Appendix D

Health Risk Assessment Methodology

A. Introduction

This document presents the methodology used to estimate the potential cancer risk from exposure to diesel particulate matter (PM) from diesel-fueled construction equipment operations at an urban area. The estimated risks and assumptions used to determine these risks are not based on the construction equipment at a specific urban site. Instead, a generic construction site and general assumptions were used. These estimated risks are used to provide an approximate range of potential risks levels in nearby communities from diesel-fueled construction equipment operations at a generic project site with typical size of a city block. To determine the extent of impacts and to compare the impacts for different scenarios, public areas affected by different risk ranges and risks at point of maximum impact (PMI) are presented for each scenario. Actual risk levels and affected public areas will vary due to site specific parameters, including: number of equipment, type of equipment, emission rates, operating schedules, site configuration, site meteorology, and distance to receptors.

The methodology used in this risk assessment is consistent with the Tier-1 analysis presented in the Office of Environmental Health Hazard Assessment (OEHHA), Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2003a). These OEHHA guidelines and this assessment utilize health and exposure assessment information that is contained in the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (OEHHA 2003b); and the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part IV, Technical Support Document for Exposure Analysis and Stochastic Analysis (OEHHA 2000), respectively.

B. Source Description and Activity

As stated above, this analysis is not based on a specific construction site; rather a generic city block is developed. The city block is assumed to be a square with a side of 120 m (393 ft) and is physically located in an urban area. Activity data, including equipment type, operation hours, horsepower, load factor, etc., were obtained from a construction company, which reflect a typical construction project in a complete city block. The project was classified into five phases: demolition, dewatering, grading/construction, construction, and pavement. The equipment horsepower ranges from about 100 to 400 hp and the operation time ranges from several hours to 1500 hours depending on the equipment type and their use proposes. Detailed activity data are shown in Table 1and Table 2.

Table 1: Activity and Emissions for Mixed EFs

Phase	Equipment	Model Year	Horsepower	Hours of Activity	Construc Days	Hours/day (Calc'd)	Load Factor	Emission Factor (g/bhp-hr)	Stack Height (Feet)	PM Emission (kg)	Phase SubTotal (kg)	Total (kg)
1-demo	CAT 345 Excavator	1998	312	210	41	5.1	0.57	0.40	8	14.94		
1-demo	CASE 9050B Excavator	1997	226	85	41	2.1	0.57	0.40	8	4.38		
1-demo	Link Belt 330L Excavator	2005	247	210	41	5.1	0.57	0.15	8	4.43		
1-demo	Pegson Jaw Crusher	2002	300	100	41	2.4	0.78	0.15	8	3.51		
1-demo	Kawasaki 95Z Loader	2005	340	126	41	3.1	0.78	0.15	6	5.01		
1-demo	Link Belt Excavator (rented)	2005	247	200	41	4.9	0.57	0.15	8	4.22	36.50	
2-dewater	Hitachi ex300lc excavator	1993	125	80	10	8.0	0.57	0.54	8	3.08		
2-dewater	John Deere 444J loader	2006	110	80	10	8.0	0.57	0.22	8	1.10	4.18	
3-grading/const	Kobelco 330 excavator	2004	238	1500	190	7.9	0.57	0.15	8	30.52		
3-grading/const	CAT 321 excavator	2005	138	600	190	3.2	0.57	0.22	8	10.38		
3-grading/const	CAT TH220B telehandler	2005	120	150	190	0.8	0.3	0.22	6	1.19		
3-grading/const	CAT 966G loader	2003	260	600	190	3.2	0.55	0.15	6	12.87		
3-grading/const	CAT D6 DOZER	2004	165	400	190	2.1	0.55	0.22	8	7.99		
3-grading/const	JD 210 SKIP LOADER	2005	73	300	190	1.6	0.55	0.30	6	3.61		
3-grading/const	ABI TM 14/17V (drill/bore/pile d	2004	640	150	190	0.8	0.75	0.30	8	21.60	88.16	
4-const	Manitowoc 4000W crane	1976	310	800	200	4.0	0.43	0.68	12	72.52		
4-const	forklift pettibone	1980	230	800	200	4.0	0.6	0.78	4	86.11		
4-const	forklift pettibone	1967	210	680	200	3.4	0.6	1.10	4	94.25		
4-const	Manitowoc 3900W crane	1978	350	680	200	3.4	0.43	0.68	12	69.59		
4-const	Skid Steer Loader	2000	62	300	200	1.5	0.55	1.09	5	11.15	333.62	
5-Paving	Paver	2002	132	6	10	0.6	0.62	0.60	10	0.29		
5-Paving	Paving Equipment	1998	111	6	10	0.6	0.53	0.60	8	0.21	0.51	
								TOTAL E's FOR 451 DAY PROJECT:				**462.97**

Table 2: Activity and Emissions for Tier-0 EFs

Phase	Equipment	Model Year	Horsepower	Hours of Activity	Construc Days	Hours/day (Calc'd)	Load Factor	Emission Factor (g/bhp-hr)	Stack Height (Feet)	PM Emission (kg)	Phase SubTotal (kg)	Total (kg)
1-demo	CAT 345 Excavator	1989	312	210	41	5.1	0.57	0.49	8	18.30		
1-demo	CASE 9050B Excavator	1989	226	85	41	2.1	0.57	0.54	8	5.91		
1-demo	Link Belt 330L Excavator	1989	247	210	41	5.1	0.57	0.54	8	15.97		
1-demo	Pegson Jaw Crusher	1989	300	100	41	2.4	0.78	0.49	8	11.47		
1-demo	Kawasaki 95Z Loader	1989	340	126	41	3.1	0.78	0.49	6	16.37		
1-demo	Link Belt Excavator (rente	1989	247	200	41	4.9	0.57	0.54	8	15.21	83.22	
2-dewater	Hitachi ex300lc	1989	125	80	10	8.0	0.57	0.54	8	3.08		
2-dewater	John Deere 444J	1989	110	80	10	8.0	0.57	0.54	8	2.71	5.79	
3-grading/const	Kobelco 330 excavator	1989	238	1500	190	7.9	0.57	0.54	8	109.88		
3-grading/const	CAT 321 excavator	1989	138	600	190	3.2	0.57	0.54	8	25.49		
3-grading/const	CAT TH220B telehandler	1989	120	150	190	0.8	0.3	0.54	6	2.92		
3-grading/const	CAT 966G loader	1989	260	600	190	3.2	0.55	0.54	6	46.33		
3-grading/const	CAT D6 DOZER	1989	165	400	190	2.1	0.55	0.54	8	19.60		
3-grading/const	JD 210 SKIP LOADER	1989	73	300	190	1.6	0.55	0.98	6	11.80		
3-grading/const	ABI TM 14/17V (drill/bore/	1989	640	150	190	0.8	0.75	0.49	8	35.28	251.30	
4-const	Manitowoc 4000W crane	1976	310	800	200	4.0	0.43	0.68	12	72.52		
4-const	forklift pettibone	1980	230	800	200	4.0	0.6	0.78	4	86.11		
4-const	forklift pettibone	1967	210	680	200	3.4	0.6	1.10	4	94.25		
4-const	Manitowoc 3900W crane	1978	350	680	200	3.4	0.43	0.68	12	69.59		
4-const	Skid Steer Loader	1989	62	300	200	1.5	0.55	0.98	5	10.03	332.49	
5-Paving	Paver	1989	132	6	10	0.6	0.62	0.54	10	0.27		
5-Paving	Paving Equipment	1989	111	6	10	0.6	0.53	0.54	8	0.19	0.46	
											TOTAL E's FOR 451 DAY PROJECT:	**673.26**

