Cleaner Air Oregon Level-3 Modeling Protocol and Risk Assessment Work Plan

Seneca Sustainable Energy
Eugene, Oregon

Prepared for:

Seneca LLC.

July 7, 2020

BRIDGEWATER GROUP, INC.

Contents

Tables

Figures

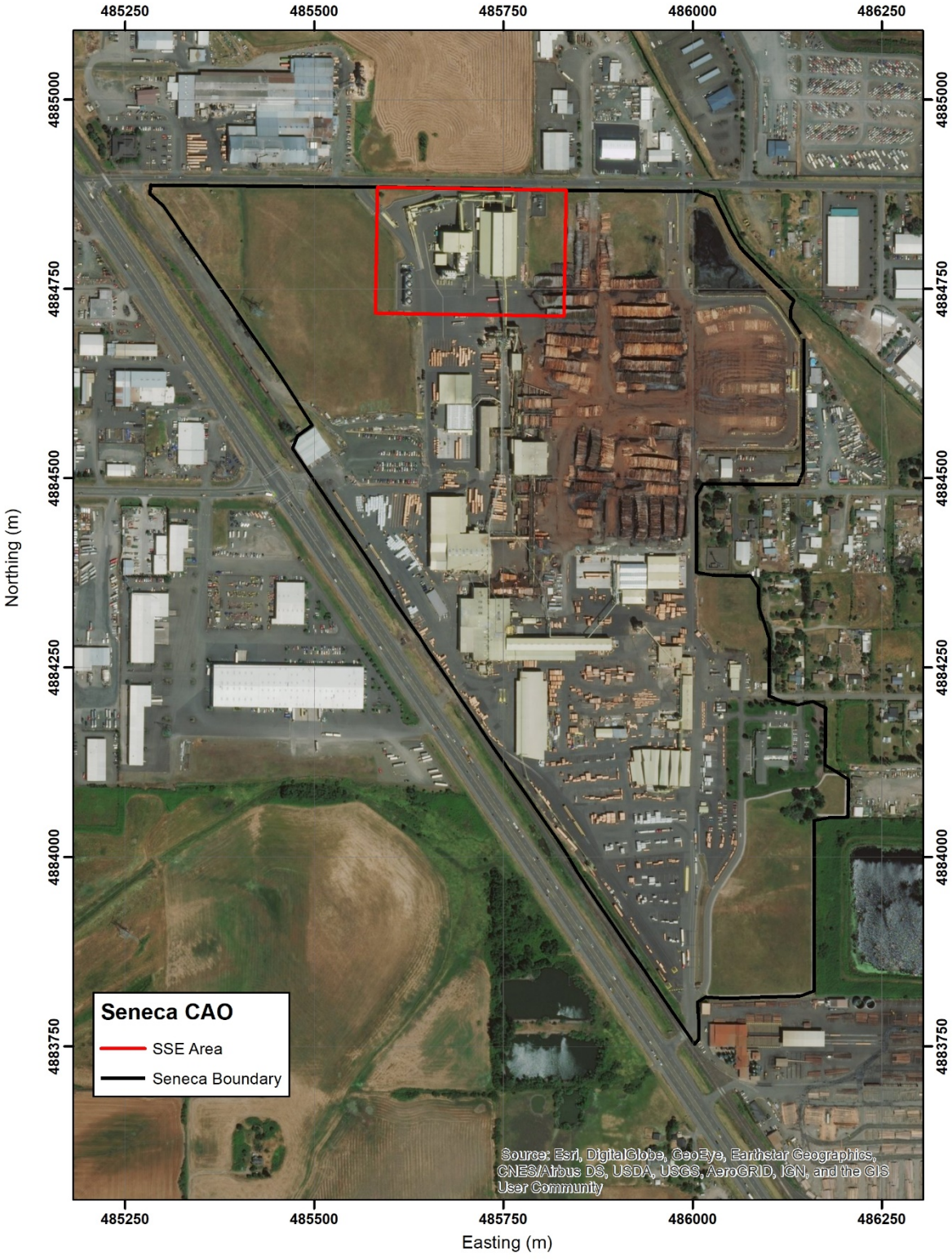
1.0 Introduction

Seneca Sustainable Energy LLC, ("Seneca", "SSE" or "the facility") is a wood-fired electrical cogeneration power plant in Eugene, Oregon with a location of latitude of N 44° 6’ 58’’ and a longitude of W 123° 10’ 44’’ (UTM NAD 1983 zone 10 coordinates of 485668 Easting and 4884771 Northing). The site is located south of East Enid Road and east of Highway 99 as shown in Figure 1. The facility began operations in January 2011.

Seneca is subject to the newly implemented Cleaner Air Oregon (CAO) regulations (OAR 340-245) as an existing source. CAO is a state health risk-based air toxics regulatory program that adds requirements to Lane Regional Air Pollution Agency’s (LRAPA) and Oregon Department of Environmental Quality’s (ODEQ) existing air permitting framework. For a variety of reasons including scope, detail, public input and technical expertise that went into the creation of the CAO program, LRAPA implemented CAO by reference without any changes.

Seneca was called into the CAO program on December 2, 2019. The facility submitted the emission inventory on February 27, 2020. LRAPA reviewed the emission inventory and requested additional information. The facility submitted revised and/or supplemental information on March 30, 2020, May 4, 2020, and June 11, 2020. LRAPA approved the emission inventory on June 15, 2020. SSE is now submitting a modeling protocol and a risk assessment work plan. In implementing the CAO program, Oregon Department of Environmental Quality (ODEQ) has approved submitting the modeling protocol and a risk assessment work plan as a single document. Thus, this document is the combined modeling protocol and a risk assessment work plan for the SSE facility.

Figure 1-1: Site Location



2.0 Conceptual Site Model

2.1 Process Overview

The only non-exempt TEU at the SSE facility is a wood-fired electrical cogeneration power plant (cogen plant) referred to in SSE Title V Air Operating Permit as EU-1.

The cogeneration process generates power and thermal energy from a single fuel source: wood biomass. The wood biomass used to fuel the cogeneration facility comes from Seneca Sawmill's bark, sawdust and shavings, as well as forest "logging residuals or slash" from Seneca Jones Timber Company LLC's sustainably managed tree farm, located nearby in Oregon's Coast and Cascade Ranges. The facility is allowed to combust only clean biomass materials in the boiler. The facility is not allowed to combust chemically-treated wood products; including painted or oil stained material, or preservative treated wood, fossil fuel, or sanderdust

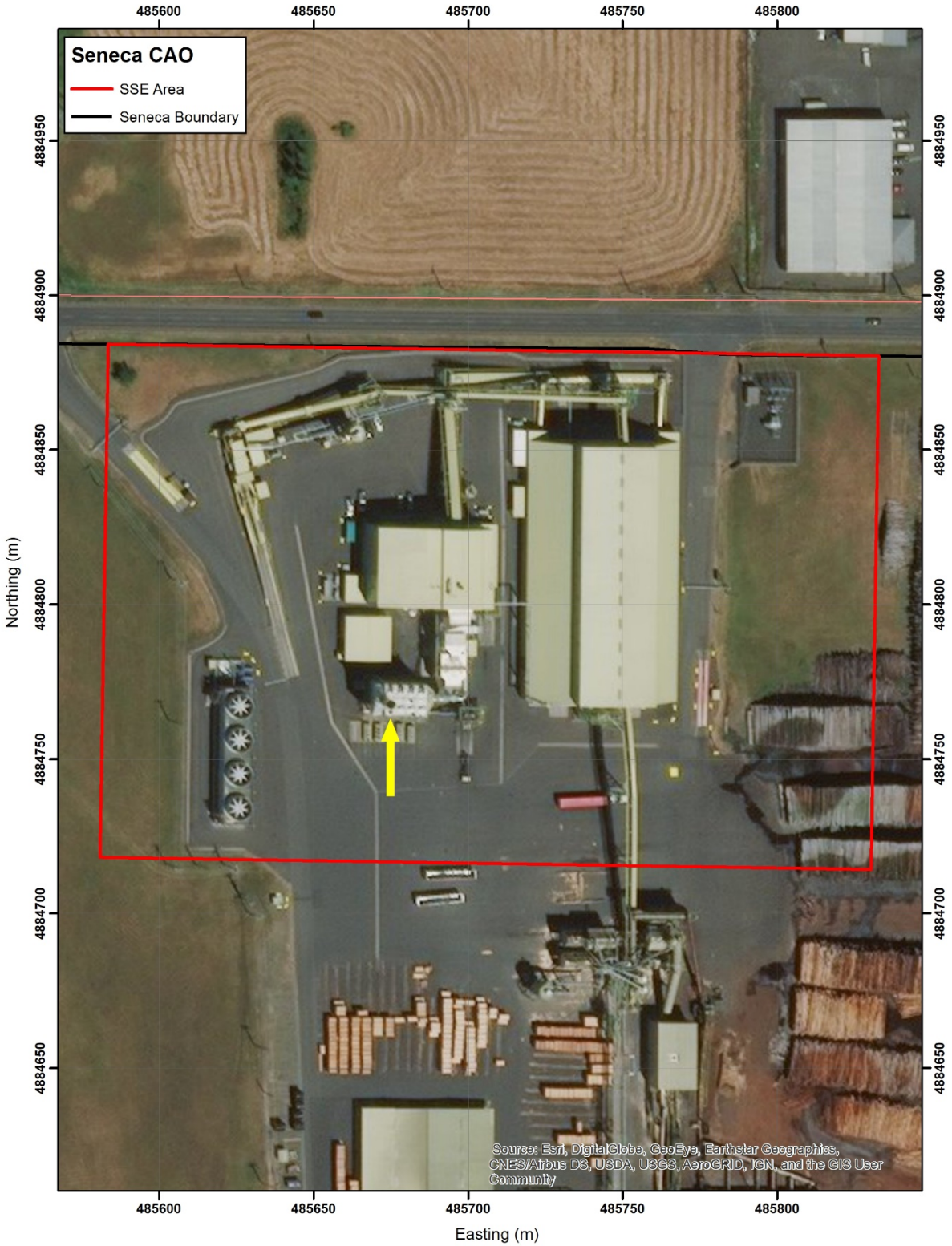
2.2 TEU Descriptions

The boiler is a six-cell rotary grate furnace, with a 352.8 MM btu/hr maximum heat rating. The unit is designed of produce 200,000 lb/hr of steam. The boiler is controlled with multiclones, a 4-cell electrostatic precipitator, urea injection selective non-catalytic reduction (SNCR), flue gas recirculation, and low-NOx combustion burners.

