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CROWN CORK & SEAL COMPANY USA, INC.

21NOC1451 MODELING ANALYSI ADDENDUM
CAN MANUFACTURING LINE 3 EXPANSION WITH RTO

Crown Cork & Seal Company, Inc.
1202 Fones Road
Olympia, Washington

RAMBOLL

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1. AIR QUALITY IMPACT ANALYSIS ADDENDUM

1.1 Project Description

Crown Cork and Seal Company (USA), Inc. (Crown) owns and operates a metal beverage can manufacturing facility located at 1202 Fones Road in Olympia, Washington (Facility). The Facility currently operates two production lines (Lines 1 and 2), each capable of processing 1,900 cans per minute (cpm). Each production line includes can washing and drying, rim coating, exterior printing/coating lines (decorators, pin ovens), interior coating lines (lacquer spray machines (LSMs), interior bake ovens (IBOs)), and solvent cleaning.

In August 2020, Crown submitted a Notice of Construction (NOC) application to install and Line 3 production line, replace the natural gas-fired Line 2 pin oven (2.59 million British thermal units per hour [MMBtu/hr]), replace Line 1 and Line 2 natural gas-fired IBOs (3.93 MMBtu/hr each). Crown is not proposing any increase or change to the can production rate for Lines 1 and 2 or any changes to other existing equipment.

Crown's NOC application also proposes to install and operate a regenerative thermal oxidizer (RTO) to reduce can decorating and coating process emissions of volatile organic compounds (VOCs) and toxic air pollutants (TAPs) from the Line 1, Line 2, and Line 2 pin ovens and IBOs. The RTO will be equipped with a natural gas-fired burner (up to 15 MMBtu/hr) to preheat RTO chamber and the new control system will include a particulate filter (baghouse) to remove overspray solids from the decorators on Line 3 and lacquer spray machines on Lines 1 through 3 to prevent solids build-up in the RTO heat exchange media as a fire safety precaution.

Crown initially requested an alternative operating scenario which would allow operating Line 3 and Line 1 or Line 2 for up to 200 hours a year bypassing the RTO control system (operating as the currently operate Lines 1 and 2). This operating scenario would accommodate required RTO maintenance activities. Typically, there are two preventative maintenance events per year, each lasting approximately 50 to 70 hours per year. The balance of the requested maximum time for operation during RTO bypass would cover other possible short-term maintenance events that may arise over the course of the year. During the RTO bypass events, the operating can manufacturing lines will vent their VOC emission sources through a series of roof-top T-damper bypass vents. Crown is updating this alternative operating scenario to only operate one of the three can manufacturing lines during any period of RTO bypass and the toxics modeling is consistent with that operating limitation.

On February 18, 2021 the Olympic Region Clean Air Agency (ORCAA) requested additional air quality modeling to evaluate Project toxic air pollutant (TAP) modeling from combustion emissions, 1-hour facility-wide formaldehyde emissions, and nitrogen dioxide (NO_2) emissions for National Ambient Air Quality Standard (NAAQS) compliance. This NOC Modeling Addendum provides the additional modeling analysis methodology and results, confirming the Project will comply with TAP regulations, ORCAA's 1-hour formaldehyde standard, and NO_2 NAAQS.

1.2 Dispersion Modeling Methodology

Ramboll prepared the additional air quality modeling scenarios requested by ORCAA, and electronic copies of the modeling input and output files are provided in an electronic file archive.

1.3 Model Selection

Ramboll reviewed regulatory modeling techniques to select an appropriate air quality model to simulate dispersion of air pollutants emitted by the Project for a near-field air quality impact analysis. The selection of regulatory modeling tools is influenced by situations where exhaust plumes have the potential to interact with onsite structures (i.e., "building downwash") or impact complex terrain. The main building on-site has the potential to interact with exhaust plumes from the Project were identified, and the modeling domain includes intermediate and/or complex terrain. As a result, the dispersion model selected for the analysis will be required to consider both complex terrain and building downwash effects to allow for the possibility of emissions from stacks shorter than dictated by Good Engineering Practice (GEP).

