendments (see the emission limits schedule in Tables F.9(a), F.9(b), F.9(c), and F.9(d)). The 100 percent reduction in individual resident cancer risk assumes that the alternative plating processes do not emit hexavalent chromium. The detailed cancer risk reductions at different spatial distances from all types of chrome plating operations with various annual activity are provided in Tables F.13 - F.20.

Figure F.8 Potential Individual Resident Cancer Risk and Risk Reduction



Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Tables F.13(a) and F.13(b) and Tables F.14(a) and F.14(b) show the potential cancer risk for individual residents under the Baseline for the year 2019.

For decorative platers, Tables F.13(a) and F.13(b) show that potential individual resident cancer risks range from less than one chance per million to approximately nine chances per million at the nearest receptor.

Table F.13(a) Individual Resident Cancer Risk – Baseline Year 2019 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
1,000,000	9	7	6	5	4	4	3	3	2	2	1	1	< 1	< 1	< 1
500,000	4	4	3	2	2	2	2	1	1	1	1	< 1	< 1	< 1	< 1
250,000	2	2	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
50,000	3	2	2	2	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
20,000	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
5,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.13(b) Individual Resident Cancer Risk – Baseline Year 2019 (Decorative Platers with Add-on Pollution Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
3,000,000	9	2	2	2	2	1	1	1	1	1	1	< 1	< 1	< 1	< 1
1,000,000	3	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
750,000	2	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
250,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

For small and large functional platers, Tables F.14(a) and F.14(b) show that potential individual resident cancer risks range from less than one chance per million to approximately 213 chances per million at the nearest receptor.

Table F.14(a) Individual Resident Cancer Risk – Baseline Year 2019 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
750,000	2	2	2	2	2	2	1	1	1	1	1	1	< 1	< 1	< 1
500,000	1	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.14(b) Individual Resident Cancer Risk – Baseline Year 2019 (Large Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
120,000,000	213	204	194	188	183	180	179	165	142	97	69	54	40	34	30
60,000,000	107	102	97	94	91	90	90	82	71	49	34	27	20	17	15
30,000,000	53	51	49	47	46	45	45	41	35	24	17	14	10	9	7
10,000,000	18	17	16	16	15	15	15	14	12	8	6	5	3	3	2
5,000,000	9	8	8	8	8	7	7	7	6	4	3	2	2	1	1
1,000,000	2	2	2	2	2	1	1	1	1	1	1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

For the year 2026, Tables F.15(a) and F.15(b) and Tables F.16(a) and F.16(b) show the potential individual resident cancer risk for each type of chrome plating facility under the Proposed Amendments. For decorative platers, Tables F.15(a) and F.15(b) show that under the Proposed Amendments in 2026, potential individual resident cancer risk ranges from less than one chance per million to approximately nine chances per million at the nearest receptor.

Table F.15(a) Individual Resident Cancer Risk – Proposed Amendments Year 2026 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
1,000,000	9	7	6	5	4	4	3	3	2	2	1	1	< 1	< 1	< 1
500,000	4	4	3	2	2	2	2	1	1	1	1	< 1	< 1	< 1	< 1
250,000	2	2	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
50,000	3	2	2	2	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
20,000	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
5,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.15(b) Individual Resident Cancer Risk – Proposed Amendments Year 2026 (Decorative Platers with Add-on Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
3,000,000	9	2	2	2	2	1	1	1	1	1	1	< 1	< 1	< 1	< 1
1,000,000	3	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
750,000	2	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
250,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

For functional platers, Tables F.16(a) and F.16(b) show that under the Proposed Amendments in 2026, potential individual resident cancer risk ranges from less than one to approximately 107 chances per million at the nearest receptor.

Table F.16(a) Individual Resident Cancer Risk – Proposed Amendments Year 2026 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
750,000	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.16(b) Individual Resident Cancer Risk – Proposed Amendments Year 2026 (Large Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
120,000,000	107	102	97	94	91	90	90	82	71	49	34	27	20	17	15
60,000,000	53	51	49	47	46	45	45	41	35	24	17	14	10	9	7
30,000,000	27	25	24	23	23	22	22	21	18	12	9	7	5	4	4
10,000,000	9	8	8	8	8	7	7	7	6	4	3	2	2	1	1
5,000,000	4	4	4	4	4	4	4	3	3	2	1	1	1	1	1
1,000,000	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

For the year 2027, Tables F.17(a) and F.17(b) and Tables F.18(a) and F.18(b) show the potential individual resident cancer risk for each type of chrome plating facility under the Proposed Amendments. For decorative platers, Tables F.17(a) and F.17(b) show that under the Proposed Amendments in 2027, when these facilities will be prohibited from using hexavalent chromium for chrome plating operations, potential individual resident cancer risk is zero.