C. Emission Factors and Emissions

The diesel PM emissions for each vehicle are calculated using the following basic equation:

Equation 1: E = AC x HP x LF x EF

Where:
E = the emission (g)
AC = the activity (hrs/project life)
HP = the equipment's horsepower (hp)
LF = the load factor
EF = the emission factor (g/bhp-hr)

Two scenarios were considered: mixed emission factors, and tier-zero emission factors. The former reflects an actual equipment fleet that are used in the actual construction project, while the latter considers a generic worst case, that is, all construction equipment is old (assuming1989 model year) with tier-zero emission standard. The construction company also provided the load factor and emission factor for all equipment (see Table 1 and Table 2). The calculated emissions for the two scenarios are summarized in Table 3 with a seasonal distribution. Detailed emission calculations for all equipment for the two scenarios are presented in Table 1and Table 2.

Table 3: Diesel PM Emissions and Seasonal Distribution

Season	Mixed EF Scenario Emission (kg)	Tier-Zero Scenario Emission (kg)
Winter	55	135
Spring	43	122
Summer	137	148
Fall	140	140
Total	375	545

D. Dispersion Model and Input Parameters

The dispersion of the diesel PM emissions was estimated using the United States Environmental Protection Agency's Industrial Source Complex Short Term Model – Version 3 (ISCST3 Version 00101). ISCST3 is an air dispersion model that allows an estimation of the annual average above ambient diesel PM concentrations. The emissions resulting from the construction equipment were modeled as area sources. It is assumed that the construction project is completed in a complete year. Activity occurs all over the project area, that is, a city block of 120 m x 120 m. The operation schedule is assumed to be 365 days, 8 hours per day starting from 9 am to 4 pm. Sensitivity studies have shown that there is an initial plume rise from the equipment due to upward buoyancy and momentum. The release heights of these area sources were determined to be 5 -10 meters (m) depending on equipment type during the operation times. The urban dispersion coefficients were used to estimate potential cancer risk in nearby community of the construction site.

Meteorological data is a site-specific parameter that is input to the air dispersion model to calculate concentrations and subsequent risks. For this exercise, two meteorological data sets - West Los Angeles (West L.A.) and Sacramento - were selected as the input to the ISCST3 model to represent atmospheric conditions in Southern and Northern California. The West L.A. meteorological data provides a more conservative estimate of risk than most of the other meteorological data sets compiled by ARB. This is because the West L.A. site tends to have the lowest average wind speed and persistent wind directions, resulting in less dispersion of pollutants. The Sacramento meteorological data represents typical atmospheric conditions in the Northern California area in that it has higher wind speeds than the West L.A. location.

The modeling receptor domain varied depending on risk impact areas. The sensitivity runs were conducted to determine the model domain for the scenarios ensuring an entire risk impact area of 1 per million being captured. The modeling domain used in this study was determined to be 2 km x 2 km. A Cartesian grid receptor network with 20 m x 20 m (around the site) and 50 m x 50 m (entire domain) resolution is used in this study. The key modeling parameters are presented in Table 4.

Table 4: Dispersion Modeling Parameters

Source Type	Area
Dispersion Setting	Urban
Receptor Height	1.5 meters
Modeled Area Source Length and Width	60 m, 60 m
Initial Release Height	5, 10 m
Operation Schedule	9 am – 4 pm, everyday
Meteorological Data	West L.A. (1981), Sacramento (1989)
Residents' Exposure Duration	9 years, 50 weeks per year (OEHHA)
Adult Daily Breathing Rate	26 m^3
Adult Body Weight	70 kg
0 to 70 year simulated Daily Breathing Rate	302 L/kg body weight -day

E. Risk Characterization

Risk characterization is defined as the process of obtaining a quantitative estimate of risk. The risk characterization process integrates the results of air dispersion modeling and relevant toxicity data (e.g., diesel PM cancer potency factor) to estimate potential cancer or non-cancer health effects associated with contaminant exposure. It is important to note that no background or ambient diesel PM concentrations are incorporated into the risk quantification. The risk assessment only considers the cancer risk by the inhalation pathway because the risk contributions by other pathways of exposure are known to be negligible relative to the inhalation pathway and difficult to quantify. In 2004, ARB recommended the interim use of the 80th percentile value (the midpoint value of the 65th and 95th percentile breathing rate) as the minimum value for risk management decisions at residential receptors for the breathing pathway. The 80th percentile corresponds to a breathing rate of 302 liters/kilogram body-day (302 l/kg-d).

This risk assessment used the 302 l/kg-d value and assumes that the receptors will be exposed for 24 hours per day for 9 years. If a receptor is exposed for a shorter amount of time to the annual average concentration of diesel PM, the cancer risk will be proportionately less. The potential cancer risk is estimated by multiplying the inhalation dose by the cancer potency factor (CPF) of diesel PM (1.1 $(mg/kg\text{-}d)^{-1}$).

To determine the extent of diesel PM risk on nearby communities and to compare the impacts for different scenarios, public areas (i.e., areas on the construction site are excluded) affected by risk ranges of greater than 10 per million are presented in this study. The risks at the PMIs at a distance of 20 meters from the construction site edge (fence line) are also presented.

F. Results and Discussion

This section presents the modeling results for eight scenarios:

(1) Mixed emission factors with release height of 5 m and West L.A. meteorological conditions;
(2) Mixed emission factors with release height of 10 m and West L.A. meteorological conditions;
(3) Tier-zero emission factors with release height of 5 m and West L.A. meteorological conditions;
(4) Tier-zero emission factors with release height of 10 m and West L.A. meteorological conditions;
(5) Mixed emission factors with release height of 5 m and Sacramento meteorological conditions;
(6) Mixed emission factors with release height of 10 m and Sacramento meteorological conditions;
(7) Tier-zero emission factors with release height of 5 m and Sacramento meteorological conditions; and
(8) Tier-zero emission factors with release height of 10 m and Sacramento meteorological conditions.

Diesel PM cancer risk isopleths for these scenarios are presented in Figure 1 through Figure 8, respectively (completed on September 1,2006).