Figure 2.1 shows the location of the cogeneration boiler.

Figure 2-1: Site Layout Drawing

(TEU-1 is identified by the yellow arrow)



2.3 Compounds Emitted

Table 2-1 shows the toxics air contaminants (TACs) emitted from the facility, along with the form of the pollutant (particulate or volatile gas), whether the pollutant has an early-life (EL) or multipath way (MP) adjustment made to its Risk Based Concentrations (RBCs). TACs without RBCs are shown at the bottom of the table. A total of 117 compounds with RBCs were identified in the emissions inventory process.

Table 2-1: Compounds Emitted from the Seneca Cogeneration Boiler

CAS #	Toxic Air Contaminant (TAC)	Type	Adjustment
Compounds with RBC's			
75-07-0	Acetaldehyde	Volatile	
67-64-1	Acetone	Volatile	
107-02-8	Acrolein	Volatile	
7664-41-7	Ammonia	Volatile	
7440-36-0	Antimony and compounds	Particulate	
7440-38-2	Arsenic and compounds	Particulate	MP
71-43-2	Benzene	Volatile	
7440-41-7	Beryllium and compounds	Particulate	
117-81-7	Bis(2-ethylhexyl) phthalate (DEHP)	Volatile	MP
74-83-9	Bromomethane (Methyl bromide)	Volatile	
78-93-3	2-Butanone (Methyl ethyl ketone)	Volatile	
7440-43-9	Cadmium and compounds	Particulate	MP
75-15-0	Carbon disulfide	Volatile	
56-23-5	Carbon tetrachloride	Volatile	
7782-50-5	Chlorine	Volatile	
108-90-7	Chlorobenzene	Volatile	
67-66-3	Chloroform	Volatile	
74-87-3	Chloromethane (Methyl chloride)	Volatile	
18540-29-9	Chromium VI, chromate and dichromate particulate	Particulate	EP,MP
7440-48-4	Cobalt and compounds	Particulate	
7440-50-8	Copper and compounds	Particulate	
106-46-7	p-Dichlorobenzene (1,4-Dichlorobenzene)	Volatile	
75-09-2	Dichloromethane (Methylene chloride)	Volatile	EP
78-87-5	1,2-Dichloropropane (Propylene dichloride)	Volatile	
121-14-2	2,4-Dinitrotoluene	Volatile	
100-41-4	Ethyl benzene	Volatile	
107-06-2	Ethylene dichloride (EDC, 1,2-Dichloroethane)	Volatile	
50-00-0	Formaldehyde	Volatile	
118-74-1	Hexachlorobenzene	Volatile	
110-54-3	Hexane	Volatile	
7647-01-0	Hydrochloric acid	Volatile	
7664-39-3	Hydrogen fluoride	Volatile	MP
67-63-0	Isopropyl alcohol	Volatile	
98-82-8	Isopropylbenzene (Cumene)	Volatile	
7439-92-1	Lead and compounds	Particulate	MP
7439-96-5	Manganese and compounds	Particulate	
7439-97-6	Mercury and compounds	Particulate	MP

CAS #	Toxic Air Contaminant (TAC)	Type	Adjustment
67-56-1	Methanol	Volatile	
108-10-1	Methyl isobutyl ketone (MIBK, Hexone)	Volatile	
91-20-3	Naphthalene	Volatile	MP
7440-02-0	Nickel compounds, insoluble	Particulate	
87-86-5	Pentachlorophenol	Volatile	
108-95-2	Phenol	Volatile	
1336-36-3	Polychlorinated biphenyls (PCBs)	Volatile	MP
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	Volatile	
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	Volatile	
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	Volatile	
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	Volatile	
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	Volatile	
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	Volatile	
3268-87-9	Octachlorodibenzo-p-dioxin (OCDD)	Volatile	
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran (TcDF)	Volatile	
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	Volatile	
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	Volatile	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	Volatile	
57117-44-9	1,2,3,4,7,8--Hexachlorodibenzofuran (HxCDF)	Volatile	
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	Volatile	
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	Volatile	
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	Volatile	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	Volatile	
39001-02-0	Octachlorodibenzofuran (OCDF)	Volatile	
56-55-3	Benz[a]anthracene	Volatile	
50-32-8	Benzo[a]pyrene	Volatile	EP,MP
205-99-2	Benzo[b]fluoranthene	Volatile	
191-24-2	Benzo[g,h,i]perylene	Volatile	
207-08-9	Benzo[k]fluoranthene	Volatile	
218-01-9	Chrysene	Volatile	
53-70-3	Dibenz[a,h]anthracene	Volatile	
206-44-0	Fluoranthene	Volatile	
193-39-5	Indeno[1,2,3-cd]pyrene	Volatile	
123-38-6	Propionaldehyde	Volatile	
7782-49-2	Selenium and compounds	Particulate	
100-42-5	Styrene	Volatile	
127-18-4	Tetrachloroethene (Perchloroethylene)	Volatile	
108-88-3	Toluene	Volatile	
71-55-6	1,1,1-Trichloroethane (Methyl chloroform)	Volatile	
79-01-6	Trichloroethene (TCE, Trichloroethylene)	Volatile	EP
88-06-2	2,4,6-Trichlorophenol	Volatile	
7440-62-2	Vanadium (fume or dust)	Particulate	
75-01-4	Vinyl chloride	Volatile	EP
1330-20-7	Xylene (mixture), including m-xylene, o-xylene, p-xylene	Volatile	
Compounds without RBC's			
83-32-9	Acenaphthene	Volatile	

CAS #	Toxic Air Contaminant (TAC)	Type	Adjustment
208-96-8	Acenaphthylene	Volatile	
98-86-2	Acetophenone	Volatile	
120-12-7	Anthracene	Volatile	
192-97-2	Benzo(e) pyrene	Volatile	
7440-39-3	Barium and Compounds	Particulate	
85-68-7	Butyl Benzyl Phthalate	Volatile	
95-57-8	2-Chlorophenol	Volatile	
4170-30-3	Crotonaldehyde	Volatile	
84-74-2	Dibutyl phthalate	Volatile	
156-60-3	1,2-Dichloroethene	Volatile	
84-66-2	Diethylphthalate	Volatile	
534-52-1	4,6-Dinitro-o-cresol (and salts)	Volatile	
51-28-5	2,4-Dinitrophenol	Volatile	
86-73-7	Fluorene	Volatile	
1313-27-5	Molybdenum Trioxide	Particulate	
91-57-6	2-Methyl Naphthalene	Volatile	
100-02-7	4-Nitrophenol	Volatile	
	PCB (decachlorobiphenyl)	Volatile	
	PCB (dichlorobiphenyl)	Volatile	
	PCB (hexachlorobiphenyl)	Volatile	
	PCB (pentachlorobiphenyl)	Volatile	
	PCB (tetrachlorobiphenyl)	Volatile	
	PCB (trichlorobiphenyl)	Volatile	
198-55-0	Perylene	Volatile	
85-01-8	Phenanthrene	Volatile	
129-00-0	Pyrene	Volatile	
57-97-6	7,12-dimethylbenzo(a)anthracene	Volatile	
56-49-5	3-methylchloanthrene	Volatile	
7723-14-0	Phosphorus and compounds	Particulate	
7440-22-4	Silver and compounds	Particulate	
7440-28-0	Thallium and compounds	Particulate	
75-69-4	Trichloro fluoromethane	Volatile	
108-38-3	m-Xylene	Volatile	
95-47-6	o-Xylene	Volatile	
7440-66-6	Zinc	Particulate	

MP = Multipathway Pollutant; EL = Early life adjustment compound

2.4 Exposure Locations

For initially defining exposure locations, a shapefile of the 2017 Oregon Zoning data from the Oregon Department of Land Conservation and Development was used. This data layer is an element of the Oregon GIS Framework and is available through the Oregon Spatial Data Library[1]. This feature class contains zoning data from 198 local jurisdictions, including the City of Eugene. The data set has 55 zoning classifications, which are binned into three categories: residential, industrial/commercial, and open space. A crosswalk between the categories and the bins is shown in Table 2-2. A receptor crosswalk text file is provided on the electronic media submitted with this document. The residential bin includes any category designating a residence. For example, mixed use commercial and residential areas and tribal reservation lands are defined as residential. The open space category includes parks, forests, beaches, public lands, and agricultural areas. Open space receptors will be evaluated for acute risk only, unless it is demonstrated that they represent a location where people do not normally congregate. Roadway receptors will be excluded.