Table F.17(a) Individual Resident Cancer Risk – Proposed Amendments Year 2027 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.17(b) Individual Resident Cancer Risk – Proposed Amendments Year 2027 (Decorative Platers with Add-on Pollution Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
3,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
750,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

For functional platers, Tables F.18(a) and F.18(b) show that under the Proposed Amendments in 2027, potential individual resident cancer risk ranges from less than one to approximately 107 chances per million at the nearest receptor.

Table F.18(a) Individual Resident Cancer Risk – Proposed Amendments Year 2027 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
750,000	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.18(b) Individual Resident Cancer Risk – Proposed Amendments Year 2027 (Large Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
120,000,000	107	102	97	94	91	90	90	82	71	49	34	27	20	17	15
60,000,000	53	51	49	47	46	45	45	41	35	24	17	14	10	9	7
30,000,000	27	25	24	23	23	22	22	21	18	12	9	7	5	4	4
10,000,000	9	8	8	8	8	7	7	7	6	4	3	2	2	1	1
5,000,000	4	4	4	4	4	4	4	3	3	2	1	1	1	1	1
1,000,000	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

For the year 2039, all chrome plating operations will be prohibited from using hexavalent chromium for chrome plating operations. Tables F.19(a) and F.19(b) and Tables F.20(a) and F.20(b) show the potential individual resident cancer risks are zero for each type of chrome plating facility under the Proposed Amendments.

Table F.19(a) Individual Resident Cancer Risk – Proposed Amendments Year 2039 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.19(b) Individual Resident Cancer Risk – Proposed Amendments Year 2039 (Decorative Platers with Add-on Pollution Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
3,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
750,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.20(a) Individual Resident Cancer Risk – Proposed Amendments Year 2039 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
750,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

Table F.20(b) Individual Resident Cancer Risk – Proposed Amendments Year 2039 (Large Functional Platers)

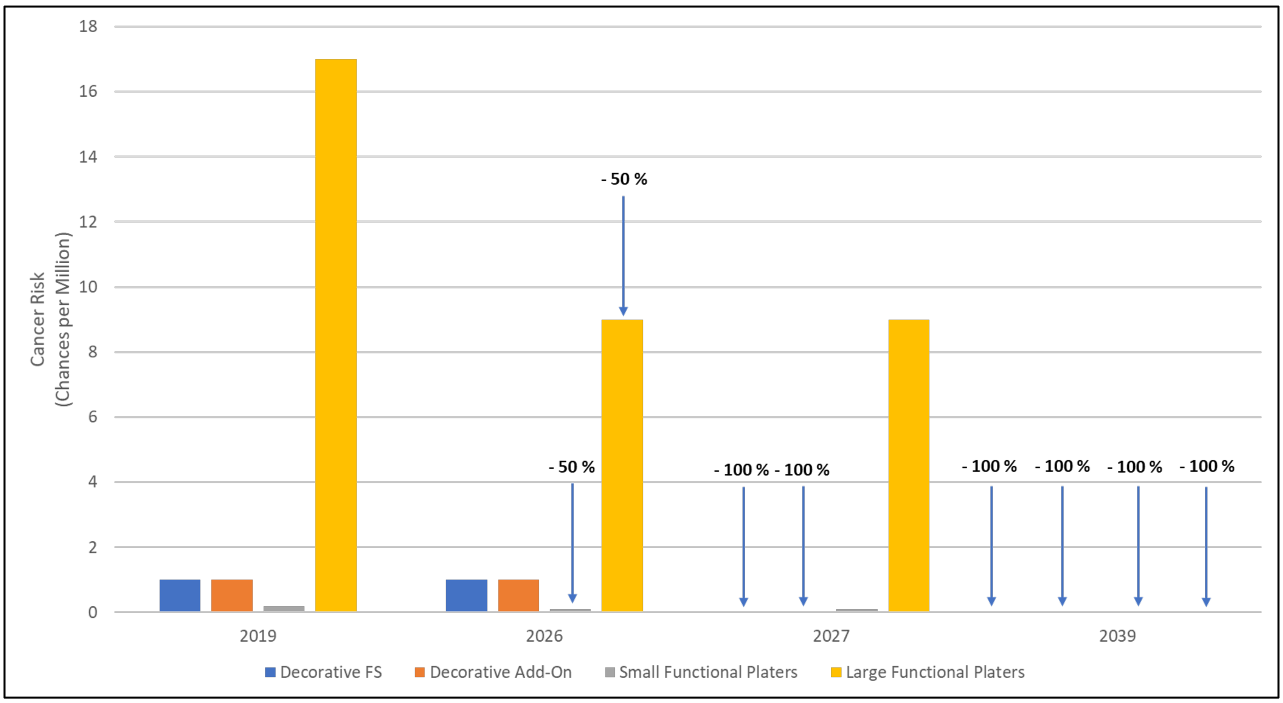
	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
120,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) derived method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins < 16 years and 0.73 for age bin 16-30 years. All numbers are rounded.