In this situation, EPA's "Guideline of Air Quality Models" in 40 CFR 51 Appendix W ("the Guideline") recommends the use of AERMOD. AERMOD was specifically designed to estimate impacts of air pollutants in areas containing both simple and complex terrain. AERMOD also includes the PRIME downwash algorithms to estimate effects of surrounding buildings on the dispersion of plumes. Ramboll used the latest version of AERMOD (Version 19191) for the dispersion modeling analysis.

1.4 Modeling Procedures

Ramboll applied AERMOD using the regulatory default options discussed below.

1.4.1 Averaging Periods

Model-predicted TAP and NO_2 concentrations attributable to natural gas combustion and curing emissions from the Project and Facility were evaluated using AERMOD for comparison to the applicable TAP Acceptable Source Impact Levels (ASILs), NAAQS, and ORCAA Rule 8.6 formaldehyde standard.

1.4.2 NO_2/NO_X Chemical Transformation

The Ambient Ratio Method (ARM2) incorporates a variable ambient ratio that is a function of model predicted 1-hr NO_X concentration based on an analysis of hourly ambient NO_X monitoring data from approximately 580 stations over the period 2001-2010. ARM2 was used in the 1-hour and annual NO_2 AERMOD simulations.

1.4.3 Elevation Data and Receptor Network

Terrain elevations for preliminary receptor locations and emission units were prepared using 1/3rd and 1 arc-second National Elevation Dataset (NED) data developed by the United States Geological Survey (USGS), and available on the internet from the USGS National Map Viewer.[1] These data have a horizontal spatial resolution of approximately 10 and 30 meters (m), or 33 and 99 feet (ft), respectively. Terrain heights surrounding the facility indicate that some of the receptors used in the simulations were located in intermediate or complex terrain (i.e., above stack or plume height). The 20-kilometer (km) square simulation domain that was used to assess near field impacts is shown in Figure 1.

For the modeling analysis, 4 nested receptor grids were used, with the grid closest to the facility having the closest spacing, 12.5-m, the next closest with 25-m spacing, then a 50-m grid, then a 100-m grid, then a 200-m grid, and, finally, an outer grid with receptors every 500-m. The ambient air

[1] http://viewer.nationalmap.gov/viewer/

boundary was defined as the facility property line and receptors spaced at 10-m (30.5-ft) intervals were placed along the boundary. The general location of the modeling domain and receptor locations are shown in Figure 4. A flagpole receptor height of 1.5 meters above ground level was applied based on discussions with ORCAA staff.