The zoning dataset does not identify schools or daycares. For schools, a statewide GIS layer[2] was used to identify the location of schools within 10 kilometers of the facility. For daycares, a manual search (e.g., using a search engine and Google Earth) was done to identify locations. Next, the zoning dataset also does not identify residences located in farmland or forested areas. For these residences, a building footprint layer[3] from the City of Eugene was used, as it identifies whether a building is a residence or not. Beyond the extent of this layer (e.g. to the north of Seneca), a manual identification was done so that most residences within 5 kilometers of the facility were identified.

Figure 2-2 shows the zoning around the facility. The facility is located in an area zoned for industrial/commercial use. The closest residential receptor is to the east of SSE, near the property line. Irving Elementary School is the closest school at about 2 km east of the facility.

[1] https://spatialdata.oregonexplorer.info/geoportal/details;id=49bfb86d4e594a3c8fa8d968aaaa45e9

[2] https://spatialdata.oregonexplorer.info/geoportal/details;id=1270fe6e833f4d0eabacc71300069738

[3] https://mapping.eugene-or.gov/datasets/eugene-buildings-hub?selectedAttribute=EntryAgenc

Figure 2-2: Land Use Around SSE

Each land use area is labeled by "CAO code (LU code)".

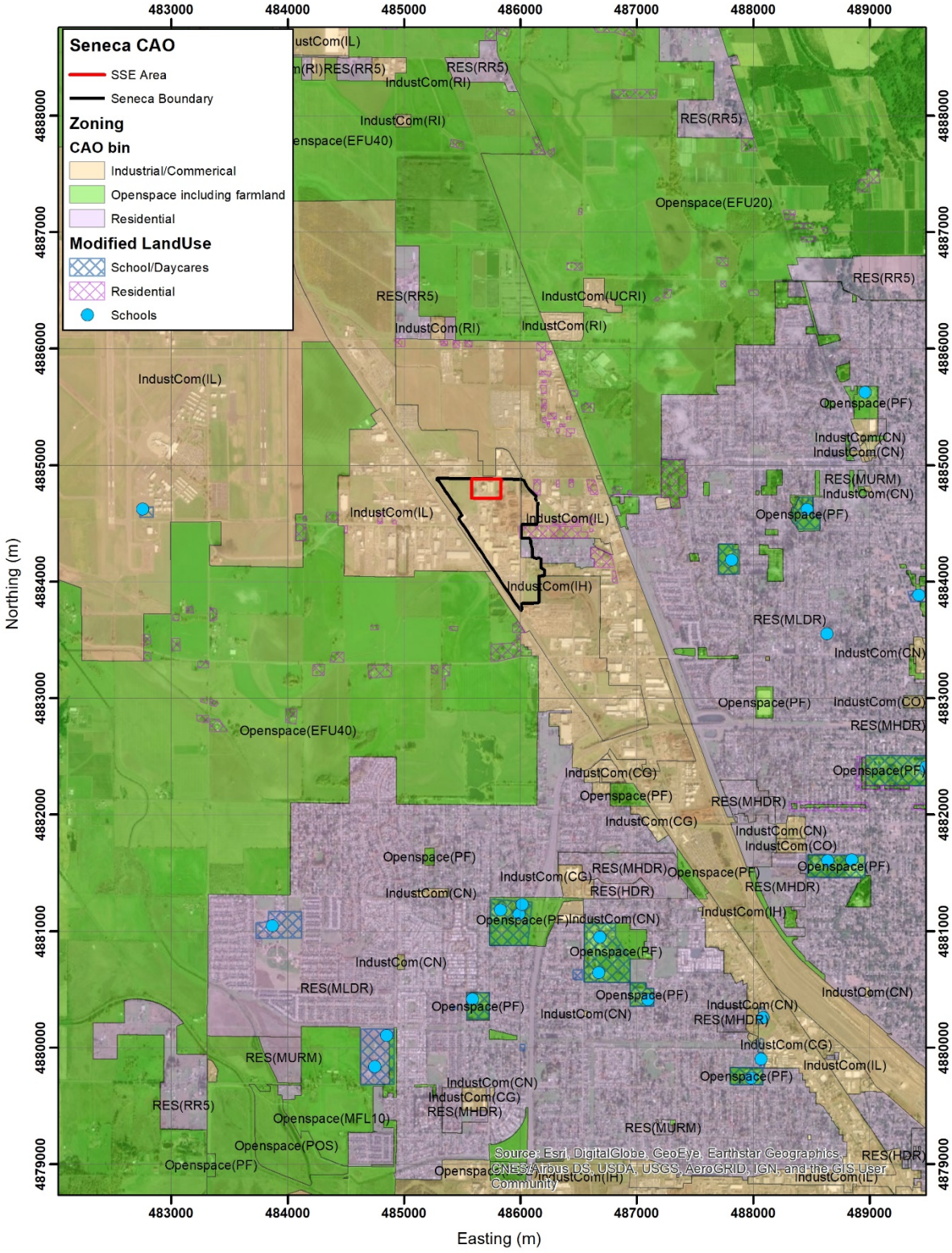


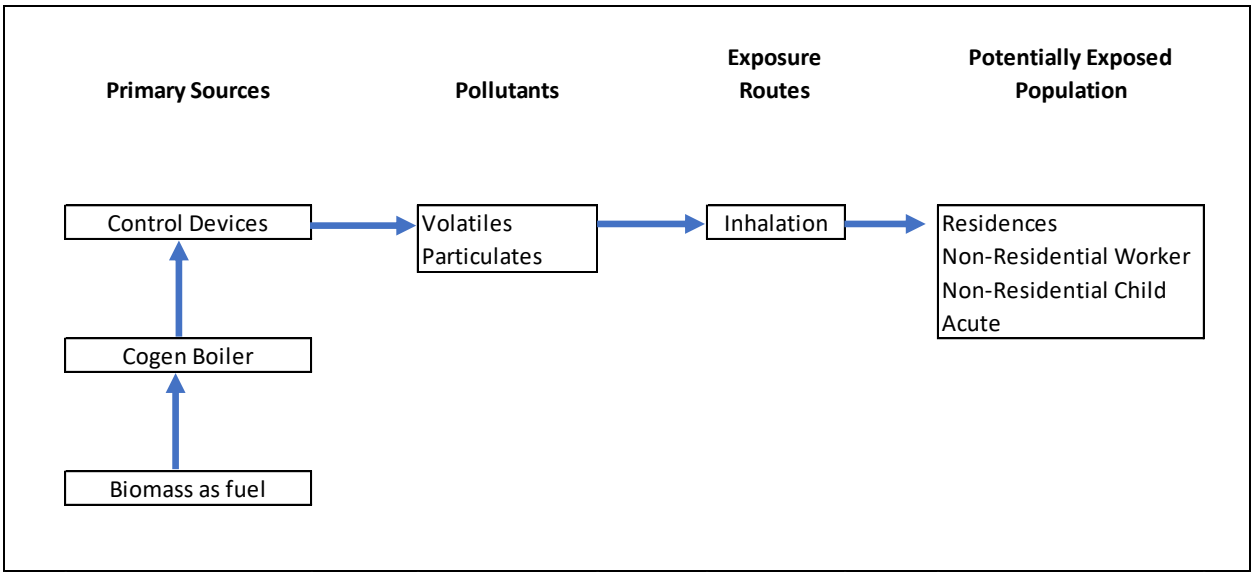
Table 2-2. Land Use Crosswalk

LU Code	Description	CAO code	LU Code	Description	CAO code
BD	Beaches and Dunes	Openspace	MFL10	Marginal Farm Land 10+	Openspace
CC	Commercial - Central	IndustCom	MHDR	Medium High-density Res.	RES
CE	Coastal Estuarine	Openspace	MLDR	Medium Low-density Res.	RES
CEE	Combo equal emphasis	IndustCom	MUREH	Mixed-Use Com. & Res. Extremely High	RES
CG	Commercial - General	IndustCom	MURH	Mixed-Use Com. & Res. High	RES
CN	Commercial – Neighborhood	IndustCom	MURL	Mixed-Use Com. & Res. Low	RES
CO	Commercial – Office	IndustCom	MURM	Mixed-Use Com. & Res. Medium	RES
CPE	Combo with priority emphasis	IndustCom	MURMH	Mixed-Use Com. & Res. Med-high	RES
CS	Coastal Shorelands	Openspace	MURVH	Mixed-Use Com. & Res. V.High	RES
EFU160	Exclusive Farm Use 160+	Openspace	ND	No Data	Openspace
EFU20	Exclusive Farm Use 20+	Openspace	O	Other	Openspace
EFU40	Exclusive Farm Use 40+	Openspace	OSC	Open Space/Conservation	Openspace
EFU80	Exclusive Farm Use 80	Openspace	PF	Public & semi-public Uses	Openspace
FF160	Mixed Farm-Forest 160+	Openspace	PF80	Prime Forest 80	Openspace
FF20	Mixed Farm-Forest 20	Openspace	POS	Parks & Open Space	Openspace
FF40	Mixed Farm-Forest 40	Openspace	RC	Rural Commercial	IndustCom
FF80	Mixed Farm-Forest 80	Openspace	RI	Rural Industrial	IndustCom
FOR	Federal Forest	Openspace	RNG	Federal Range	Openspace
FUD	Future Urban Development	IndustCom	RR1	Rural Residential 1 acre	RES
HDR	High-density Res.	RES	RR10	Rural Residential 10 acres	RES
IC	Industrial Campus	IndustCom	RR2	Rural Residential 2-4 acres	RES
IH	Industrial – Heavy	IndustCom	RR5	Rural Residential 5 acres	RES
IL	Industrial – Light	IndustCom	SF80	Secondary Forest 80	Openspace
IO	Industrial Office	IndustCom	UCRC	UC Rural Commercial	IndustCom
IRM	Indian reservation/tribal trust	Openspace	UCRI	UC Rural Industrial	IndustCom
LDR	Low-density Res.	RES	VHDR	Very High-density Res.	RES
MA	Mineral and Aggregate	IndustCom	VLDR	Very Low-density Res.	RES
MDR	Medium-density Res.	RES			

2.5 Conceptual Site Model Diagram

Figure 2-3 shows the conceptual site model for the CAO process. Only the inhalation pathway is considered in this evaluation.

Figure 2-3: CAO Conceptual Site Model



3.0 Level-3 Modeling Protocol