b) Potential Off-Site Worker Cancer Risk

Figure F.9 highlights the reduction in potential off-site worker cancer risk by the year 2039 after full implementation of the Proposed Amendments. The figure shows that the potential off-site worker cancer risk is reduced by 50 percent in 2026, and 100 percent in 2039 when compared to the Baseline. The amount of off-site worker cancer risk reduction achieved in 2026 is dependent on the facility type. This is due to the different requirements and implementation schedules for decorative and functional platers under the Proposed Amendments. The 100 percent reduction in potential off-site worker cancer risk assumes that the alternative plating processes do not emit hexavalent chromium.

Figure F. 9 Potential Off-Site Worker Cancer Risk and Risk Reduction



Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Tables F.21(a) and F.21(b) and Tables F.22(a) and F.22(b) show the potential cancer risk for off-site workers, under the Baseline for the year 2019. Depending on facility type, potential cancer risk ranges from less than one to approximately 17 chances per million. Tables F.21(a) and F.21(b) show that, for decorative platers, potential cancer risk ranges from less than one chance per million to approximately one chance per million at the nearest receptor.

Table F.21(a) Off-Site Worker Cancer Risk – Baseline Year 2019 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
1,000,000	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
250,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
20,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
5,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.21(b) Off-Site Worker Cancer Risk – Baseline Year 2019 (Decorative Platers with Add-on Pollution Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
3,000,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,000,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
750,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
250,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For small and large functional platers, Tables F.22(a) and F.22(b) show that in 2019 potential cancer risk for off-site workers ranges from less than one chance per million to approximately 17 chances per million at the nearest receptor.

Table F.22(a) Off-Site Worker Cancer Risk – Baseline Year 2019 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
750,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.22(b) Off-Site Worker Cancer Risk – Baseline Year 2019 (Large Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
120,000,000	17	17	16	15	15	15	15	13	12	8	6	4	3	3	2
60,000,000	9	8	8	8	7	7	7	7	6	4	3	2	2	1	1
30,000,000	4	4	4	4	4	4	4	3	3	2	1	1	1	1	1
10,000,000	1	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1
5,000,000	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,000,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For the year 2026, Tables F.23(a) and F.23(b) and Tables F.24(a) and F.24(b) show the potential cancer risk for off-site workers for each type of chrome plating facility under the Proposed Amendments. For decorative platers, Tables F.23(a) and F.23(b) show that potential cancer risk for off-site workers ranges from less than one chance per million to approximately one chance per million at the nearest receptor.

Table F.23(a) Off-Site Worker Cancer Risk – Proposed Amendments Year 2026 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
1,000,000	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
250,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
20,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
5,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.23(b) Off-Site Worker Cancer Risk – Proposed Amendments Year 2026 (Decorative Platers with Add-on Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
3,000,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,000,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
750,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
250,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For functional platers, Tables F.24(a) and F.24(b) show that in 2026 under the Proposed Amendments potential cancer risk for off-site workers ranges from less than one chance per million to approximately nine chances per million at the nearest receptor.