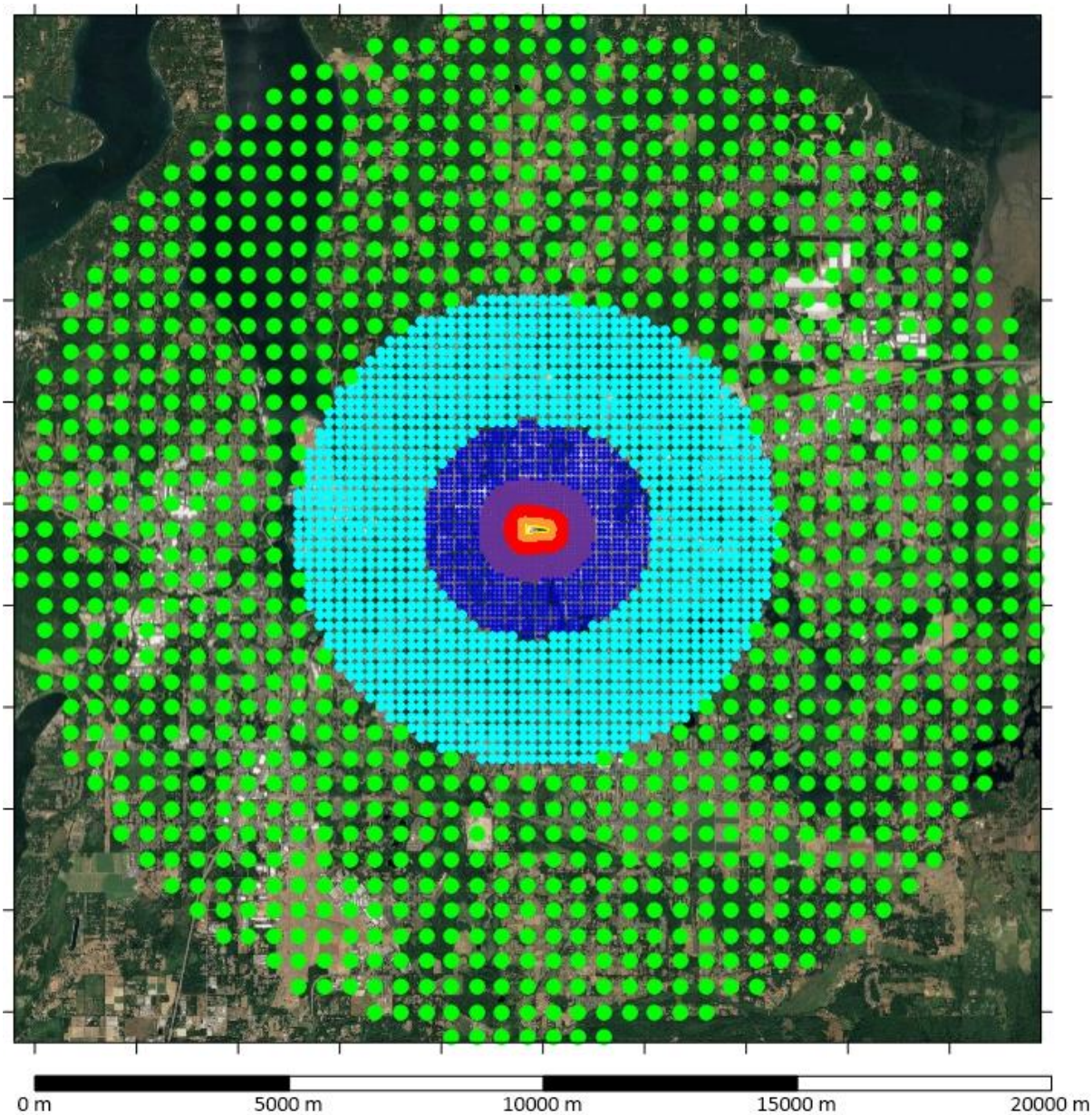

Figure 1: Receptor Locations

1.4.4 Meteorological Data

Ramboll developed a representative meteorological data set using a combination of surface data from the National Weather Service (NWS) observations at Olympia Regional Airport (KOLM) and NWS upper air data from Quillayute, Washington, (KUIL). Missing data were treated according to EPA guidance.

According to the Guideline, five years of representative meteorological data are considered adequate for dispersion modeling applications. Hourly and 1-minute average wind speed and wind direction data from January 2014 through December 2018 were obtained from the NWS. A wind rose describing the wind speed and wind direction data recorded at the KOLM meteorological monitoring station over the entire 5-year dataset is shown in Figure 2. Twice-daily sounding data recorded by the Quillayute upper air station were obtained for the same period.