This section is a Level-3 modeling protocol and is intended to outline the assumptions and methodologies that will be used in an air quality analysis for calculating 24-hour and annual risk values for the cogeneration boiler for use in the Risk Assessment Work Plan (Section 4). LRAPA has requested that the start-up condition also be evaluated. This condition only applies to the 24-hour acute risk. Thus, two sets of parameters are provided.

All coordinates are in Universal Transverse Mercator (UTM) NAD 83 Zone 10.

3.1 Source Characterization

Table 3-1 shows the steady state and start-up source parameters for the boiler.

Table 3-1: Stack Parameters

Parameter	Boiler (steady state)	Boiler (startup)
X-Coordinate (m)	485668.6	485668.6
Y-Coordinate (m)	4884770.9	4884770.9
Base Elevation (m)	114.5	114.5
Height (ft)	98.0	98.0
Height (m)	29.87	29.87
Temp (°F)	369.7	229.9
Temp (K)	460.8	383.1
Diameter (ft)	9.0	9.0
Diameter (m)	2.74	2.74
Flow Rate (ACFM)	144171	81670
Velocity (m/s)	11.51	6.52

The steady state boiler stack parameters are based on an average of the last three stack tests (2017, 2018, and 2019). Boiler startups at Seneca typically occur 2-3 times per year. During startup, the boiler is heated gradually to avoid thermal stresses that could physically damage the boiler. The entire startup period may last up to 24 hours. During the first part of the startup period, the ESPs are not energized. Fuel is gradually added and once a proper temperature (250°F) is achieved, the ESPs are energized, reducing particulate matter emissions. Then, over the remainder day, the fuel loading is increased until steady state conditions are reached.

For the start-up conditions, a worst-case daily average temperature (*Ts*) and flow (*Vs*) were estimated from the average conditions before and after the ESPs were started, and are given by:

$$T_s(F) = \left[\frac{0.5\ (Te + To)\ t}{24} + \frac{0.5\ (Tss + Te)(24 - t)}{24}\right]$$

$$V_s(ACFM) = \left[\frac{0.5\ (Ve + Vo)\ t}{24} + \frac{0.5\ (Vss + Ve)(24 - t)}{24}\right]$$

where *t* is the number of hours before the ESPs are started, *To* and *Vo* are the initial temperature (50°F) and flow when start-up commences, Te and *Ve* are the temperature (250°F) and flow (67,297 acfm at 20% moisture) when the ESPs are started, and *Tss* and *Vss* are the steady state temperature and flow (369.7°F and 144,171 acfm). Vo was assumed to be one third of the steady state flow. From the historical data, the maximum time before the ESPs are started is 9.5 hours. However, to be conservative, *t* was assumed to be 12 hours.

3.2 Model Selection

For this analysis, the most recent version (19191) of the AERMOD (AMS [American Meteorological Society]/EPA [Environmental Protection Agency] Regulatory Model) will be used to estimate the unit concentrations resulting from the cogeneration boiler stack. Building downwash will be incorporated into the model runs. The most recent version of the Building Profile Input Program (BPIP) with PRIME (BPIPPRM, version 04274) was used to calculate building downwash parameters for input to AERMOD.

Figure 3.1 shows the buildings around the SSE area along with their heights. The building information is used to calculate the building downwash parameters for the stack.

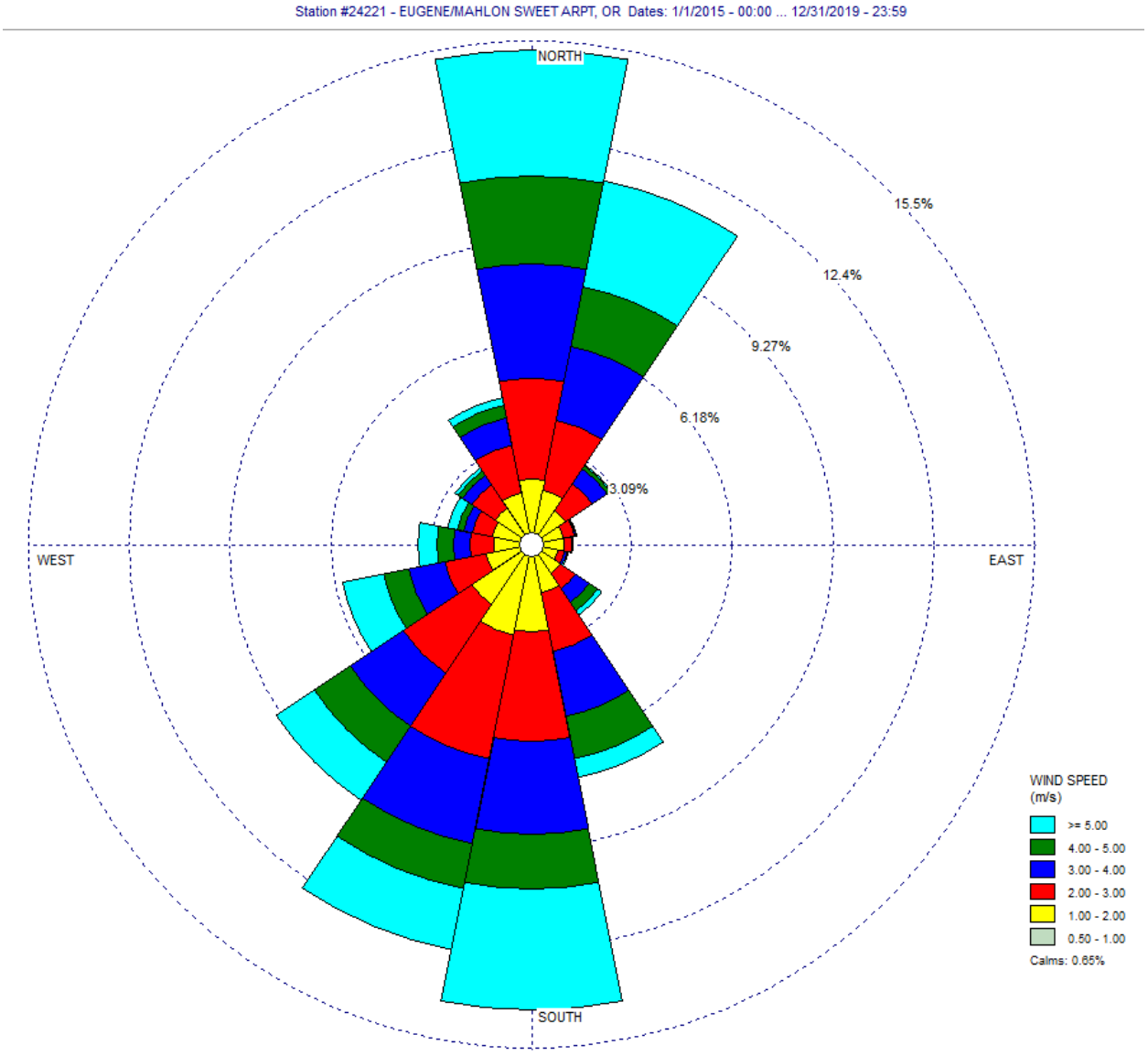
3.3 Meteorological Data

Five years (2015-2019) of AERMOD-ready hourly meteorological data were provided by LRAPA. These data are from the National Weather Service (NWS) station at the Eugene airport (WBAN 24221). The station is located about 3 kilometers west of the project site. Since there is no significant nearby terrain differences between the station and SSE, the Eugene Airport data is representative to model maximum impacts from the proposed SSE facility. Upper air data from Salem Airport (WBAN 24232) were used by LRAPA. A five-year wind rose is shown in Figure 3-2. LRAPA processed the dataset to include the Adjust U* option.