Table F.24(a) Off-Site Worker Cancer Risk – Proposed Amendments Year 2026 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
750,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
100,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
50,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
25,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
10,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.24(b) Off-Site Worker Cancer Risk – Proposed Amendments Year 2026 (Large Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
120,000,000	9	8	8	8	7	7	7	7	6	4	3	2	2	1	1
60,000,000	4	4	4	4	4	4	4	3	3	2	1	1	1	1	1
30,000,000	2	2	2	2	2	2	2	2	1	1	1	1	< 1	< 1	< 1
10,000,000	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
5,000,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,000,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For the year 2027, Tables F.25(a) and F.25(b) and Tables F.26(a) and F.26(b) show the potential off-site worker cancer risk for each type of chrome plating facility under the Proposed Amendments. For decorative platers, Tables F.25(a) and F.25(b) show that under the Proposed Amendments in 2027, when these facilities will be prohibited from using hexavalent chromium for chrome plating under the Proposed Amendments, potential off-site worker cancer risk zero.

Table F.25(a) Off-Site Worker Cancer Risk – Proposed Amendments Year 2027 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.25(b) Off-Site Worker Cancer Risk – Proposed Amendments Year 2027 (Decorative Platers with Add-on Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	5	10	15	20	25	30	35	40	45	50	75	105	150	175	200
3,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
750,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For functional platers, Tables F.26(a) and F.26(b) show that in 2027 under the Proposed Amendments potential cancer risk for off-site workers ranges from less than one to approximately nine chances per million at the nearest receptor.

Table F.26(a) Off-Site Worker Cancer Risk – Proposed Amendments Year 2027 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
750,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
500,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
100,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
50,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
25,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
10,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.26(b) Off-Site Worker Cancer Risk – Proposed Amendments Year 2027 (Large Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
120,000,000	9	8	8	8	7	7	7	7	6	4	3	2	2	1	1
60,000,000	4	4	4	4	4	4	4	3	3	2	1	1	1	1	1
30,000,000	2	2	2	2	2	2	2	2	1	1	1	1	< 1	< 1	< 1
10,000,000	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
5,000,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
1,000,000	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For the year 2039, all chrome plating operations will be prohibited from conducting plating operations using hexavalent chromium. Tables F.27(a) and F.27(b) and Tables F.28(a) and F.28(b) show the potential cancer risks for off-site workers are zero for each type of chrome plating facility under the Proposed Amendments.

Table F.27(a) Off-Site Worker Cancer Risk – Proposed Amendments Year 2039 (Decorative Platers with Fume Suppressant Only)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.27(b) Off-Site Worker Cancer Risk – Proposed Amendments Year 2039 (Decorative Platers with Add-on Pollution Controls)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
3,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
750,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.28(a) Off-Site Worker Cancer Risk – Proposed Amendments Year 2039 (Small Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
750,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

Table F.28(b) Off-Site Worker Cancer Risk – Proposed Amendments Year 2039 (Large Functional Platers)

	Distance from Source to Receptor (m)														
Annual Activity (amp-hrs)	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**75**	**105**	**150**	**175**	**200**
120,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Chances per million. Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

5. Summary of Noncancer Chronic and Acute Results

CARB staff evaluated the noncancer health impacts associated with exposure to hexavalent chromium and trivalent chromium emissions from chrome plating facilities. Under the Proposed Amendments, one of the options available to chrome plating facilities is to transition to the use of trivalent chromium in their operations. To characterize the health risks associated with the use of trivalent chrome, staff conducted an analysis of acute and chronic health impacts from hexavalent and trivalent chromium using the appropriate exposure pathways. Consistent with the OEHAA Guidelines, staff evaluated the chronic noncancer inhalation and chronic noncancer oral pathways from hexavalent chromium, and the acute, 8-hour, and chronic noncancer inhalation pathways from trivalent chromium.

A reference exposure level (REL) is a reference concentration level and is used as an indicator of potential noncancer adverse health effects. RELs are designed to protect the most sensitive persons in the population by including safety factors. Noncancer chronic and acute health impacts are expressed in terms of a hazard index (HI), which is a unitless ratio of modeled concentration to the REL for hexavalent chromium. A hazard index greater than 1.0 may indicate potential health impacts and may require further investigation, otherwise no adverse health impacts are anticipated to occur with an HI value equal to, or less than, one.

