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Estimated Air Quality Impacts on Surrounding Communities of PM2.5 and SO_2 Emissions Resulting From Maritime Operations at the Elizabeth Port Authority Marine Terminal and Port Newark: Phase 2 Future Impacts (2015)

EXECUTIVE SUMMARY

In order to better understand the potential impact that diesel emissions resulting from maritime operations at the Elizabeth Port Authority Marine Terminal and Port Newark may have on local and regional air quality, as well as on local residents, NJDEP undertook a three phase risk modeling analysis.

- Phase 1 (the baseline scenario) evaluated emissions from diesel engines operating in and around the port property and predicted that emissions from port activities did not cause a violation of the annual PM2.5 NAAQS at any modeled location, but they did contribute significantly to an existing violation of the 24-hour standard within the surrounding communities. Of most concern was the incremental cancer risk which predicted 150 in a million increased risk in Bayonne. That report was released on October 9, 2009.
- Phase 1 (the baseline scenario) evaluated emissions from diesel engines operating in and around the port property and predicted that emissions from port activities did not cause a violation of the annual SO2 NAAQS at any modeled location.
- Phase 2 (the future scenario), which is the subject of this report, predicts diesel emissions from port maritime operations in 2015, taking into account the expected growth in goods movement, fleet turnover, federal requirements, and the various emission reduction strategies that the Port Authority and its partners have begun, or committed to, in the Clean Air Strategy for the Port of NY and NJ.
- Phase 3 focuses on the offsite impacts of Port trucks as they move between the Port and the surrounding communities.

BACKGROUND

New Jersey is the most densely populated state in the country and home to major elements of the busiest port on the eastern seaboard. Two of these elements are the marine terminals at Port Newark and the Elizabeth Port Authority Marine Terminal. Moving goods to, from, and through the marine terminals requires a multitude of equipment, almost all powered by diesel engines. These include the ships, harbor craft, trucks, trains, and cargo handling equipment that work on or in the waters around the marine terminal property. Diesel engines emit a variety of pollutants, with diesel particulate matter having the greatest impact. Diesel particulate matter is linked to cancer, asthma, premature death, and other adverse effects, including reduced visibility. Health studies have shown that there is no clear threshold below which adverse effects are not experienced by at least some segments of the population. As the maritime industry grows and as regulations and advancements in technology combine to reduce emissions from power plants, industry, motor vehicles and heating oil, emissions from maritime-related activities may be a bigger portion of the local and regional air pollution problem in the future, unless regulations, advancement in technology and voluntary efforts continue to reduce port emissions.

METHODOLOGY

In order to better understand the potential impact that port-related emissions may have on local and regional air quality, as well as on local residents, NJDEP undertook a three phase risk modeling analysis. In Phase 1 of this modeling analysis NJDEP extracted data from the Port Authority of New York and New Jersey, Port Commerce Department 2006 Baseline Multi-facility Emissions Inventory on the emissions of fine particulate matter and sulfur dioxide from diesel engines operating in an area encompassing Port Newark and the Elizabeth Port Authority Marine Terminals and the adjacent harbor waters. The purpose was to establish the baseline conditions or pollutant "loading" from which future emission projections were to be compared.

In Phase 2 these emissions were then "grown" by using the Port Authority's container projections (in the form of 20 ft. equivalent units, or TEUs) for 2015. In addition, NJDEP used USEPA's MOBILE 6.2 model and NONROAD model to predict fleet turnover and corresponding emission rates, and then applied reductions from strategies in the Clean Air Strategy for the Marine terminals of NY and NJ. These data formed key inputs for the AERMOD Dispersion Model, and NJDEP predicted the concentrations of these pollutants at various locations, including Bayonne, Newark, Elizabeth, Staten Island and Jersey City.

The predicted concentrations were compared to NJDEP's "Significant Impact Levels" which help gauge whether the impact from an emissions source (such as the marine terminals) may significantly affect air quality on a long-term basis (annual significant impact level) or on a short-term basis (24-hour significant impact level).