Figure 3-1: Building IDs and Heights

Bldg ID	Name	Hgt (ft)
CT	Cooling Tower	36
BMAIN	Boiler Buiding Main	65
BEC1	Boiler Emis Control Economizer	62
BEC2	Boiler Buiding S 2	45
BEC3	Boiler Buiding S 3	41
ESP	ESP, Stack building	59
FSB	Fuel Storage Building Lower Tier	40
FSBUP	Fuel Storage Building Upper Tier	81
WTB	Water Treatment building	21
HS1	Screen	45
TD	Truck Dump	30

Figure 3-2: Eugene Airport Wind Rose (2015-2019)



3.4 Receptor Grid

Under the Cleaner Air Oregon Rules, OAR 340-245-0020 (43) indicates that residential exposure locations are to be located “outside the boundary where people may reasonably be present for most hours of the day over a period of many years.” Likewise, OAR 340-245-0020 (36) indicates "nonresidential exposure location” means an exposure location outside the boundary of a source where people may reasonably be present for a few hours several days per week, possibly over a period of several years”. Where the property borders other commercial property, receptors on the property boundary will be evaluated. When the property line is adjacent to a roadway, railroad track, or an easement under power poles, the CAO boundary is expanded to exclude these areas from the evaluation, as these areas are not where the public would normally congregate. Thus, the receptor boundary for the CAO assessment was expanded to exclude these areas, as shown below in Figure 3-3.

Receptor elevations for AERMOD will be determined using the AERMAP pre-processor (version 18081). AERMAP uses United States Geological Survey (USGS) 1-degree and 7.5-minute Digital Elevation Model (DEM) files and a newer National Elevation Dataset (NED). AERMAP was run to generate the receptor elevations using the NED data.

The following receptor grid spacing was used in the modeling analyses:

- 25-meter spacing along the CAO boundary,
- 25-meter spacing out to 200 m from the CAO boundary,
- 50-meter spacing out to 1.0 kilometers,
- 100-meter spacing out to 2.0 kilometers,
- 200-meter spacing out to 5.0 kilometers,
- 500-meter spacing out to 10.0 kilometers.

3.5 Model Execution

AERMOD will be run to model each generator separately using a 1 g/s unit emission. Thus, the outputs will be plot files of the maximum 24-hour concentrations and the 5-year average annual concentrations at each receptor for each generator. These plot files then be used in the risk assessment for the risk calculations as described below.

Figure 3-3: CAO Boundary and Near Field Receptors

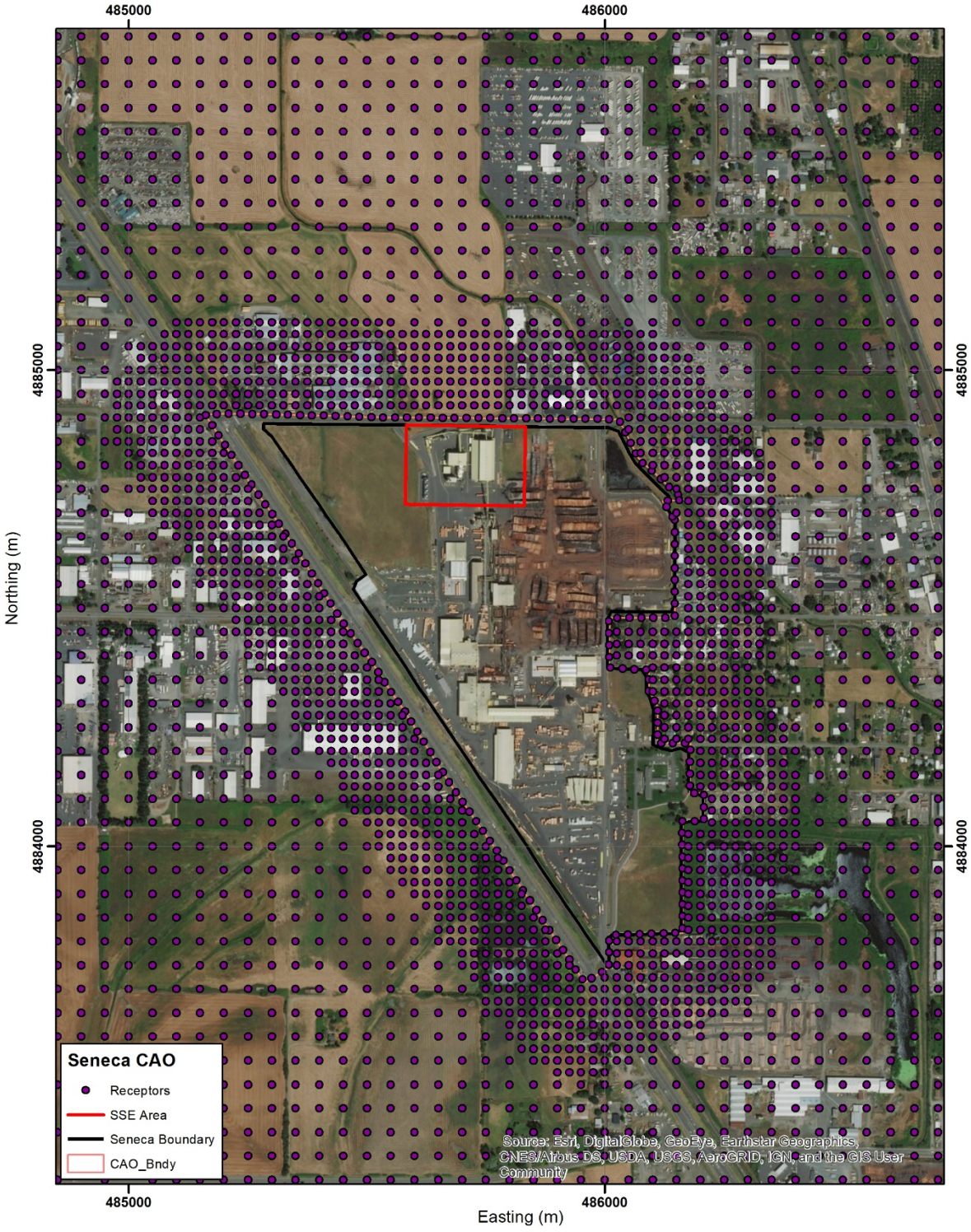
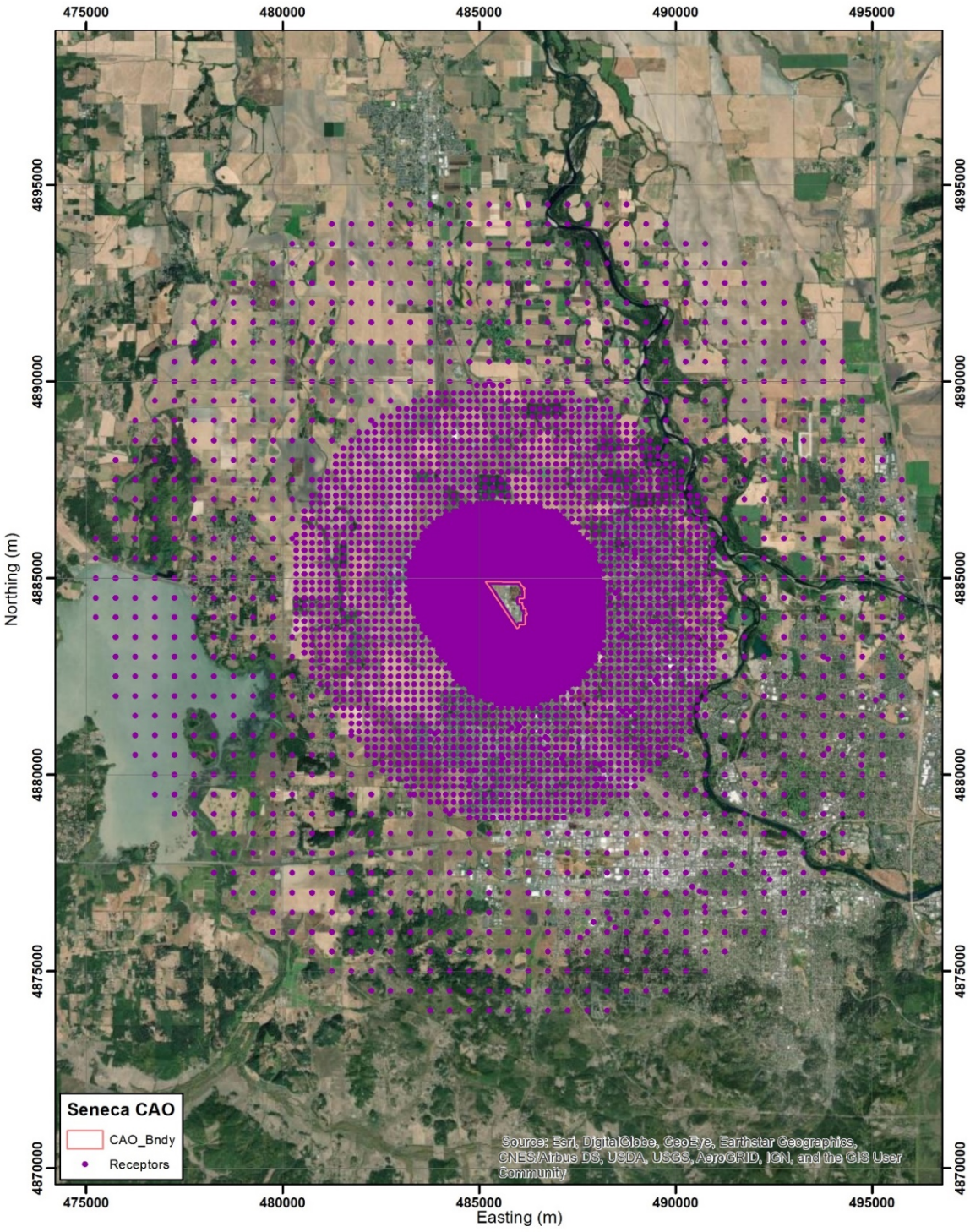