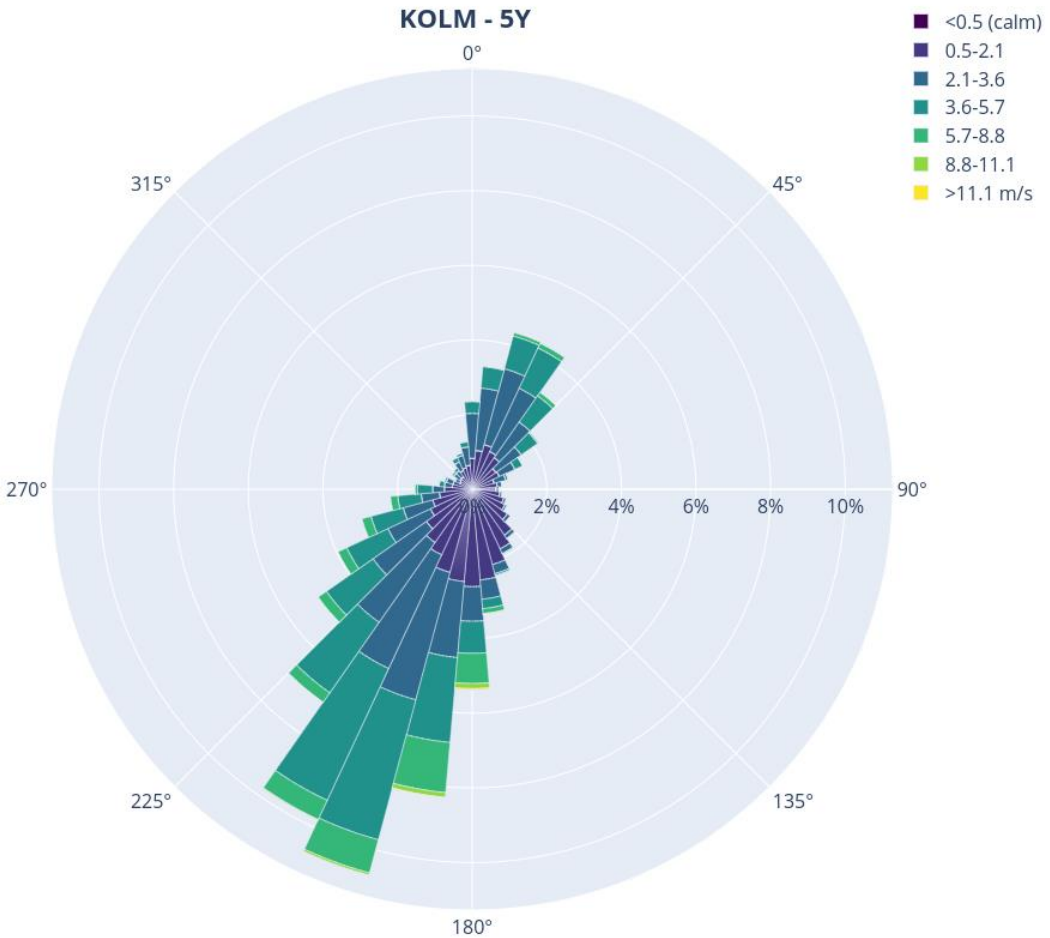

Figure 2: KOLM Windrose

Additional meteorological variables and geophysical parameters are required for use in the AERMOD dispersion modeling analysis to estimate the surface energy fluxes and construct boundary layer profiles. Surface characteristics including albedo, Bowen ratio, and surface roughness length were determined for the area surrounding the KOLM meteorological station using the AERMET surface characteristic preprocessor, AERSURFACE (Version 13016), and the USGS 1992 National Land Cover (NLCD92) land use data set. The NLCD92 data set used in the analysis has a 30-m mesh size and 21 land use categories. Seasonal surface parameters were determined using AERSURFACE according to the EPA's guidance.

Seasonal albedo and Bowen ratio values were based on averaging over a 10-km by 10-km region centered on the KOLM meteorological station. An unweighted arithmetic average was used for calculating seasonal albedo; and an unweighted geometric average was used for calculating seasonal Bowen ratio. Seasonal surface roughness values were calculated for twelve 30-degree sectors within 1 km of the KOLM meteorological station. An inverse-distance weighted geometric average was used to calculate seasonal surface roughness length values for each of the 12 sectors.

The AERSURFACE input file requires the user to provide additional location and climatological information regarding the primary meteorological site (KOLM). The following information was used to process seasonal surface parameters for the meteorological station:

- The site is located at an airport.
- The site is not located in an arid region.
- The surface moisture conditions at the site are average.