Figure 1: Estimated Cancer Risk from Construction Activity with Mixed EFs and Release Height of 5 m using West L. A. Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)

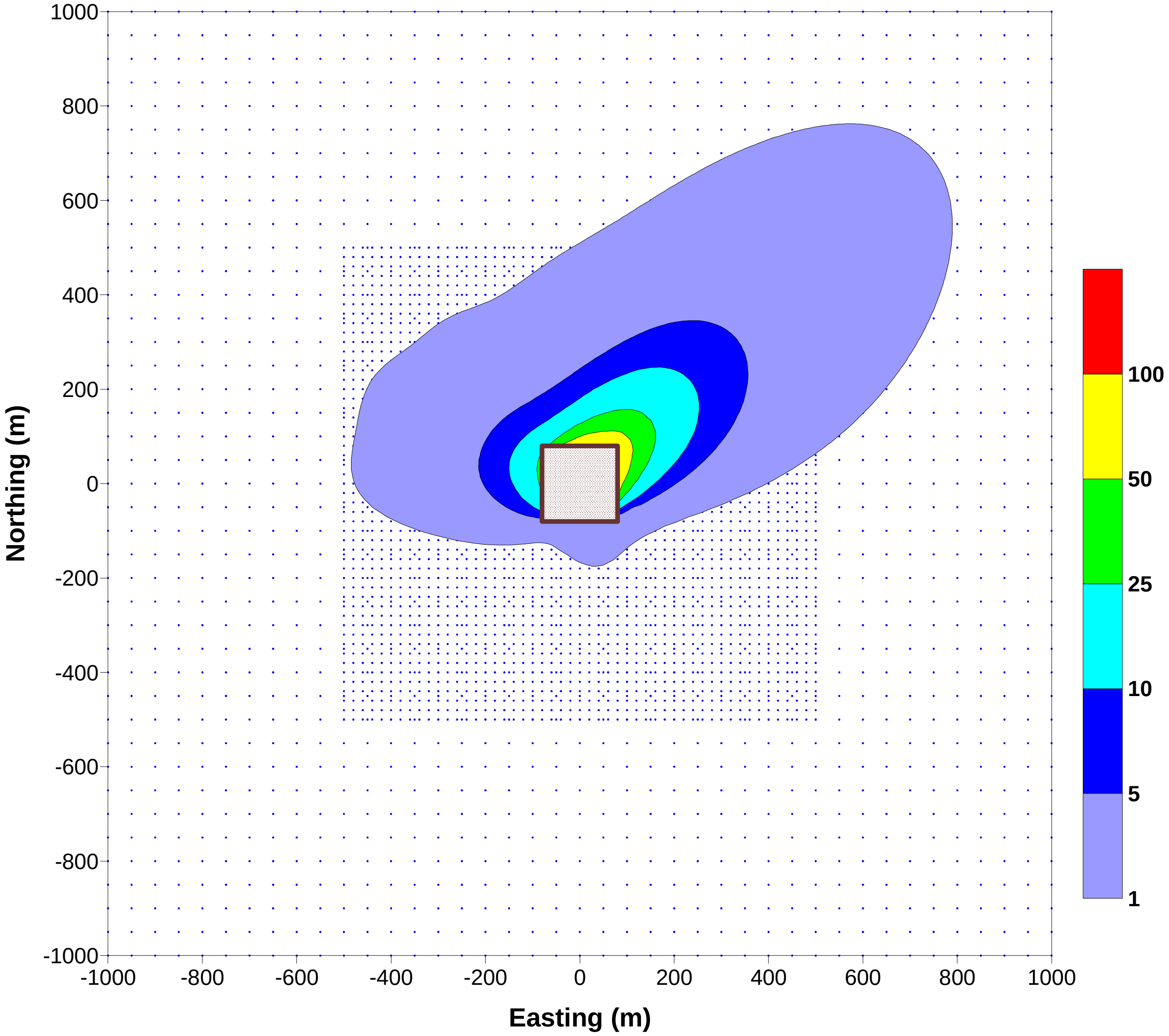


Figure 2: Estimated Cancer Risk from Construction Activity with Mixed EFs and Release Height of 10 m using West L. A. Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)

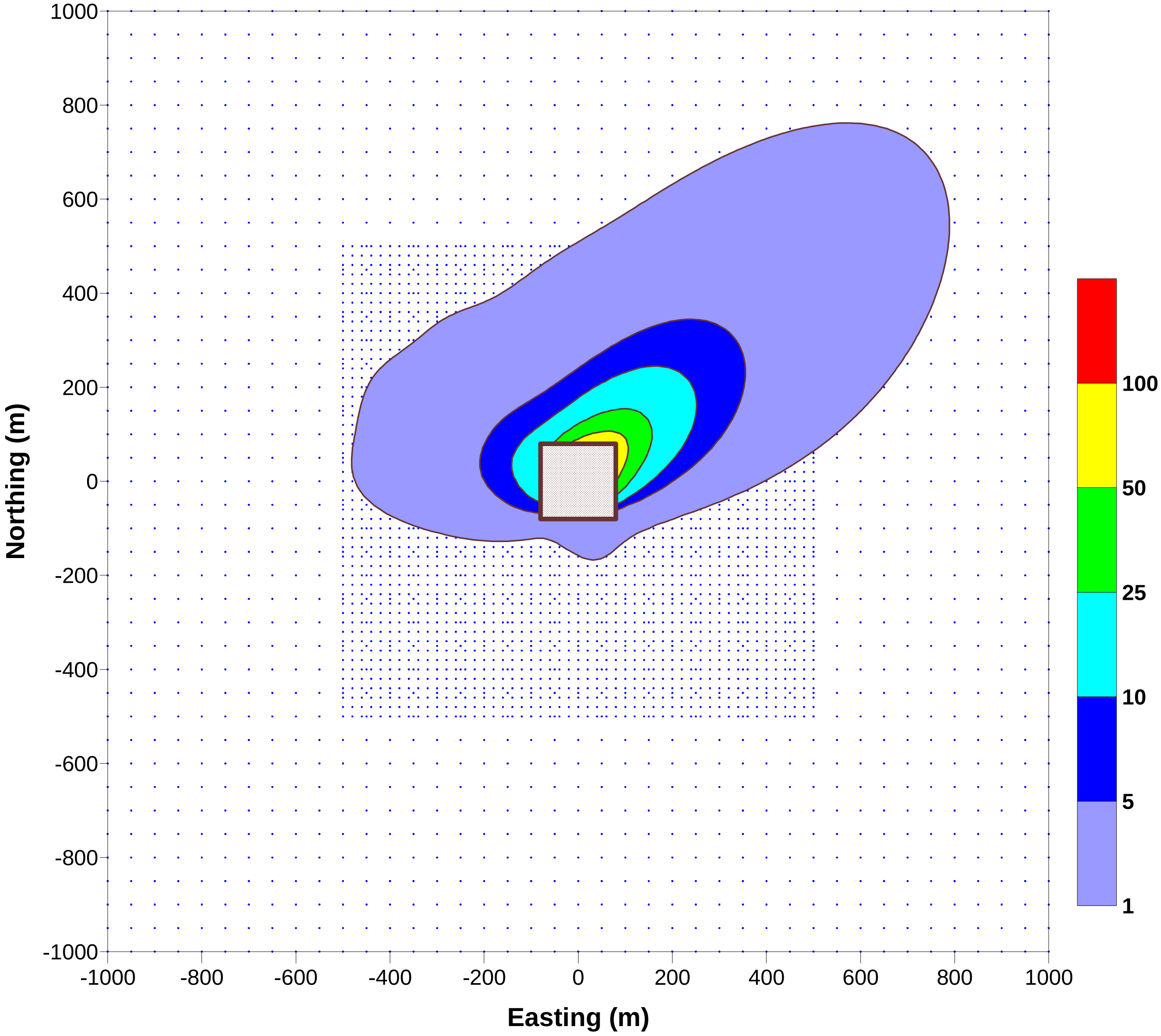


Figure 3: Estimated Cancer Risk from Construction Activity with Tier-0 EFs and Release Height of 5 m using West L. A. Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)