Tables F.29(a) and F.29(b) summarize the noncancer health impacts (by hazard indices) from exposures to hexavalent and trivalent chromium for 2019 Baseline. The results show that there are no anticipated noncancer health impacts from exposure to hexavalent or trivalent chromium from chrome plating facilities.

Table F.29(a) Noncancer Hazard Indices (2019) for Hexavalent Chromium by Facility Plating Type

Exposure Pathway	Decorative Platers with Fume Suppressant Only	Decorative Platers with Add-on Controls	Small Functional Platers	Large Functional Platers
Chronic Inhalation	< 1	< 1	< 1	< 1
Chronic Oral	< 1	< 1	< 1	< 1

Table F.29(b) Noncancer Hazard Indices (2019) for Trivalent Chromium by Facility Plating Type

Exposure Pathway	Decorative Platers with Fume Suppressant Only	Decorative Platers with Add-on Controls	Small Functional Platers	Large Functional Platers
Acute Inhalation	< 1	< 1	< 1	< 1
8-Hour Inhalation	< 1	< 1	< 1	< 1
Chronic Inhalation	< 1	< 1	< 1	< 1

G. Fugitive Emissions

As previously stated, CARB staff cannot directly estimate risk from fugitive emissions based on the currently available data. There have been no definitive source tests and comparative ambient air studies that provide data on the rate of fugitive emissions coming from chrome plating facilities. Limited ambient monitoring data collected by CARB's Monitoring and Laboratory Division shows that elevated air concentrations of hexavalent chromium are observed near facilities even with the presence of add-on air pollution control devices.[9] While ambient monitoring data gathered by the South Coast Air Quality Management District near a facility in Paramount shows as much as a 91 percent drop in concentrations of hexavalent chromium at the monitoring sites that were located just outside of the facility after the South Coast Rule 1469 requirements were put in place.[10] This suggests that fugitive emissions can contribute to near-source chromium concentrations.

CARB staff conducted a high-level directional analysis to estimate the potential cancer risks associated with fugitive emissions. The analysis assumes that hexavalent chromium not captured by emissions control equipment associated with plating tanks could be released to the atmosphere as fugitive emissions.

<u>Chrome Plating Facility Generic Diagram</u>

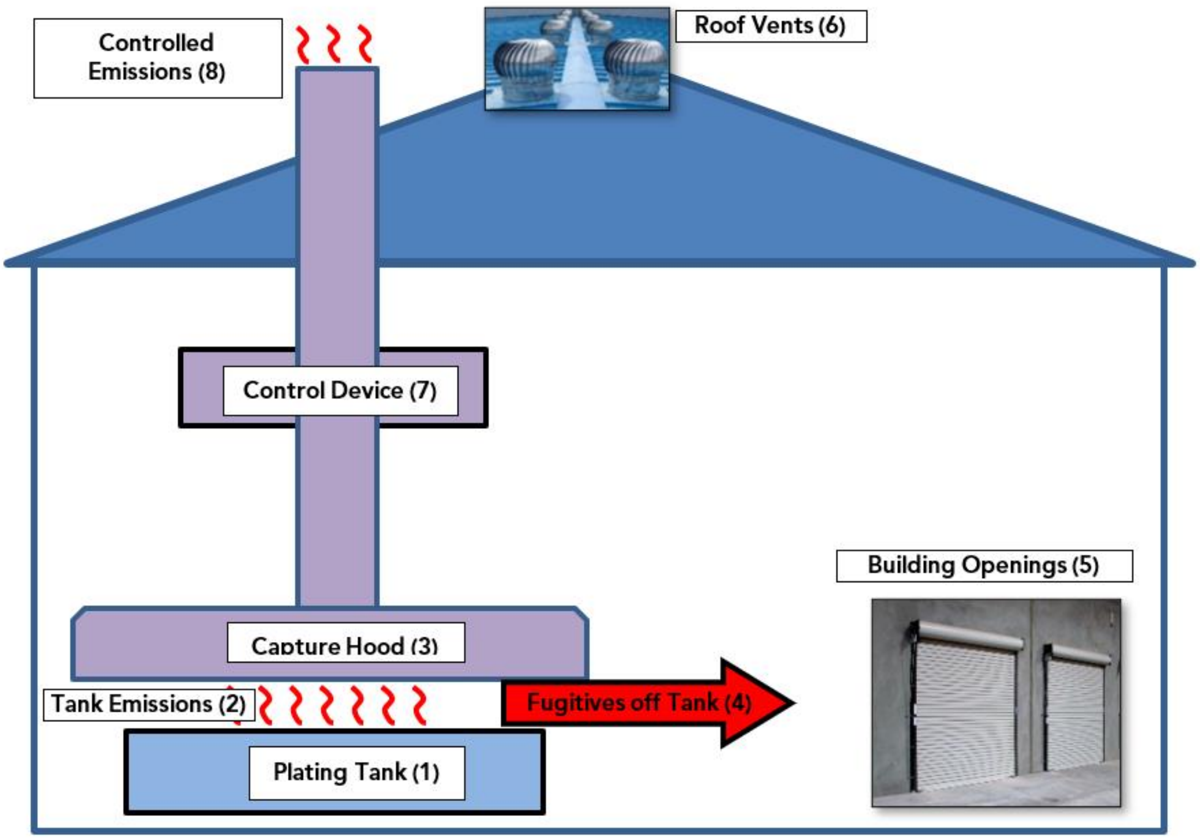
Figure F.10 shows a diagram representing a chrome plating facility. The emissions originate at the chrome plating tank (1). Those emissions can either be uncontrolled or they may be controlled using a fume suppressant in the tank (2). The emissions coming from the plating tank are often captured using a fume hood (3). Any emissions not captured by the fume hood are emitted into the interior of the building (4). Those fumes that are emitted into the building could potentially leave the building through building openings such as windows and doors (5) or through roof vents (6). The emissions captured by the hood could then be routed to a control