Figure 3-4: Far Field Receptor Grid

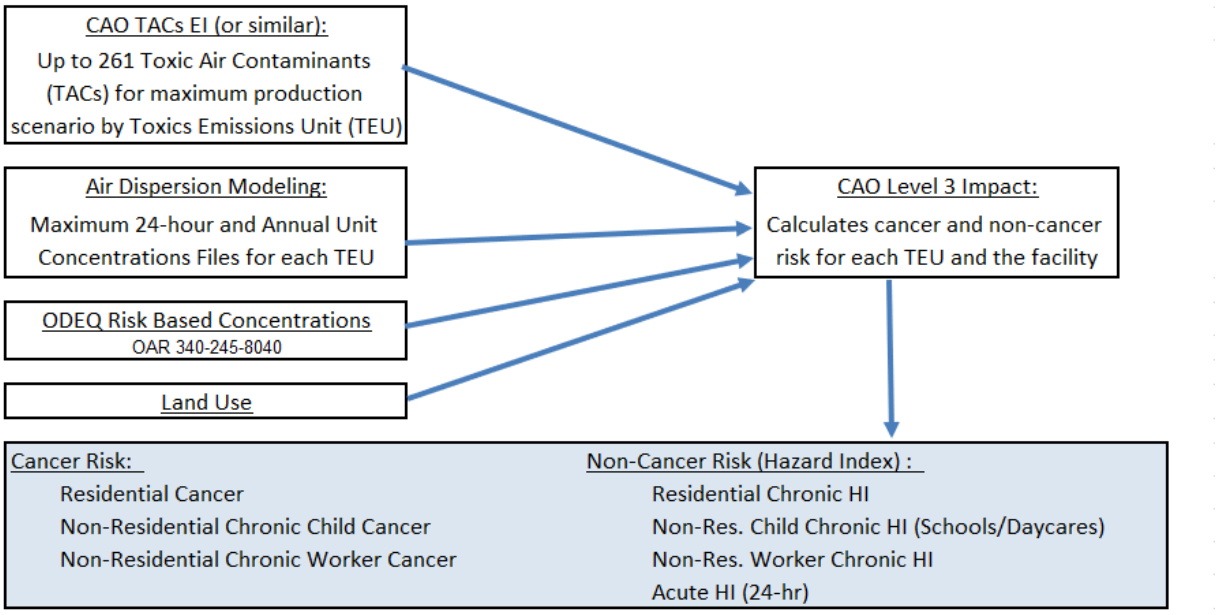


4.0 Risk Assessment Work Plan

4.1 Methodology

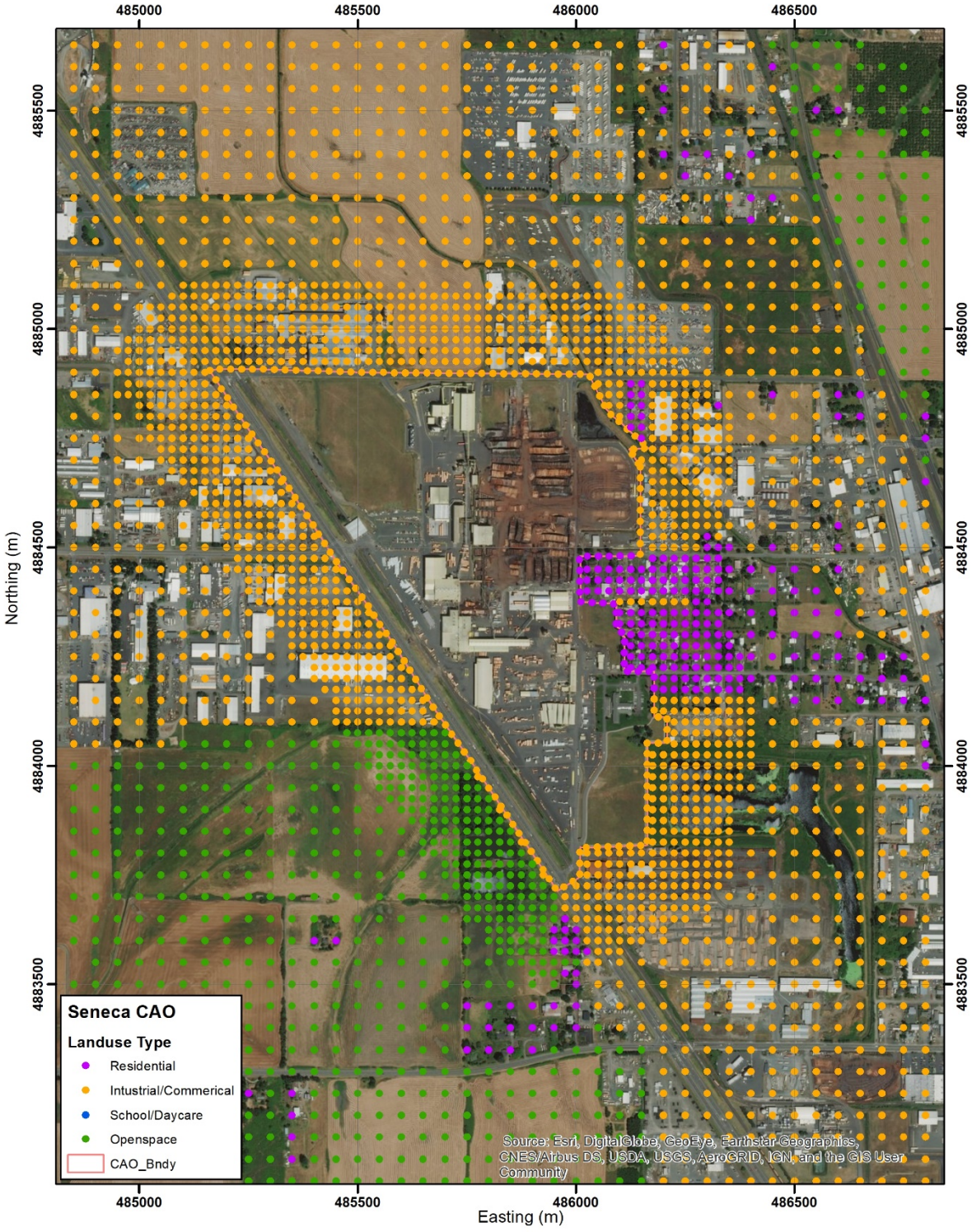
Figure 4-1 shows the Level-3 Risk Assessment process. Using the CAO toxic air pollutant emissions inventory (e.g., AQ405CAO), the 24-hr and annual average concentration files from AERMOD runs, the Risk Based Concentrations, and the land use designations at each receptor, the chronic cancer, chronic non-cancer and acute hazard index risk will be found at every receptor.

Figure 4-1: Level-3 Refined Risk Assessment



The land use classifications are applied to reach receptors around the facility to define their exposure class. The receptors, identified by class, are shown in Figure 4-2. Receptors exposure classes are defined as residential, non-residential child (schools/daycares), non-residential worker (industrial/comm.), open space, and excluded. The excluded class applies to receptors where the risk is not calculated, for example, along roads or highways or along the facility property line or train tracks where people will likely not congregate. Chronic exposure is only applicable to residential, non-residential child, and non-residential worker classes. The acute exposure is applied to all classes except the excluded class.

Figure 4-2: Receptor Exposure Classes



The chronic RBCs used at a receptor are a function of the land use at that receptor based on whether it is residential, worker (industrial commercial), or child (schools/daycares). The RBCs are shown in Table 4-1 for each applicable compound. Calculated risk is inversely proportional to the RBC.