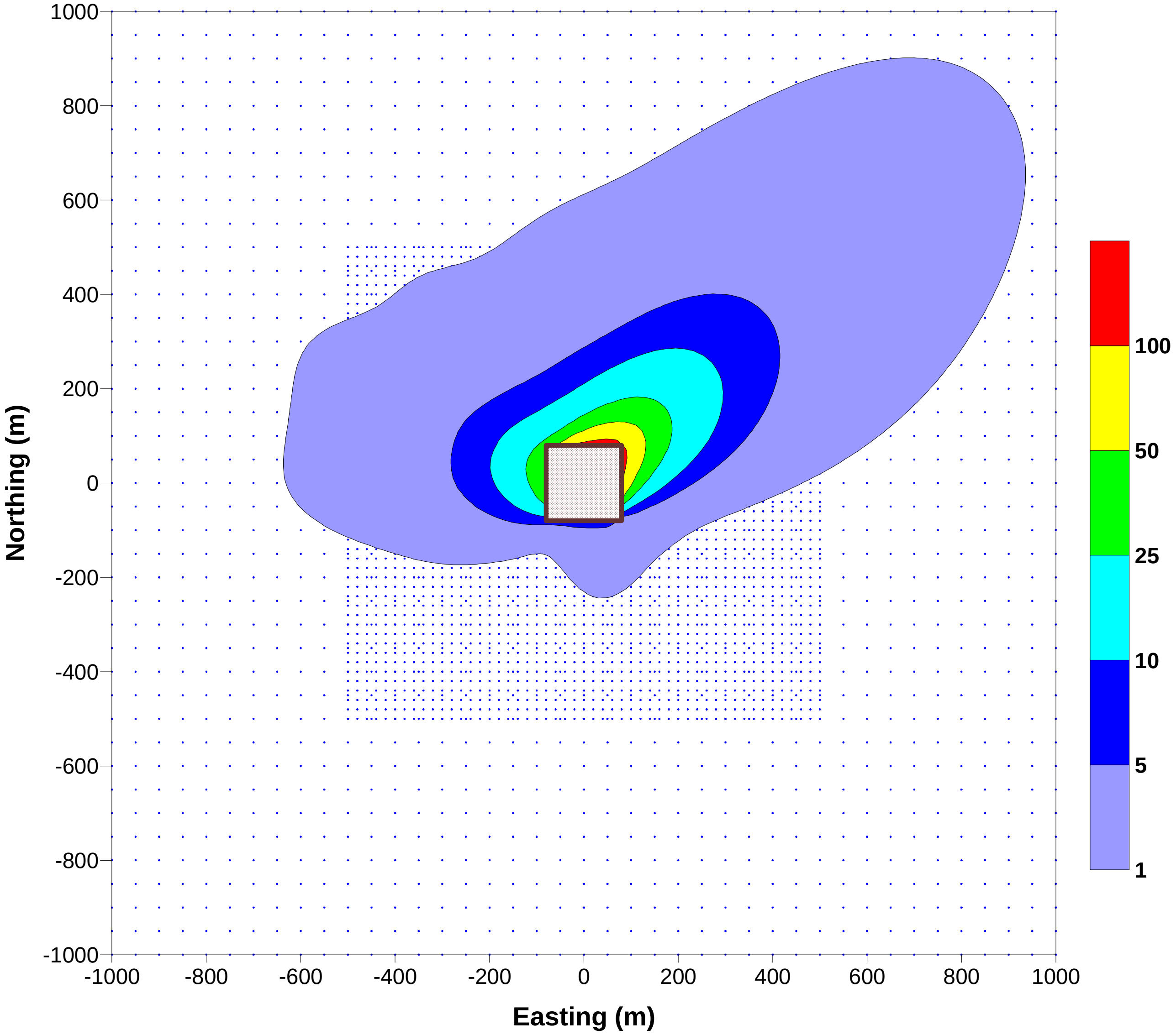


Figure 4: Estimated Cancer Risk from Construction Activity with Tier-0 EFs and Release Height of 10 m using West L. A. Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)