[9] Air Monitoring Results for Hexavalent Chromium and Other Metals Around Chrome Plating and Chromic Acid Anodizing Operations – Facility 1.

[10] Paramount Hexavalent Chromium Monitoring Results.

device (7) prior to being vented to the atmosphere through a stack (8).

Figure F.10 Chrome Plating Facility Diagram



1. Description of Assumptions

a) Plating Tank Emissions

To estimate the uncontrolled emissions that could be coming from the plating tanks, staff started with the certification assumptions for fume suppressants. In order to be certified by CARB, the controlled emissions coming from a plating tank using a fume suppressant cannot exceed 0.01 mg/amp-hr. In addition, the assumed control efficiency of fume suppressants is between 95 percent and 99 percent.[11] Applying these assumptions, staff estimated the uncontrolled emissions using the following equation:

$$Uncontrolled\ Tank\ Emissions = 0.01(mg/amp \cdot hr)/(1 - 0.99)$$

Based on this equation, uncontrolled tank emissions are 1 mg/amp-hr.

[11] Fume suppressant certification standard

b) Fume Suppressants

In this analysis, staff is assuming that fume suppressants have a control efficiency of 99 percent.

c) Fume Hood Capture Efficiency

Limited information is available regarding the capture efficiency of industrial fume hoods like those used in chrome plating facilities. Staff found one document published by the U.S. EPA in 1986, which evaluated the capture efficiency of canopy fume hoods in the steel industry. That document shows capture efficiencies ranging from as little as 50 percent to as high as 100 percent.[12]

The plating industry uses a different style of hood, but lacking better information about its performance, staff chose to evaluate fugitive emissions using a range of capture efficiency from 85 percent to 95 percent.

d) Emissions Released into the Building

Those emissions not captured by the fume hood are assumed to be released into the interior of the building. The rate of release is estimated using the following equation:

$$Emission\ Rate = Tank\ Emissions\left(\frac{mg}{amp \cdot hr}\right) \times (1 - Hood\ Efficiency)$$

e) Building Capture

Since there is no definitive source test data regarding the fraction of emissions released into the interior of the building that leave the building, staff choose to conservatively assume that 50 percent of the emissions released into the building leave the building as fugitive emissions.

f) Building Openings and Roof Vents

Again, since there is no definitive source test data, staff assumed that, of those emissions that leave the building, 50 percent were emitted though the building openings, such as windows and doors, and 50 percent were emitted through roof vents.

2. Model Setup

To run AERMOD, modelers are required to define and setup the project and emissions sources, select meteorological data files, and specify the receptor locations. These are specified in the model's input file as the control pathway, source pathway,

[12] USEPA Hood System Capture of Process Fugitive Particulate Emissions, 1986.