The predicted concentrations from the activities at the marine terminals were then added to "background" concentrations monitored in the area. Background concentrations are quantities of pollutants measured at monitors located throughout the state and reflect the emissions from motor vehicles, power plants, industrial sources, the marine terminals and pollution from nearby states. To make the modeling as accurate as possible, emissions from the marine terminals were deducted from the "background" concentrations before determining whether ambient air quality standards had been exceeded. The combination of the port-specific emissions and the background concentrations was then compared with the USEPA's National Ambient Air Quality Standards (NAAQS).

Phase 3 of the project will specifically model emissions from trucks traveling on local roads between the marine terminals and the surrounding communities and will be discussed in a separate report.

HEALTH RISK ASSESSMENT

NJDEP then performed a health risk assessment to evaluate the potential for the predicted concentrations of diesel particulate matter to cause cancer and other adverse health effects. Health scientists use risk assessments to estimate the increased risk of health problems in people who are exposed to different amounts of toxic air pollutants, such as diesel particulate matter. Health risk assessments generally do not gather information or health data on specific individuals, but instead provide estimates of the potential health risk impacts to a hypothetical individual exposed to the predicted off-site concentration over a 70 year period, which tends to result in overestimates of the actual risk. The prediction of cancer risk for diesel particulate matter was taken from values published by the California Air Resources Board. (A more detailed discussion of the cancer risk factor is discussed in Appendix E). Using the US EPA Integrated Risk Information System (IRIS), NJDEP also predicted whether the estimated concentrations of diesel particulates from the marine terminals could be continuously inhaled over a lifetime without an appreciable risk of adverse non-cancerous health effects.

RESULTS

The modeling predicts that:

- Diesel exhaust non-cancer risk: The predicted concentrations of diesel particulate are below the levels that would cause non-cancerous health effects based on IRIS in both the Phase 1 baseline and the Phase 2 future scenario.
- Diesel exhaust cancer risk: The predicted cancer risk in surrounding residences decreases between the Phase 1 baseline and Phase 2 future years by an average of nearly 40 in a million but is still between 10 and 100 in a million which is high enough to justify long term efforts to further reduce cancer risk.
- PM 2.5 NAAQS: Emissions from marine terminal activities do not cause a violation of the annual PM2.5 NAAQS at any modeled location in either the Phase 1 baseline or the Phase 2 future scenario.
- Emissions from marine terminal activities are below New Jersey's significant impact levels (SIL's) for annual PM2.5 in all the surrounding communities in both the Phase 1 and Phase 2 scenarios.
- Emissions from port marine terminal activities did contribute to a violation of the 24-hour PM2.5 NAAQS in the Phase 1 baseline but no violation was modeled in the Phase 2 future scenario.
- Emissions from marine terminal activities were above New Jersey's significant impact levels (SIL's) for 24-hour PM2.5 in some surrounding communities in the Phase 1 baseline but not in the Phase 2 future case.
- SO_2 NAAQS: Marine terminal-related SO_2 emissions do not violate the annual, 24 hour or 1 hour NAAQS in either the Phase 1 baseline or Phase 2 future case. However, they did exceed the annual and 24-hour SIL in most of the surrounding communities in the Phase 1 baseline. No exceedances were predicted in the Phase 2 future case.

NJDEP also individually analyzed the various categories of diesel goods movement equipment (i.e., trucks, ships, locomotives, and cargo handling equipment). This is referred to later as culpability analyses and found that:

- There is no one source category primarily responsible for the risks identified in nearby residential areas: each of the main emission sources has some contribution.
- Emissions from cargo-handling equipment (CHE) and trucks at the marine terminals, resulting in a cancer risk of between 0 and 10 in a million at most locations, posed negligible risk to off-site areas including those currently used for residential purposes. In the Phase 1 baseline year, the maximum predicted cancer risks were in the 100 to 1000 in a million range for CHE and 10 to 100 in a million for trucks (see Table 1). In off-site residential areas, the Phase 1 baseline year maximum predicted cancer risks were in the 10 to 100 in a million range.
- Emissions from oceangoing vessels result in an order of magnitude or more lowering of cancer risk from between 100-1000 in a million in the Phase 1 baseline to 10-100 in a million in the Phase 2 future scenario, but this still warrants long term efforts to further reduce cancer risk.
- Emissions from tugboats remain very similar in the Phase 2 future year because the Port Authority has not yet calculated emission benefits for most of the tugboat specific strategies in the Clean Air Strategy Plan. Therefore, the cancer risk remains in the 100 to 1000 in a million category and NJDEP guidelines recommend short term efforts to reduce it.
- Emissions from locomotives increased in the Phase 2 future year, due to projected increases in goods movement, but the cancer risk remains in the 10 to 100 in a million category. The predicted impacts do not extend much beyond the marine terminal's property.

Table 1: Comparison of maximum off-site predicted cancer risks between Phase 1 and Phase 2

Emission source category	**Phase 1**	**Phase 2**
Ocean-going vessels	100 to 1000 in a million	10 to 100 in a million
Tugboats	100 to 1000 in a million	100 to 1000 in a million
Cargo-handling equipment	100 to 1000 in a million	0 to 10 in a million
Locomotives	10 to 100 in a million	10 to 100 in a million
Trucks	10 to 100 in a million	0 to 10 in a million

MONITORING

In addition to implementing strategies to reduce diesel emissions, it may be useful to undertake a local ambient air monitoring study. Ambient air monitoring requires a long-term investment of resources and the results will not be definitive in pinpointing exact sources of diesel emissions, in part because there is no direct way to distinguish diesel exhaust from other particles in the ambient air.

INTRODUCTION

I. Background

This memo describes the modeling of the estimated future emissions for 2015 and the predicted impacts of fine particulates (PM2.5) and SO_2 from operations at the roughly 2300 acres of marine terminals at the Elizabeth Port Authority Marine Terminal and Port Newark. This report incorporates the comments of all stakeholders involved.

II. Modeling Methodology and Assumptions:

Dispersion Model - AERMOD Version (09292).

Meteorological Data/Land Use – The same meteorological and land use data was used in the modeling of future conditions as was used in the baseline, and is as follows. The nearest meteorological site is less than one mile away at Newark International Airport. The most reliable measurements available are from 1991-1995. It is NJDEP policy to use worst-case annual meteorological conditions from a five year period to provide conservative estimates of air quality impacts. NJDEP re-ran the model using recently available meteorological data from 2005-2009 and found small increases in concentrations, but these increases did not warrant re-running all of the results. Therefore, the year with the highest predicted concentrations is used to define the source impact. Impacts from an average meteorological year would be less. The meteorological data from the airport site includes hourly wind direction, wind speed, and atmospheric temperature. Upper air data from Atlantic City and Brookhaven was also used. For the AERMOD air quality model, urban dispersion coefficients are used because the area at the impacted receptors is comprised of industrial, commercial and compact residential land uses.

Emissions. In Phase 1 NJDEP extracted data from the Port Authority of New York and New Jersey, Port Commerce Department 2006 Baseline Multi-facility Emissions Inventory on the emissions of fine particulate matter and sulfur dioxide from diesel engines operating in and around the marine terminals. The inventory uses an activity-based approach and focuses on emissions of criteria air pollutants, diesel particulate matter and greenhouse gases for all marine terminal-related sources. NJDEP separated out from the Starcrest inventory those diesel particulate and sulfur dioxide emissions related to Port Newark and the Elizabeth Port Authority Marine Terminal and used them as the basis for the air quality modeling. In addition to these on-terminal activities, emissions from trucks transporting marine terminal cargo on nearby roads between the marine terminals and the N.J. Turnpike were estimated by NJDEP.