The EPA meteorological program AERMET (Version 19191) was used to combine the KOLM meteorological station surface meteorological observations with twice-daily upper air soundings from Quillayute, and to derive the necessary meteorological variables and profiles for AERMOD. The meteorological data was processed using the ADJ_U* method. A March 8, 2013 EPA memorandum regarding the use of ASOS metrological data in AERMOD dispersion modeling recommends using the AERMINUTE program to resolve calm and variable wind conditions in the standard ASOS data. One-minute wind speed and wind direction data from KOLM were used to resolve calm and variable wind conditions using the current version of AERMINUTE (Version 15272) pre-processor, which will accept five-minute data when one-minute data is not available. The adjusted U-star (ADJ U*) option was used to adjust the u-star value for low wind speeds.

1.4.5 Building Downwash Evaluation

Building dimensions and facility configuration information were provided to AERMOD to assess potential downwash effects. Wind-direction-specific building profiles were prepared for the modeling using the EPA's Building Profile Input Program for the PRIME algorithm (BPIP PRIME). The facility layout and building elevations provided by Crown were used to prepare data for BPIP PRIME, which provides the necessary input data for AERMOD. Building heights are provided in Table 1-1.

Table 1-1: Building Information

Building Name	Building Height (m)
Main Building	10.7

Based on the site layout shown in Figure 3 and the main building structure height, it was assumed that emissions from the facility release stacks are potentially subject to downwash effects from nearby structures, and the necessary information provided by BPIP PRIME was included in the simulations to reflect these effects.

1.5 Line 3 – Analysis for Natural Gas Combustion, Decorator Cleaning, and Can Washing

Figure 3 shows the location of the RTO stack associated with natural gas combustion emissions from the Project (NO_2, arsenic, cadmium, chromium vi, and 7,12-Dimethylbenz[a]anthracene), rooftop vents near the Line 3 decorators (ipa), and the Line 3 can wash vent (H_2SO_4). Table 1-2 summarizes the stack parameters used in the Project modeling analysis. Two roof vents will be located near the Line 3 decorators, and the modeling analysis assumes fugitive IPA emissions from decorator cleaning will be split between the two roof vents. Crown provided rooftop vent heights and exhaust air flow rates through the vents.

Table 1-2: Stack Release Parameters

Stack ID	Emission Unit	Stack Height (m)	Temperature (K)	Exit Velocity (m/s)	Diameter (m)
RTO011	RTO Stack	18.3	450	13.8	1.83
RVENT1	Rooftop Vent near Line 3 Decorators	13.7	293	3.59	0.91
RVENT2	Rooftop Vent near Line 3 Decorators	13.7	293	3.59	0.91
WSH361	Line 3 Can Wash Vent	17.4	319	12.4	0.46