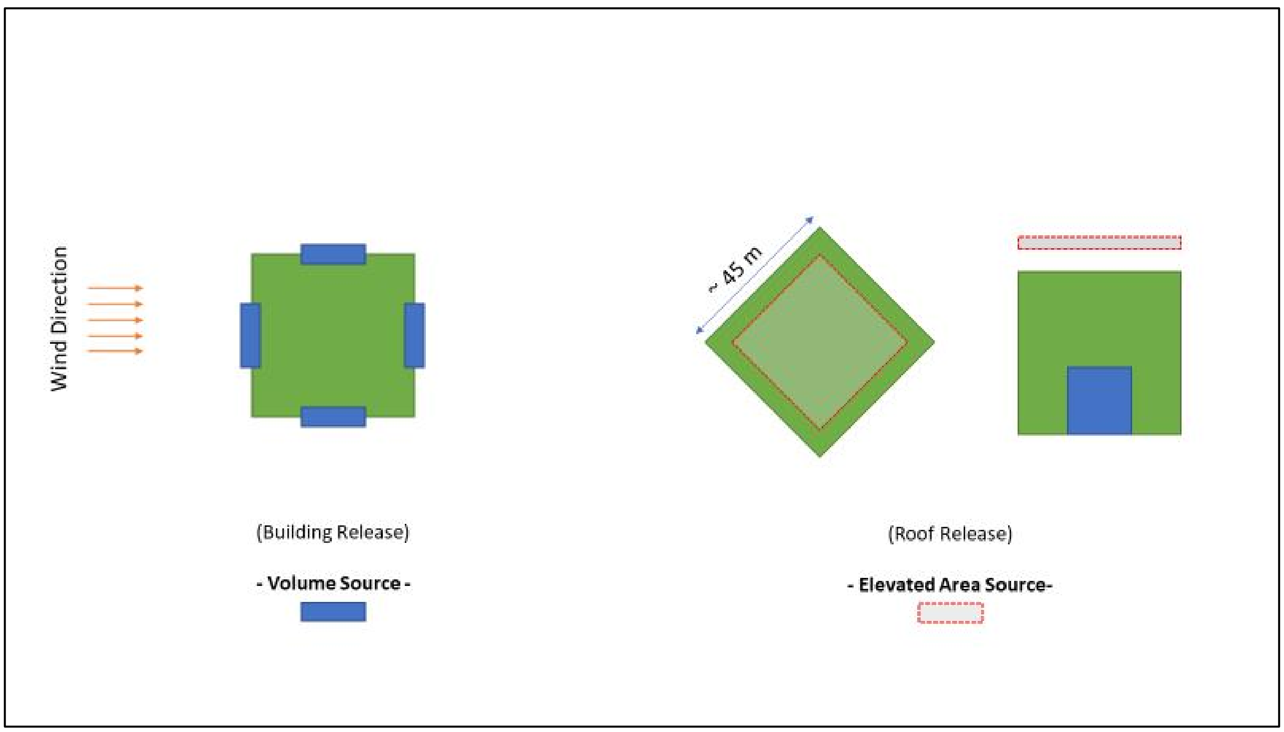
meteorology pathway, and receptor pathway. As with the health analysis, staff used the same control pathway (please see section II.F.3 for details) five meteorological (please see section II.D.2 for details) and averaged resulting concentrations.

a) Model Schematic

As stated above, emissions that are not captured by the pollution control system are assumed to leave the building through the roof vents or the building openings. Emissions that leave through building openings, such as open windows or doors, are represented with a collection of four volume sources that are placed at the edge of the building envelope representing a small functional plater or decorative plater (see Section II.F.3 for building details) and equidistant from the center of building.

Emissions that leave the building through roof vents were represented with a single elevated area source that is of the same length and width as the building representing a small functional plater or decorative plater.[13] Figure F.11 presents the model schematic for fugitive emissions.

Figure F.11 Schematic of Facility Layout Model



Note: Figure not to scale.

Tables 30(a) and 30(b), below, outline the inputs used for the volume and area sources used to evaluate the assumptions described in the previous section.