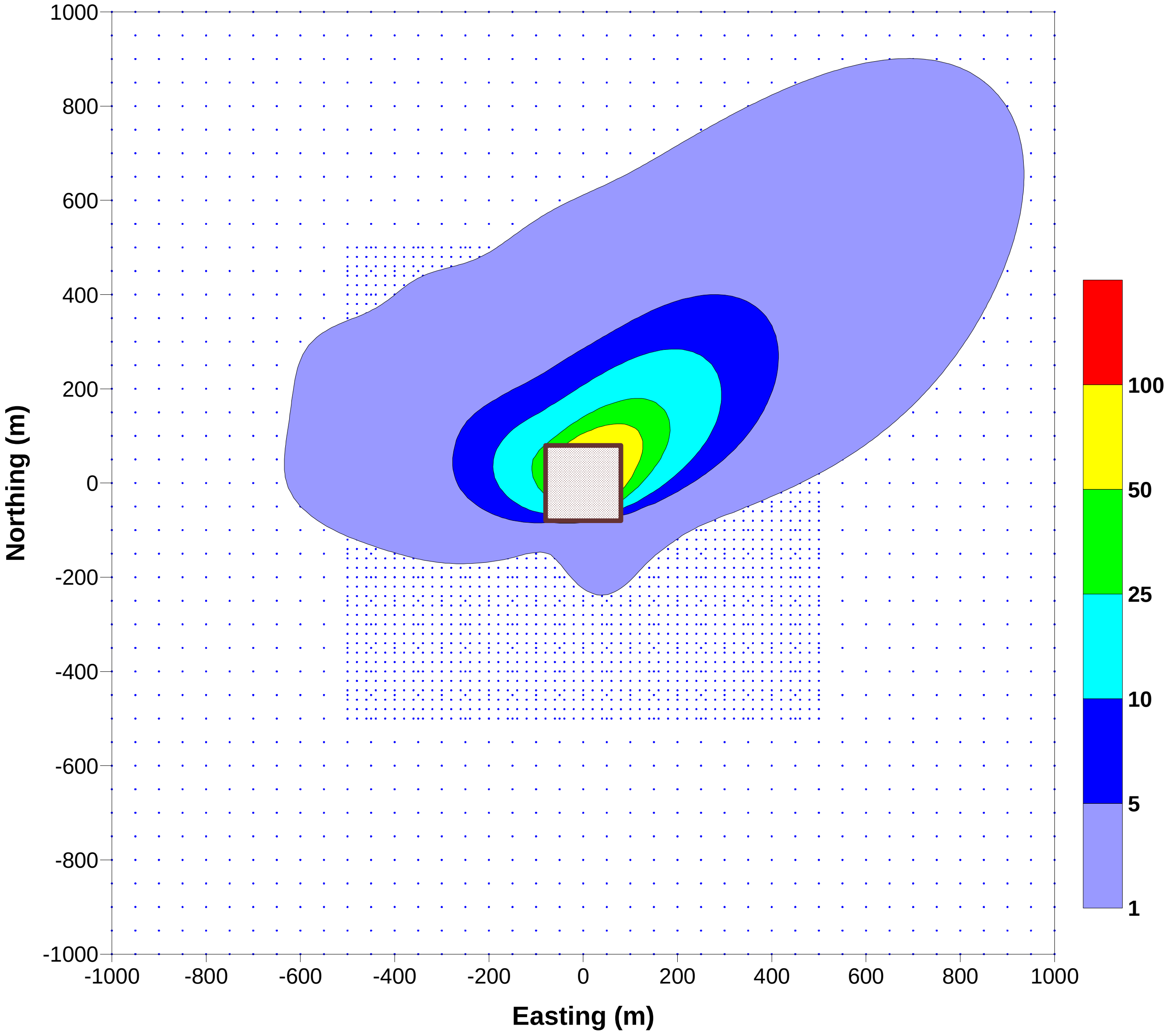


Figure 5: Estimated Cancer Risk from Construction Activity with Mixed EFs and Release Height of 5 m using Sacramento Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)

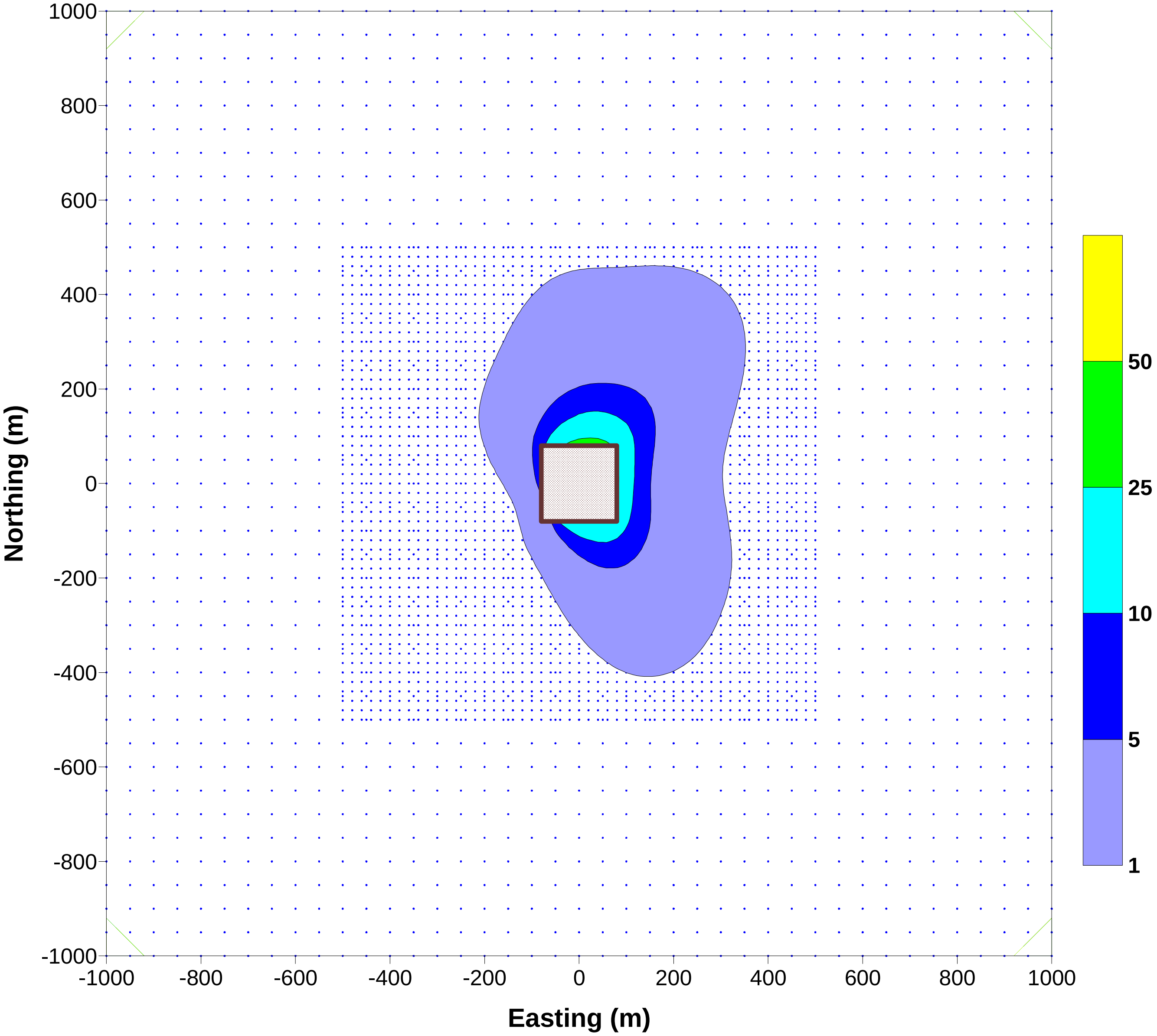


Figure 6: Estimated Cancer Risk from Construction Activity with Mixed EFs and Release Height of 10 m using Sacramento Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)