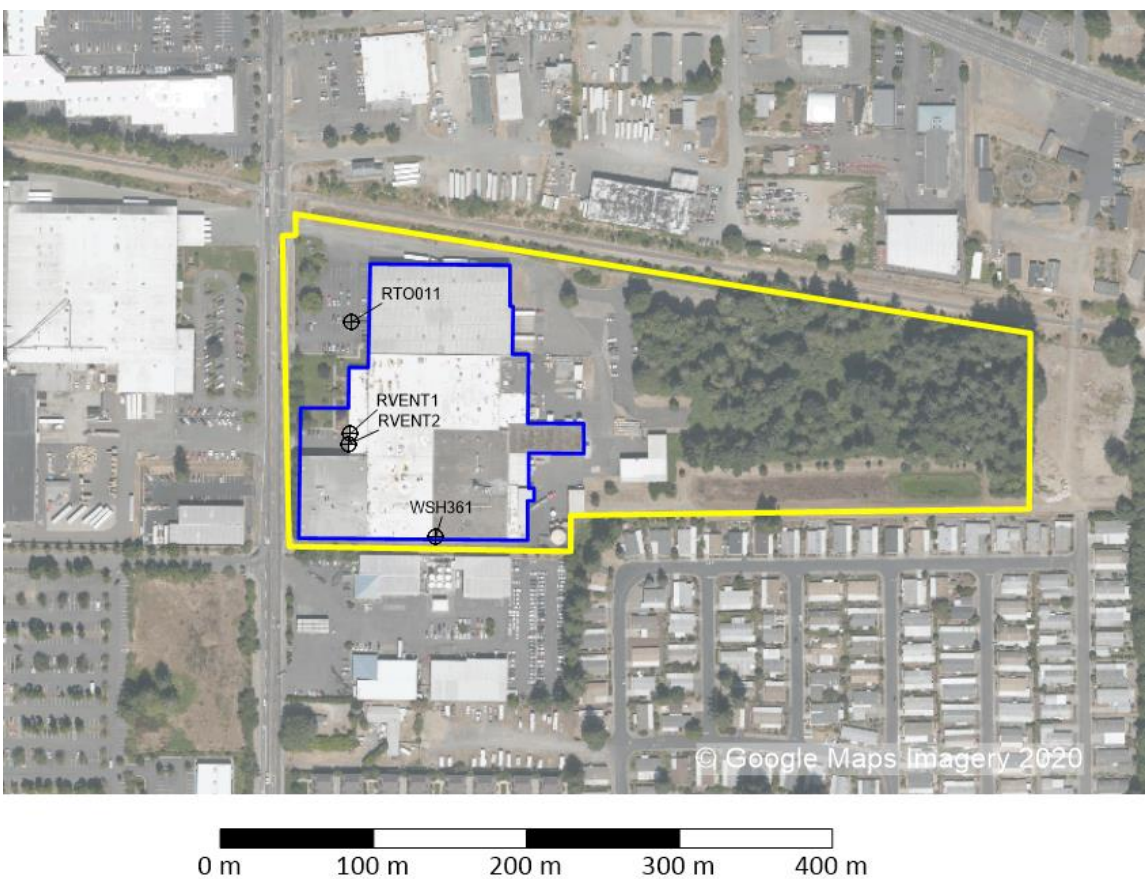

Figure 3: Site Layout with RTO Stack Location

1.5.1 Project Natural Gas Combustion Emissions

The April 20, 2021 cover letter and enclosed Project emission inventory summarizes additional TAP emissions attributable to natural gas combustion from the Project (new Line 3 curing ovens, Lines 1 and 2 replacement curing ovens, and RTO burner), Line 3 decorator cleaning, and Line 3 can washing. Table 1-3 summarizes the seven TAPs with emissions above applicable SQERS, including: NO_X, arsenic, cadmium, chromium vi, 7,12-Dimethylbenz[a]anthracene, ipa, and H_2SO_4. Emissions from the RTO, rooftop vents, and Line can wash vent were modeled using AERMOD, and model-predicted concentrations were compared to the applicable SILs and ASILs.

Table 1-3: Project Emissions for AERMOD

Stack ID	Modeled Emission Rate (g/s)						
	NO_X	**Arsenic [2]**	**Cadmium [2]**	**Chromium VI [2]**	**7,12-Dimethylbenz[a] anthracene [2]**	**IPA**	**H_2SO_4**
RTO011 [1]	0.374	8.49E-07	4.67E-06	2.38E-07	6.79E-08	--	--
RVENT1	--	--	--	--	--	1.07	--
RVENT2	--	--	--	--	--	1.07	--
WSH361	--	--	--	--	--	--	5.90E-03

Notes:

1 RTO emissions include natural gas combustion from Line 3 Pin Ovens, Line 3 IBOs, replacement Line 2 Pin Oven, replacement Line 1 IBO, replacement Line 2 IBO, and the RTO burner.

2 TAP emissions were too low for AERMOD to predict concentrations; therefore, Ramboll multiplied TAP emissions by 10^6 and divided aermod-predicted concentrations by 10^6.