Table 4-1: Compound RBCs

		Chronic Cancer RBC			Chronic Non-Cancer			
CAS#	Compound	Res. µg/m³	Worker µg/m³	Child µg/m³	Res. µg/m³	Worker µg/m³	Child µg/m³	Acute µg/m³
75-07-0	Acetaldehyde	0.45	5.5	12	140	620	620	470
67-64-1	Acetone				31000	140000	140000	62000
107-02-8	Acrolein				0.35	1.5	1.5	6.9
7664-41-7	Ammonia				500	2200	2200	1200
7440-36-0	Antimony				0.3	1.3	1.3	
7440-38-2	Arsenic	0.000024	0.00062	0.0013	0.00017	0.0024	0.0024	0.2
71-43-2	Benzene	0.13	1.5	3.3	3	13	13	29
7440-41-7	Beryllium	0.00042	0.005	0.011	0.007	0.031	0.031	0.02
117-81-7	Di(2-ethylhexyl) phthalate	0.08	5	11				
74-83-9	Bromomethane				5	22	22	3900
78-93-3	Methyl Ethyl Ketone				5000	22000	22000	5000
7440-43-9	Cadmium Compounds	0.00056	0.0067	0.014	0.005	0.037	0.037	0.03
75-15-0	Carbon Disulfide				800	3500	3500	6200
56-23-5	Carbon Tetrachloride	0.17	2	4.3	100	440	440	1900
7782-50-5	Chlorine				0.15	0.66	0.66	170
108-90-7	Chlorobenzene				50	220	220	
67-66-3	Chloroform				300	1300	1300	490
74-87-3	Methyl Chloride				90	400	400	1000
18540-29-9	Chromium (VI)	0.000031	0.001	0.00052	0.083	0.88	0.88	0.3
7440-48-4	Cobalt Compounds				0.1	0.44	0.44	
7440-50-8	Copper Compounds							100
106-46-7	p-Dichlorobenzene (1,4-Dichlorobenzene)	0.091	1.1	2.4	60	260	260	12000
75-09-2	Methylene Chloride	59	1200	620	600	2600	2600	2100
78-87-5	1,2-Dichloropropane (Propylene dichloride)				4	18	18	230
121-14-2	2,4-Dinitrotoluene	0.011	0.13	0.29				
100-41-4	Ethyl Benzene	0.4	4.8	10	260	1100	1100	22000
107-06-2	Ethylene dichloride (EDC, 1,2-Dichloroethane)	0.038	0.46	1	7	31	31	
50-00-0	Formaldehyde	0.17	2	4.3	9	40	40	49
118-74-1	Hexachlorobenzene	0.002	0.024	0.051				
110-54-3	n-Hexane				700	3100	3100	
7647-01-0	Hydrochloric Acid				20	88	88	2100

		Chronic Cancer RBC			Chronic Non-Cancer			
CAS#	**Compound**	**Res. µg/m³**	**Worker µg/m³**	**Child µg/m³**	**Res. µg/m³**	**Worker µg/m³**	**Child µg/m³**	**Acute µg/m³**
7664-39-3	Hydrogen Fluoride				2.1	19	19	16
67-63-0	Isopropyl Alcohol				200	880	880	3200
98-82-8	Cumene				400	1800	1800	
7439-92-1	Lead				0.15	0.66	0.66	0.15
7439-96-5	Manganese Compounds				0.09	0.4	0.4	0.3
7439-97-6	Mercury				0.077	0.63	0.63	0.6
67-56-1	Methanol				4000	18000	18000	28000
108-10-1	Methyl Isobutyl Ketone				3000	13000	13000	
91-20-3	Naphthalene	0.029	0.35	0.76	3.7	16	16	200
7440-02-0	Nickel	0.0038	0.046	0.1	0.014	0.062	0.062	0.2
87-86-5	Pentachlorophenol	0.2	2.4	5.1				
108-95-2	Phenol				200	880	880	5800
1336-36-3	Total PCBs	0.00053	0.0092	0.02				
1746-01-6	2,3,7,8-tetrachlorodibenzo-p-dioxin	1E-09	4.2E-08	9E-08	1.3E-07	0.000026	0.000026	
40321-76-4	1,2,3,7,8-pentachlorodibenzo-p-dioxin	1E-09	4.2E-08	9E-08	1.3E-07	0.000026	0.000026	
39227-28-6	1,2,3,4,7,8-hexachlorodibenzo-p-dioxin	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
57653-85-7	1,2,3,6,7,8-hexachlorodibenzo-p-dioxin	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
19408-74-3	1,2,3,7,8,9-hexachlorodibenzo-p-dioxin	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
35822-46-9	1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin	1E-07	4.2E-06	0.000009	0.000013	0.0026	0.0026	
3268-87-9	1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin	3.4E-06	0.00014	0.0003	0.00042	0.085	0.085	
51207-31-9	2,3,7,8-tetrachlorodibenzofuran	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
57117-41-6	1,2,3,7,8-pentachlorodibenzofuran	3.4E-08	1.4E-06	0.000003	4.2E-06	0.00085	0.00085	
57117-31-4	2,3,4,7,8-pentachlorodibenzofuran	3.4E-09	1.4E-07	3E-07	4.2E-07	0.000085	0.000085	
70648-26-9	1,2,3,4,7,8-hexachlorodibenzofuran	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
57117-44-9	1,2,3,6,7,8-hexachlorodibenzofuran	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
72918-21-9	1,2,3,7,8,9-hexachlorodibenzofuran	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
60851-34-5	2,3,4,6,7,8-hexachlorodibenzofuran	1E-08	4.2E-07	9E-07	1.3E-06	0.00026	0.00026	
67562-39-4	1,2,3,4,6,7,8-heptachlorodibenzofuran	1E-07	4.2E-06	0.000009	0.000013	0.0026	0.0026	
55673-89-7	1,2,3,4,7,8,9-heptachlorodibenzofuran	1E-07	4.2E-06	0.000009	0.000013	0.0026	0.0026	
39001-02-0	1,2,3,4,6,7,8,9-octachlorodibenzofuran	3.4E-06	0.00014	0.0003	0.00042	0.085	0.085	
56-55-3	Benzo(a) anthracene	0.00021	0.015	0.0078				
50-32-8	Benzo(a) pyrene	0.000043	0.003	0.0016	0.002	0.0088	0.0088	0.002
205-99-2	Benzo(b) fluoranthene	0.000053	0.0038	0.002				
191-24-2	Benzo(g,h,i)perylene	0.0047	0.34	0.17				
207-08-9	Benzo(k)fluoranthene	0.0014	0.1	0.052				

		Chronic Cancer RBC			Chronic Non-Cancer			
CAS#	Compound	Res. µg/m³	Worker µg/m³	Child µg/m³	Res. µg/m³	Worker µg/m³	Child µg/m³	Acute µg/m³
218-01-9	Chrysene	0.00043	0.03	0.016				
53-70-3	Dibenzo(a,h) anthracene	4.3E-06	0.0003	0.00016				
206-44-0	Fluoranthene	0.00053	0.038	0.02				
193-39-5	Indeno (1,2,3-c,d) pyrene	0.00061	0.043	0.022				
123-38-6	Propionaldehyde				8	35	35	
7782-49-2	Selenium							2
100-42-5	Styrene				1000	4400	4400	21000
127-18-4	Perchloroethylene	3.8	46	100	41	180	180	41
108-88-3	Toluene				5000	22000	22000	7500
71-55-6	Methyl Chloroform				5000	22000	22000	11000
79-01-6	Trichloro ethylene	0.2	2.9	3.5	2.1	9.2	9.2	2.1
88-06-2	2,4,6-Trichloro phenol	0.05	0.6	1.3				
7440-62-2	Vanadium (fume or dust)				0.1	0.44	0.44	0.8
75-01-4	Vinyl Chloride	0.11	2.7	0.22	100	440	440	1300
1330-20-7	Xylene (mixture), including m-xylene, o-xylene, p-xylene				220	970	970	8700

The steady state and start-up emission factors are shown in Table 4-2.

Table 4-2: Cogeneration Boiler Emissions

CAS	Pollutant	Metal	Steady State Emissions (lb/yr)	Steady State Emissions (lb/day)	Start-up Emissions (lb/day)
75-07-0	Acetaldehyde	-	1.01E+03	2.77E+00	1.03E+00
67-64-1	Acetone	-	3.68E+03	1.01E+01	3.73E+00
107-02-8	Acrolein	-	3.23E+02	8.86E-01	3.28E-01
7664-41-7	Ammonia	-	2.14E+04	5.85E+01	2.17E+01
7440-36-0	Antimony and compounds	Yes	9.33E-01	2.56E-03	2.38E-03
7440-38-2	Arsenic and compounds	Yes	5.81E+00	1.59E-02	8.60E-03
71-43-2	Benzene	-	3.03E+03	8.30E+00	3.07E+00
7440-41-7	Beryllium and compounds	Yes	9.30E-02	2.55E-04	1.47E-04
117-81-7	Bis(2-ethylhexyl) phthalate (DEHP)	-	1.44E-01	3.94E-04	1.46E-04
74-83-9	Bromomethane (Methyl bromide)	-	3.51E+01	9.61E-02	3.56E-02
78-93-3	2-Butanone (Methyl ethyl ketone)	-	4.82E+01	1.32E-01	4.89E-02
7440-43-9	Cadmium and compounds	Yes	1.13E+00	3.10E-03	3.50E-03
75-15-0	Carbon disulfide	-	3.87E+02	1.06E+00	3.92E-01
56-23-5	Carbon tetrachloride	-	6.21E+01	1.70E-01	6.30E-02
7782-50-5	Chlorine	-	2.26E+03	6.20E+00	2.29E+00
108-90-7	Chlorobenzene	-	5.13E+01	1.41E-01	5.20E-02
67-66-3	Chloroform	-	6.21E+01	1.70E-01	6.30E-02
74-87-3	Chloromethane (Methyl chloride)	-	1.17E+02	3.20E-01	1.18E-01