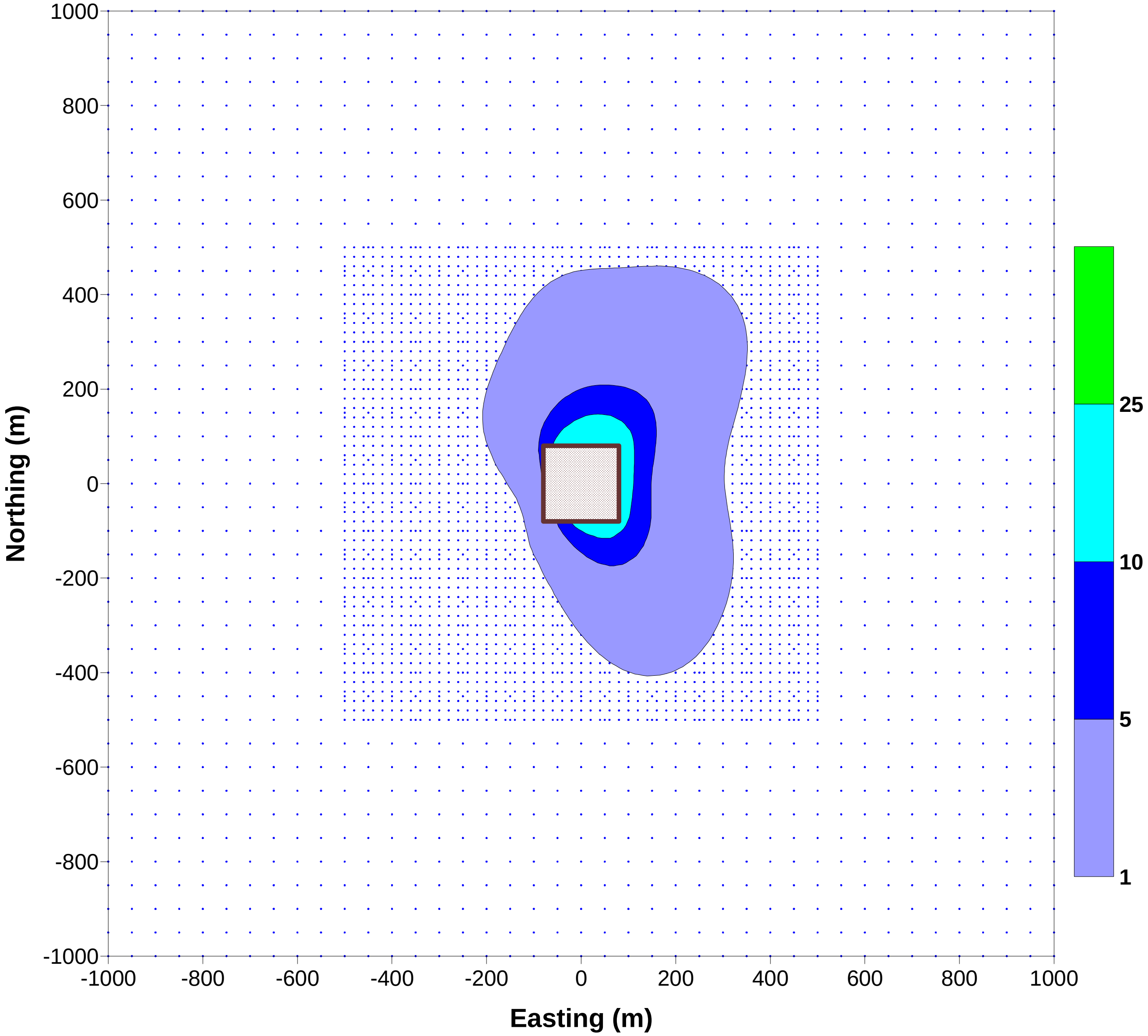


Figure 7: Estimated Cancer Risk from Construction Activity with Tier-0 EFs and Release Height of 5 m using Sacramento Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)

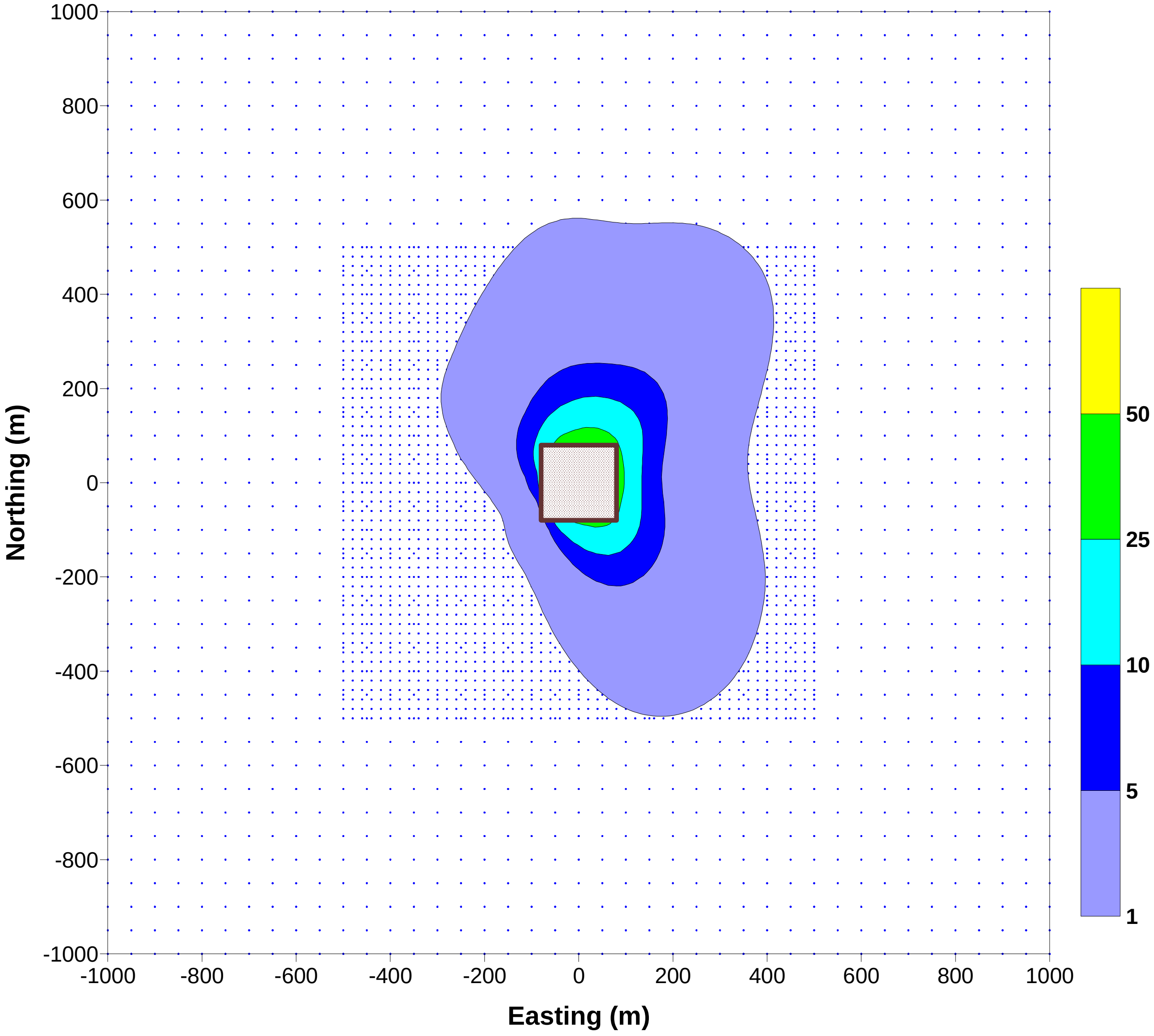
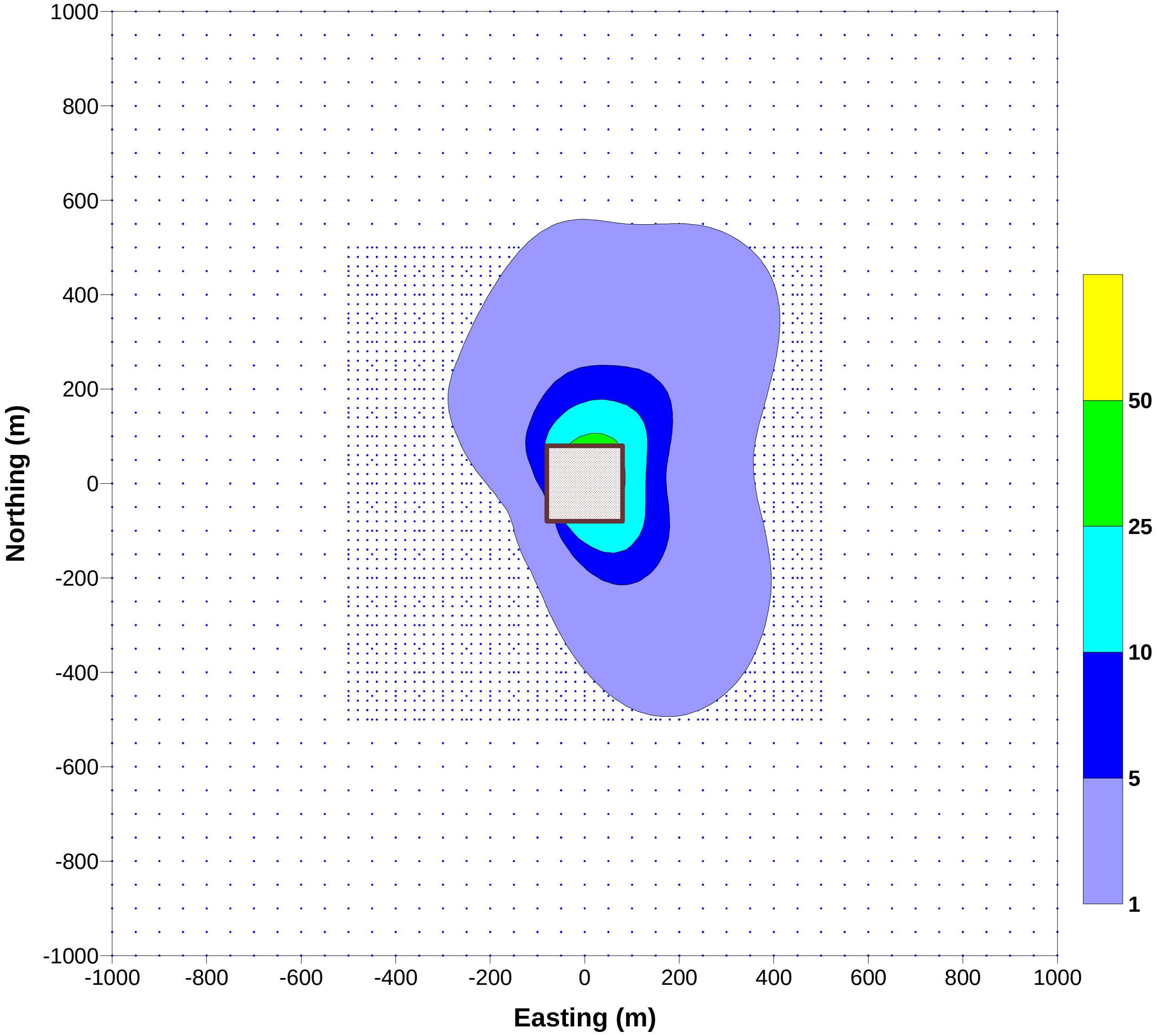