1.5.2 Summary Modeling Results for Line 3

The results of the modeling simulations for Project are summarized and compared with the appropriate SILs and ASILs in Table 1-4. The modeled-predicted annual NO_2 concentrations are above the SIL, requiring additional NAAQS modeling. The model-predicted NO_2, arsenic, cadmium, chromium vi, and 7,12-Dimethylbenz[a]anthracene, ipa, and H_2SO_4 concentrations are less than the applicable ASILs.

Table 1-4: Model-Predicted Concentrations for Project

Criteria Pollutant	Averaging Period	Maximum Modeled Concentration (µg/m³)	SIL [a] (µg/m³)	Over SIL?
NO_2 [b]	Annual	2.3	1.0	Yes
TAP	**Averaging Period**	**Maximum Modeled Concentration (µg/m³)**	**ASIL [a] (µg/m³)**	**Over ASIL?**
NO_2 [b]	1-hour	33	470	No
Arsenic	Annual	5.9E-06	3.0E-04	No
Cadmium	Annual	3.3E-05	2.4E-04	No
Chromium VI	Annual	1.7E-06	4.0E-06	No
7,12-Dimethylbenz[a]anthracene	Annual	4.7E-07	8.5E-06	No
IPA	1-hour	3,100	3,200	No
H_2SO_4	24-hour	0.90	1.0	No

[a] Annual-average NO_2 SILs from WAC 173-400-113, Table 4a.
TAP-specific acceptable source impact levels (ASILs) from WAC 173-460-150.

[b] NOx was modelled using ARM2

1.6 Facility-Wide NO_2 Modeling

Ramboll expanded the NO_2 modeling analysis to include other Crown combustion equipment (i.e., Line 1 Pin Oven, Washer Dryer Oven for Lines 1 and 2, Washer Dryer Oven for Line 3, the Hot Water heater for Lines 1 and 2, and the Hot Water heater for Line 3), and background concentrations that include existing emissions from other facilities.[2]

Figure 4 shows the location of the RTO stack and other NO_X emission source stacks at the facility for normal operation and Line 3 bypass. Table 1-5 summarizes the facility-wide stack parameters used in the NO_X NAAQS modeling analysis, and Table 1-6 summarizes facility-wide NO_X emissions. NO_X Emissions from the Project and other facility sources were modeled using AERMOD.

Table 1-5: Facility-Wide NO_X Stack Release Parameters

Stack ID	Emission Unit	Stack Height [1] (m)	Temperature (K)	Exit Velocity (m/s)	Diameter (m)
RTO011	RTO Stack	18.3	450	13.8	1.83
DRY161	Dryer Stack for Lines 1 & 2 Washer	13.7	448	17.8	0.45
DRY361	Dryer Stack for Line 3 Washer	13.7	448	17.8	0.45
HWH151	Hot Water for Lines 1 & 2	13.7	412	6.3	0.40
HWH351	Hot Water for Line 3	13.7	412	6.3	0.40
Line 3 Curing Oven Bypass Stacks					
IBO321	Line 3 IBO – Zone 1	14.0	383	20.0	0.30
IBO322	Line 3 IBO – Zone 2	14.0	453	17.8	0.45
PO311	Line 3 Pin Oven	14.3	448	20.7	0.38
PO312	Line 3 Pin Oven	14.3	448	20.7	0.38

Notes:

1 Stack height for the washer dryers and hot water heaters are approximately 10 feet above the roof height (35 feet).

[2] The background pollutant concentration data were obtained from the NW AIRQUEST lookup tool (http://lar.wsu.edu/nw-airquest/lookup.html) for the four grid cells adjacent to the Crown Facility (47.0385, -122.8457). Ramboll conservatively selected the highest background concentrations from the adjacent grid cells. The NW AIRQUEST background lookup tool includes both available monitoring data and emissions from industry, traffic, and other area sources.