For the future case the emissions were "grown" to 2015 by assuming a growth factor that was determined using the Port Authority's actual container moves (TEUs) from 2006 and the Port Authority's projected TEU's in 2015 (see Table 2), which is a 7% growth rate over the 9 year period. This growth rate was then applied to the Starcrest formulas or "method" of calculating emissions (number of truck calls X miles driven and number of truck calls X idling time) from the Port Authority of New York and New Jersey, Port Commerce Department 2006 Baseline Multi-facility Emissions Inventory. Currently, the Port Authority is projecting annual growth in TEUs at 3.6%. Any projected growth rate involves uncertainty and assumptions need to be made to calculate emissions for the purpose of this modeling exercise.

Because the greater majority of containers (70%) are transported from Port Newark and the Elizabeth Port Authority Marine Terminal, NJDEP assumed that the total TEUS projected and estimated for all PANYNJ container terminals can be readily applied to determine a growth rate for nonroad cargo-handling equipment and HDDV (heavy duty diesel vehicle) and CMV (commercial marine vessel) transportation of TEUs just at these two terminals. The emissions were calculated using USEPA's MOBILE6.2 emissions model and USEPA's NONROAD model. These models also account for fleet turnover following the particular age distribution used.

Table 2: Projection of Port Authority Cargo by TEU of Source Categories in 2015 compared to 2006

Source Category	2006	2015
1) HDDV	4,407,000	4,717,500
2) Rail Locomotive	250,000	832,500
3) CHE	4,657,000	5,550,000
4) OGV	4,657,000	5,550,000

Emission Reduction Strategies: The emissions used in the modeling also took into account the Clean Air Strategy for the Port of NY and NJ (http://www.panynj.gov/about/pdf/CAS-FINAL.pdf). The Clean Air Strategy for the Port of NY and NJ was developed during 2008 and 2009, with input from a diverse set of stakeholders. The purpose of CASP is to define a commitment by the Port Authority of New York and New Jersey (Port Authority) and its Strategy Group Partners to ensure that air emissions generated by mobile sources associated with marine terminal operations and activities decline even with anticipated future maritime transportation growth over the next ten years. The goal of the Clean Air Strategy for the Port of NY and NJ is to achieve a minimum 30% net reduction of criteria pollutants (including $PM_{2.5}$) and 50% net reduction of greenhouse gases over 10 years, after accounting for emission increases resulting from increases in goods movement. On March 10, 2010 NJDEP, and other Strategy Group partners on the Clean Air Strategy Plan Steering Committee, signed a "Joint Statement of Intent to Support Port Sustainability for the New York-New Jersey Metropolitan Area." The agreement memorializes the shared commitment to work collaboratively to reduce emissions from the maritime operations of the Port of NY and NJ.

NJDEP consequently used information from pages 15-28 of the Clean Air Strategy for the Port of NY and NJ to calculate the emission benefits of strategies that the Port Authority and its Strategy Group Partners has committed to implement. Specifically, we included "Implemented Actions" that were not in place at the time of the 2006 baseline inventory as well as "Committed Actions" for which the Port Authority had provided corresponding emissions benefit calculations. The benefits were then extrapolated for the Elizabeth Port Authority Marine Terminal and Port Newark. These strategies and expected reductions are listed in Appendix D.

PM2.5 The following assumptions made for the Phase 1 baseline were followed for the Phase 2 future modeling except as noted.