Figure 8: Estimated Cancer Risk from Construction Activity with Tier-0 EFs and Release Height of 10 m using Sacramento Meteorological Data (Urban Dispersion Coefficient, 80th Percentile Breathing Rate, Adults 9-Year Exposure)



The risks at the PMIs and the areas affected by risk range of greater than 10 per million are summarized in Table 5 for all scenarios.

Table 5: Summary of Affected Areas by Risk > 10 and PMIs at 20m from the Fence

Case	Scenario	Risk > 10 (acres)	Risk at PMI (per million)
1	Mixed-EF -West L. A. Met Data (H = 5)	17	97
2	Mixed-EF -West L. A. Met Data (H = 10)	17	77
3	Tier-0 EF – West L. A. Met Data (H = 5)	26	134
4	Tier-0 EF – West L. A. Met Data (H = 10)	26	102
5	Mixed EF – Sac Met Data (H = 5)	6	30
6	Mixed EF – Sac Met Data (H = 10)	6	25
7	Tier-0 EF – Sac Met Data (H = 5)	11	50
8	Tier-0 EF – Sac Met Data (H = 10)	11	36

G. Emission Factors

As expected, higher emission factors result in higher emissions, which exert higher impacts over a larger nearby community area and produce higher maximum impacts. From Table 5, we can easily see that scenario 3 (i.e., tier-zero EF with the release height of 5 m and West L.A. meteorological data) exerts the greatest impacts on the nearby community. As the emission decreases, the impact diminishes. As a general finding, the same amount of emission results in less impact in Northern California than in Southern California.

1. Meteorological Data

As expected, the West L.A. meteorological data produces much higher impacts than the Sacramento meteorological data does (see Table 5). This is because the West L.A. site tends to have the lowest average wind speed and persistent wind directions, which results in less dispersion of pollutants. The Sacramento meteorological data represents typical atmospheric conditions in the Sacramento, or Northern California area where there are usually higher wind speeds than the West L.A. location. The annual average wind speeds for the two sites are 1.53 meters per second (m/s) and 2.93 m/s, respectively.

2. Initial Release Height

The sensitivity study (data not shown here) indicated that the initial release heights (physical height + plume rise) of the emission source plumes range from 5 to 10 meters above the ground depending on the equipment type. We conducted modeling runs using the release heights of 5 and 10 meters to capture the ranges of corresponding risks. From Figure 1 through Figure 8 and Table 5, we can see that there not is a significant impact difference using the two release heights for the same emission and meteorological conditions. Nevertheless, the shorter release height results in the higher nearby impacts, specially the higher risks at the PMIs.

3. Risks vs. Downwind Distance

To quantitatively estimate how the risk changes with the downwind distance, 16 receptors in the predominated wind directions at distances of 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 400, 800, 1200, 1600, 2400, 3200 meters from the edge of construction site were selected. As shown in Figure 9 and Figure 10, the risks decrease rapidly with the downwind distances.

Figure 9: Risk Change with Downwind Distance from Edge of Construction Site using West L.A. Meteorological Data