[13] San Joaquin Valley Air District – Guidance for Air Dispersion Modeling

Table F.30(a) Volume Source Parameters

Parameters	Volume Source
Release Height (m)	4
Lateral Dimension (m)	1.4
Vertical Dimension (m)	3.7

Table F.30(b) Area Source Parameters

Parameters	Volume Source
Release Height (m)	8.8
Vertical Dimension (m)	4.65
Length (m)	1.4
Width (m)	3.7

b) Receptor Pathway

Table 31 summarizes the receptor grid inputs used to calculate the concentrations of fugitive emissions. The receptor grid parameters, below, were used to evaluate the assumptions described in the previous section.

Table F.10 Polar Receptor Grid Inputs

No. of Radials	No. of Receptor Rings	Modeled Distance (m)	Receptor Height (m)
72	28	500	1.2

3. Results

Since the concentrations calculated by the model were based on a unit emissions rate, they could be multiplied by the estimated emissions rate from each release path (roof vents and building openings) to estimate the concentration. To estimate potential risks the model concentrations from each release path were added together then multiplied by the inhalation cancer potency factor.

Risk values were estimated for annual plating electrical consumption rates ranging from 5,000 to 120,000,000 amp-hrs and for receptor distances ranging from 10 meters from the source to 500 meters from the source.

Based on the assumptions and model setup described above, staff estimated potential cancer risks ranging from one chance per million to greater than 1,000 chances per million.

4. Conclusion

Staff recognizes that this is a high-level directional analysis and is not intended to definitively estimate fugitive emissions rates from specific chrome plating facilities. Nevertheless, the assumptions made are reasonable and this analysis provides information regarding what the potential cancer risks from fugitive emissions might be. Based on these results, it is reasonable to conclude that fugitive emissions of hexavalent chromium from chrome plating facilities are likely to contribute to cancer risks in communities surrounding such facilities.

III. Uncertainty Associated with the HRA Analysis

Health risk assessment is a complex process, which requires the integration of many variables and assumptions. The potential health risks presented in this health risk assessment are based on several assumptions, many of which are designed to be health protective so that potential risks to individuals are not underestimated.

A. Health Values

The toxicity of toxic air contaminants is often established by available epidemiological studies or use of data from animal studies where data from humans are not available. Human exposures are often based on limited availability of data and are mostly derived based on estimates of emissions and duration of exposure. In addition, the differences within human populations usually cannot be easily quantified and incorporated into risk assessments. Factors including metabolism, target site sensitivity, diet, immunological responses, and genetics may influence the response to toxicants. Therefore, the quantification of each uncertainty applied in the estimate of cancer potency is very difficult and can be itself uncertain.

B. Air Dispersion Model

This analysis used air dispersion modeling to estimate the concentrations to which the public is exposed. While air dispersion models are based on state-of-the-art formulations using the best science, uncertainties are associated with the models.

Over the years, the air dispersion model predictions have been continuously improved for mathematical representations in the model structure. In 2006, the U.S. EPA regulatory modeling guidance adopted AERMOD as the preferred dispersion model for near-source dispersion up to a 50-kilometer distance. Many updated numerical approaches have been incorporated into the model representation for better predictions from the air dispersion process. The primary purpose of this HRA analysis is to quantify the health impacts and benefits that would result from the Proposed Amendments.

C. Model Inputs

There are several inputs required in air dispersion model, including emission rates, source characteristic parameters, and meteorological conditions on which the air dispersion depends. Each of the inputs in the model has uncertainty associated with it. Among these inputs, emission rates and meteorological conditions have the greatest effect on modeling results.

The emission rate for the target pollutant (i.e., hexavalent chromium) was estimated from the emission inventory. The emission inventory has several sources of uncertainty, including emission factors, equipment type and age, and activity. The uncertainties in the emission inventory can lead to over predictions or under predictions in the modeling results.

The modeling source parameters also have several sources of uncertainty, such as stack height, stack temperature, stack exit velocity, and building downwash parameters. These parameters are based on the previous HRA study of hexavalent chromium and source test data conducted by CARB staff.

The meteorological conditions are commonly different from region to region in terms of wind speed, wind direction, and ambient temperature profile, etcetera. To account for the variability of different meteorological conditions, CARB staff chose five meteorological datasets for model simulations. The predicted air concentrations of hexavalent chromium are calculated at each receptor by averaging the concentrations from five model simulation results. However, the number of meteorological datasets used in this report may only represent limited meteorological conditions for the dispersion of toxic air contaminants.

IV. Reference

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