CAS	Pollutant	Metal	Steady State Emissions (lb/yr)	Steady State Emissions (lb/day)	Start-up Emissions (lb/day)
18540-29-9	Chromium VI, chromate and dichromate particulate	Yes	8.41E-01	2.31E-03	4.26E-03
7440-48-4	Cobalt and compounds	Yes	7.27E+00	1.99E-02	7.02E-03
7440-50-8	Copper and compounds	Yes	1.54E+01	4.23E-02	6.96E-02
106-46-7	p-Dichlorobenzene (1,4-Dichlorobenzene)	-	8.62E+02	2.36E+00	8.75E-01
75-09-2	Dichloromethane (Methylene chloride)	-	1.69E+03	4.63E+00	1.71E+00
78-87-5	1,2-Dichloropropane (Propylene dichloride)	-	5.20E+01	1.43E-01	5.28E-02
121-14-2	2,4-Dinitrotoluene	-	2.91E+00	7.98E-03	2.95E-03
100-41-4	Ethyl benzene	-	1.22E+03	3.35E+00	1.24E+00
107-06-2	Ethylene dichloride (EDC, 1,2-Dichloroethane)	-	9.02E+01	2.47E-01	9.15E-02
50-00-0	Formaldehyde	-	3.25E+02	8.90E-01	3.30E-01
118-74-1	Hexachlorobenzene	-	3.18E+00	8.72E-03	3.23E-03
110-54-3	Hexane	-	8.90E+02	2.44E+00	9.03E-01
7647-01-0	Hydrochloric acid	-	2.92E+03	7.99E+00	2.96E+00
7664-39-3	Hydrogen fluoride	-	7.26E+02	1.99E+00	7.37E-01
67-63-0	Isopropyl alcohol	-	1.12E+04	3.08E+01	1.14E+01
98-82-8	Isopropylbenzene (Cumene)	-	5.47E+01	1.50E-01	5.55E-02
7439-92-1	Lead and compounds	Yes	1.61E+01	4.41E-02	2.95E-02
7439-96-5	Manganese and compounds	Yes	2.82E+02	7.73E-01	1.64E+00
7439-97-6	Mercury and compounds	Yes	3.29E+00	9.02E-03	3.68E-03
67-56-1	Methanol	-	2.26E+03	6.20E+00	2.29E+00
108-10-1	Methyl isobutyl ketone (MIBK, Hexone)	-	1.38E+03	3.77E+00	1.40E+00
91-20-3	Naphthalene	-	3.08E+02	8.43E-01	3.12E-01
7440-02-0	Nickel compounds, insoluble	Yes	8.66E+00	2.37E-02	1.41E-02
87-86-5	Pentachlorophenol	-	7.08E-01	1.94E-03	7.18E-04
108-95-2	Phenol	-	4.94E+02	1.35E+00	5.02E-01
1336-36-3	Polychlorinated biphenyls (PCBs)	-	2.43E-02	6.65E-05	2.46E-05
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	-	2.03E-06	5.55E-09	2.06E-09
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	-	4.45E-06	1.22E-08	4.51E-09
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	-	2.84E-06	7.78E-09	2.88E-09
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	-	6.89E-06	1.89E-08	6.99E-09
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	-	6.89E-06	1.89E-08	6.99E-09
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	-	3.04E-05	8.33E-08	3.08E-08
3268-87-9	Octachlorodibenzo-p-dioxin (OCDD)	-	7.70E-05	2.11E-07	7.81E-08
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran (TcDF)	-	2.56E-05	7.00E-08	2.59E-08
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	-	1.26E-05	3.45E-08	1.28E-08
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	-	1.74E-05	4.78E-08	1.77E-08
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	-	1.13E-05	3.11E-08	1.15E-08
57117-44-9	1,2,3,4,7,8--Hexachlorodibenzofuran (HxCDF)	-	9.74E-06	2.67E-08	9.88E-09
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	-	2.03E-06	5.55E-09	2.06E-09
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	-	8.10E-06	2.22E-08	8.21E-09
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	-	1.78E-05	4.89E-08	1.81E-08
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	-	2.84E-06	7.78E-09	2.88E-09
39001-02-0	Octachlorodibenzofuran (OCDF)	-	1.58E-05	4.34E-08	1.61E-08
56-55-3	Benz[a]anthracene	-	1.04E-01	2.86E-04	1.06E-04
50-32-8	Benzo[a]pyrene	-	5.77E-02	1.58E-04	5.85E-05
205-99-2	Benzo[b]fluoranthene	-	1.29E-01	3.53E-04	1.31E-04

CAS	Pollutant	Metal	Steady State Emissions (lb/yr)	Steady State Emissions (lb/day)	Start-up Emissions (lb/day)
191-24-2	Benzo[g,h,i]perylene	-	1.57E-01	4.29E-04	1.59E-04
207-08-9	Benzo[k]fluoranthene	-	2.50E-01	6.85E-04	2.54E-04
218-01-9	Chrysene	-	1.79E-01	4.91E-04	1.82E-04
53-70-3	Dibenz[a,h]anthracene	-	3.18E-02	8.71E-05	3.22E-05
206-44-0	Fluoranthene	-	3.85E+00	1.06E-02	3.91E-03
193-39-5	Indeno[1,2,3-cd]pyrene	-	4.54E-02	1.24E-04	4.60E-05
123-38-6	Propionaldehyde	-	7.79E+02	2.13E+00	7.90E-01
7782-49-2	Selenium and compounds	Yes	5.01E+00	1.37E-02	5.91E-03
100-42-5	Styrene	-	1.23E+01	3.36E-02	1.24E-02
127-18-4	Tetrachloroethene (Perchloroethylene)	-	7.61E+01	2.09E-01	7.72E-02
108-88-3	Toluene	-	2.17E+01	5.94E-02	2.20E-02
71-55-6	1,1,1-Trichloroethane (Methyl chloroform)	-	1.79E+02	4.90E-01	1.81E-01
79-01-6	Trichloroethene (TCE, Trichloroethylene)	-	6.14E+01	1.68E-01	6.23E-02
88-06-2	2,4,6-Trichlorophenol	-	8.53E-01	2.34E-03	8.66E-04
7440-62-2	Vanadium (fume or dust)	Yes	1.84E+00	5.03E-03	4.58E-03
75-01-4	Vinyl chloride	-	5.69E+01	1.56E-01	5.77E-02
1330-20-7	Xylene (mixture), including m-xylene, o-xylene, p-xylene	-	1.61E+01	4.42E-02	1.64E-02

The risk ($R_{r,L,m}$) at each receptor *r* with an exposure class *L*, and operation mode *m* (steady state or start-up) is given by:

$$R_{r,L,m} = \chi_r * C * TO_m * \sum_p \frac{E_{p,m}}{RBC_{p,L}}$$

where χ_r is the unit concentration at receptor *r*, *C* is a constant to convert g/s to either lbs/day or lbs/year, $E_{p,m}$ is the emissions of pollutant *p* and mode *m* (steady state or start-up), $RBC_{p,L}$ is the risk based concentration for pollutant *p* (Table 4-1) and exposure class type *L*, and TO_m is the target organ factor (Table 4-3) for mode *m* (non-cancer only).

Since different pollutants impact different parts of the body, the non-cancer risk is not additive. Thus, the non-cancer risk will be evaluated by the worst-case target organ contribution. Regular operation and start-up emissions have different target organ values as the pollutant mixtures are different for these two cases. An electronic spreadsheet with the target organ calculation is provided with this document.

In the end, each receptor will have three risk numbers: chronic cancer risk, chronic non-cancer risk, and acute risk based on the exposure class. For informational purposes, the chronic risk values will be grouped by exposure type (residential, non-residential child, and worker) from which the maximum risk will be determined. This results in seven risk levels being determined.

The risks are then compared to the applicable risk action level (Table 4-4) for an existing source. The RAL for the non-cancer risk depends on the pollutant, with either a RAL value of 3 or 5. Only two of the acute risk compounds (Acrolein and Propionaldehyde) have a RAL of 5, while the remaining acute TACs have a RAL of 3. To account for the different RALs, ODEQ has a "Risk Determination Ratio (RDR)" which weights the noncancer risk from a source's emissions relative to both HI benchmarks of 3 and 5. The RDR is given by:

$$RDR = \frac{\sum Risk_{HI=3}}{3} + \frac{\sum Risk_{HI=5}}{5}$$

If the RDR rounds to 1 or less, then a TBACT analysis is not required.

Table 4-3: Target Organ Factors

	Steady State Operation		Start-up	
Exposure Scenario	**Factor**	**Target Organ**	**Factor**	**Target Organ**
Chronic Residential	0.66	Nerv	NA	
Chronic Child	0.53	Resp	NA	
Chronic Worker	0.53	Resp	NA	
Acute	0.64	Nerv	0.88	Nerv

Table 4-4: Risk Action Levels

Level Description	Cancer	Non-Cancer
Source Permit (De Minimis) Level	5	0.5
Community Engagement Level	25	1
TBACT Level	50	5, 3 or RDR = 1
Risk Reduction Level	200	10, 6 or RDR = 2
Immediate Curtailment Level	500	20, 12 or RDR = 4

4.2 Uncertainty Analysis

CAO rules require that a quantitative or qualitative uncertainty evaluation be included in a Level 3 and Level 4 risk assessment. The uncertainty in the various elements of the analysis will be described.