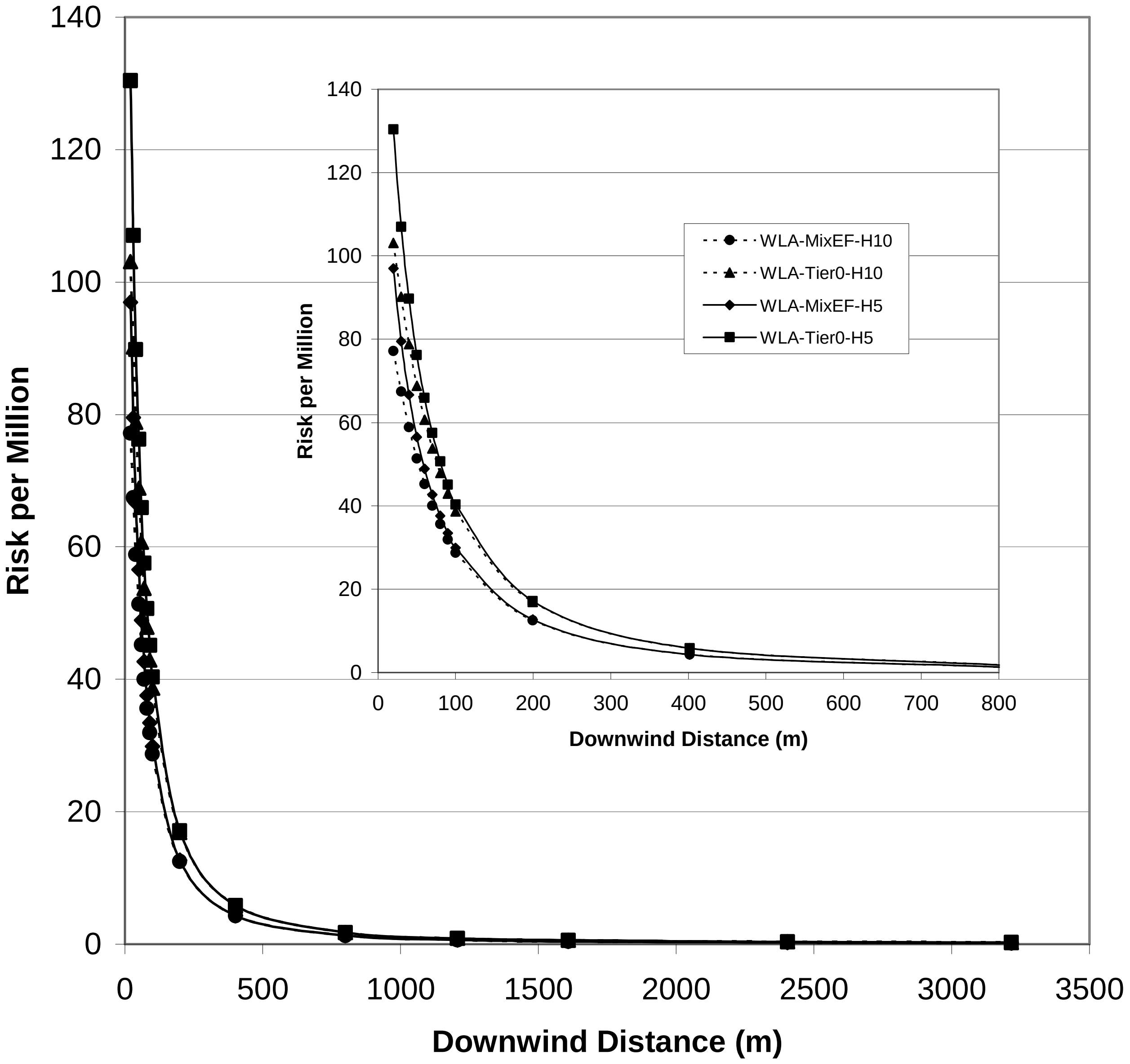
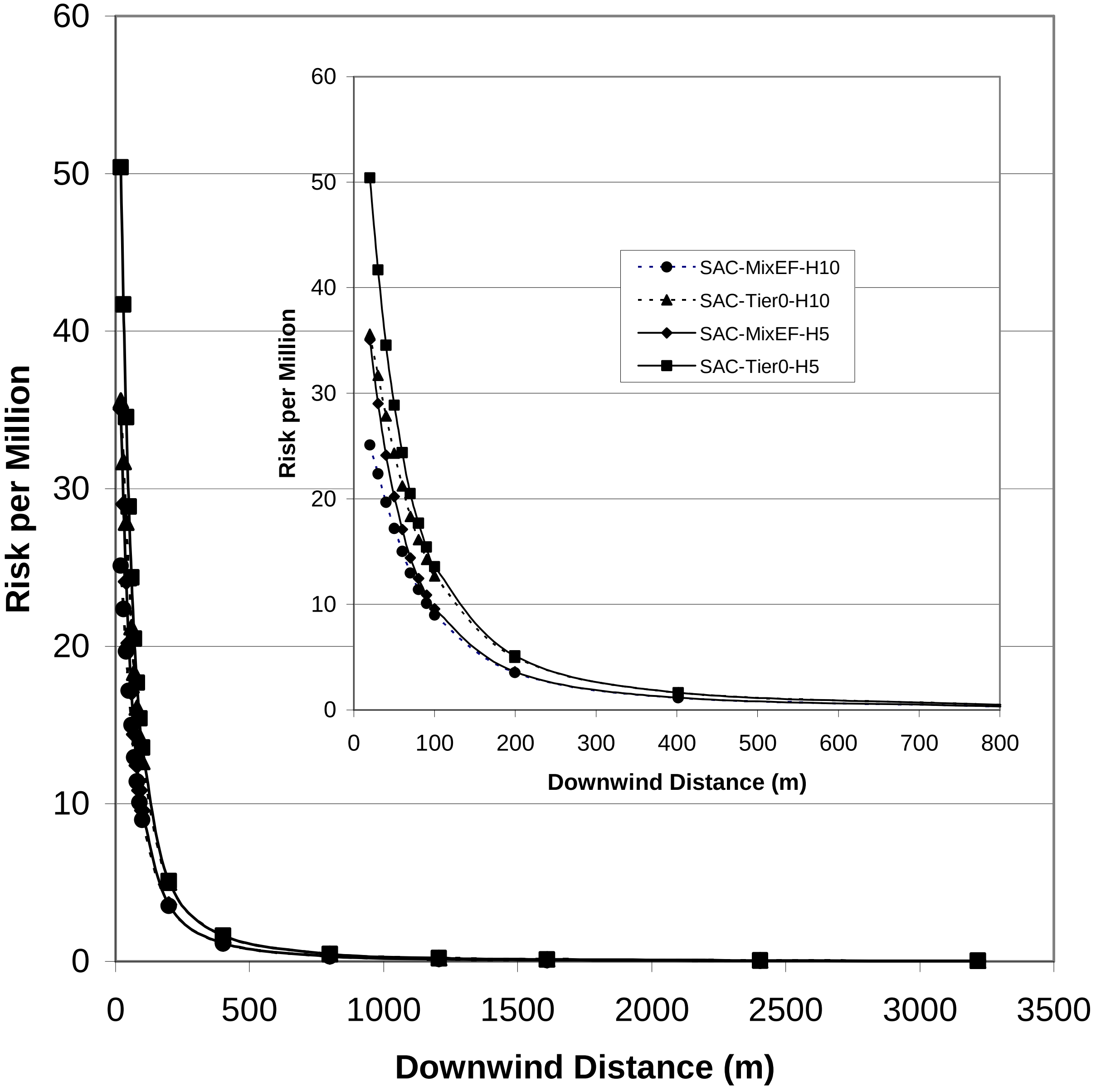


Figure 10: Risk Change with Downwind Distance from Edge of Construction Site using Sacramento Meteorological Data



After certain downwind distances, the changes in the risks with distances become small. Figure 9 and Figure 10 also show that there is a greater slope (indicating a faster decrease in risk with distance) using the Sacramento meteorological data as compared to using the West L.A. meteorological data.

H. REFERENCE

ARB, 2004. *ARB Recommended Interim Risk Management Policy for Inhalation-Based Residential Cancer Risk*. California Air Resources Board 2004.

OEHHA. 2000. *The Air Toxics Hot Spot Program Risk Assessment Guidelines: Part IV-Technical Support Document for Exposure Analysis and Stochastic Analysis*. Office of Environmental Health Hazard Assessment, 2000.

OEHHA. 2003a. *Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments*. Office of Environmental Health Hazard Assessment, 2003.

OEHHA. 2003b. *The Air Toxics Hot Spot Program Risk Assessment Guidelines: Part II-Technical Support Document for Describing Available Cancer Potency Factors*. Office of Environmental Health Hazard Assessment, 2003.