Figure 4: Site Layout with Facility Stack Locations

Table 1-6: Facility-Wide NO_X Emission Rates for AERMOD

Stack ID	NO_X Modeled Emission Rate (g/s)	
	Normal [1]	Line 3 Bypass
RTO011	0.436	0.136
DRY161	0.108	0.108
DRY361	0.0315	0.0315
HWH151	0.0147	0.0147
HWH351	0.0147	0.0147
IBO321	--	0.0159
IBO322	--	0.0319
PO311	--	0.0315
PO312	--	0.0315

Notes:

1 RTO emissions during normal operation include natural gas combustion from Lines 1 through 3 curing ovens and the RTO burner.

1.6.1 Summary of Facility-Wide NO_2 Modeling Results

The results of the 1-hour NO_2 modeling simulations for the two bypass scenarios are summarized and compared with the NAAQS in Table 1-5. The modeled-predicted 1-hour NO_2 concentrations, combined with background concentrations, are less than the NAAQS for all scenarios.

Table 1-7: Model-Predicted NO_2 NAAQS Concentrations

Pollutant	Model Scenario	Modeled Concentration (µg/m³)	Background [a] (µg/m³)	Total (µg/m³)	NAAQS (µg/m³)
1-Hour NO_2	Normal	50.5 [b]	79.7	130.2	188
	Line 3 Byass	81.1 [b]		160.8	
Annual NO_2	--	8.0	22.3	30.3	100

[a] Background concentrations from:http://lar.wsu.edu/nw-airquest/lookup.html for the four grid cells adjacent to the Crown Facility (47.0385, -122.8457). Ramboll conservatively selected the highest background concentrations from the adjacent grid cells. The NW AIRQUEST background lookup tool includes both available monitoring data and emissions from industry, traffic, and other area sources.

[b] Maximum 5-year average of the 98th percentile modeled concentration at each receptor. NOx was modelled using ARM2.

1.7 Facility-Wide Formaldehyde Modeling

Figure 4 shows the location of the RTO stack and other formaldehyde emission source stacks at the facility for normal operation and Line 3 bypass. Table 1-5 summarizes the facility-wide stack parameters used in the 1-hour formaldehyde modeling analysis, and Table 1-8 summarizes facility-wide formaldehyde emissions. Formaldehyde emissions from the Project and other facility sources were modeled using AERMOD.

Table 1-8: Facility-Wide Formaldehyde Emission Rates for AERMOD

Stack ID	Formaldehyde Modeled Emission Rate (g/s)	
	Normal [1]	Line 3 Bypass [2]
RTO011	6.70E-02	1.38E-04
DRY161	8.11E-05	8.11E-05
DRY361	2.39E-05	2.39E-05
HWH151	2.99E-05	2.99E-05
HWH351	2.99E-05	2.99E-05
IBO321 [2]	--	1.61E-02
IBO322 [2]	--	3.22E-02
PO311 [2]	--	4.37E-02
PO312 [2]	--	4.37E-02

Notes:

1 RTO emissions during normal operation include natural gas combustion from Lines 1 through 3 curing ovens and the RTO burner.

2 Curing Oven Emissions during Line 3 bypass based on 2,000 cpm throughput and 8.9 lb formaldehyde/mm cans. Curing oven emissions split between IBO and Pin Ovens based on 35.6 and 64.4 ratio from past Line 1 testing. IBO emissions split between two zones based on air flow through each IBO zone.

1.7.1 Summary of Formaldehyde Modeling Results

The results of the 1-hour formaldehyde modeling simulations are summarized and compared with the ORCAA standard in Table 1-9. The modeled-predicted 1-hour formaldehyde concentrations for all scenarios are less than the ORCAA standard. The model simulations for the Line 3 RTO bypass scenarios assume the RTO is bypassed every hour of the five-year model simulation. Crown has proposed a total of 200 hours of RTO bypass and actual RTO bypass is expected to be much lower.

Table 1-9: Model-Predicted Formaldehyde Concentrations

Model Scenario	1-hour Maximum Modeled Concentration ($\mu g/m^3$)	ORCAA Standard [a] ($\mu g/m^3$)	Over ORCAA Standard?
Normal (Controlled)	6.7	61	No
Line 3 RTO Bypass)	59.3		No
[a] ORCAA Rule 8.6(b).			