- Emissions from all marine terminal operations are included [ocean-going vessels (OGV), locomotives, cargo handling equipment (CHE) and marine terminal-related truck traffic only] (see Table 3);
- Dwelling, transit and boiler emissions from ocean going vessels are included. Transit emissions are the engine emissions occurring while the ocean going vessels destined for berths at Port Newark and the Elizabeth Port Authority Marine Terminal travel from the Lower New York Bay through the Newark Bay to dock at the marine terminals.
- 365 days/year activity was assumed for all emission sources, except for truck-related activity, which operated on 250 days per year; Operating hours per year are taken from the 2006 inventory (e.g., Table 2:12, p.50). These hours were equally divided up into 365 days, since any piece of equipment could potentially be used on any day. Marine terminal-related truck emissions are restricted to the opening times of the port gates (i.e., 6am-6pm - obtained from terminal operators). Idling truck emissions are confined to the same period. Marine terminal-related truck activity is restricted to 250 days/year, which correlates to the number of days/year the marine terminals are open.
- In the Phase 1 baseline, the age distribution of the trucks was based on USEPA's Mobile 6.2 defaults according to the Port Authority's 2006 inventory. In the Phase 2 future scenario, the age distribution was based on the Port Authority's 2008 Drayage Truck Characterization Survey. See Appendix A for a comparison.
- The emission rates for each sector were lower for the Phase 2 future scenario because of fleet turnover and/or federal fuel requirements and emission reduction measures taken by the Port Authority and its Strategy Group Partners (see Appendix D for details). Despite this, however, the total emissions rate for locomotives increased in Phase 2 due to growth projections in that sector.
- All ship, locomotive, cargo handling, and truck diesel particulate emissions used in this modeling effort are assumed to be PM-2.5.

SO_2 For the SO2 emissions below, the same assumptions used in the Phase 1 baseline scenario were followed except that the sulfur content of fuel was lower in this Phase 2 future scenario.

- The days of operation per year assumed were the same as for PM2.5. Operating hours per year were also the same as assumed for PM2.5. These hours were equally divided up into 365 days, since any piece of equipment could potentially be used on any day.
- Sulfur content of diesel fuel for ocean-going vessels is assumed to be 0.1% as required by MARPOL Annex VI Emission Control Area designations. Sulfur content of fuel for tugboats and locomotives is assumed to be 0.015% as required by USEPA's 2004 Nonroad Locomotive and Marine Vessel Rule.
- No secondary formation of particulates (sulfates) from sulfur dioxide emissions is considered in this modeling evaluation, which focuses on local effects rather than longer range transport of air pollution.

Table 3: Projected PM2.5 and SO2 Emissions for 2015 Including the Effect of Clean Air Strategy for the Port of NY and NJ Benefits When Compared to 2006

Operation	2006	2015	2006	2015	Additional CASP reductions in 2015[1]		Final emissions modeled in 2015	
	PM2.5 (tpy)	PM2.5 (tpy)	SO_2 (tpy)	SO_2 (tpy)	PM2.5 (tpy)	SO_2 (tpy)	PM2.5 (tpy)	SO_2 (tpy)
Cargo Handling Equipment	74.3	24.3	194	0.7	16.5	--	7.8	0.7
Ocean-going Vessels (OGV-Dwelling)	49.7	14.6	648.2	120.5	-	--	14.6	120.5[1]
Ocean-going Vessels (OGV-Transit)	65.7	19.3	608.6	113.2	2.2	--	17.1	113.2[1]
Ocean-going Vessels (OGV-Boilers)	25.6	7.5	663.0	123.3	-	--	7.5[3]	123.3[1]
Ocean-going Vessels (OGV-Tugboats)	10.4	9.1	21.5	0.6	--	--	9.1	0.6[1]
Locomotives	4.2	8.5	11.8	0.8	2.1	--	6.4	0.8[1]
Trucks – idling	11.9	7.1	2.9	0.1	5.9	--	1.2	0.1[1]
Trucks – on terminal	1.3	0.5	1.3	0.1	0.4	--	0.1	0.1
Trucks – Port roads	7.8	3.6	4.6	0.3	2.8	--	0.8	0.3

Source characterization – All of the port-related emission sources were characterized in exactly the same manner as they were in the baseline (2006). All of these sources are mobile sources and are characterized as area sources, except for ocean-going vessels dwelling at berth ("hotelling"), which represent point sources as they do not move. Model parameters for area sources include emission rate, release height, lengths of X and Y sides of rectangular areas or vertices for polygons, and the initial vertical (σ_{zo}) dimensions of the area source plume. Model parameters for point sources include estimates of emission rate, stack height, stack diameter, stack exhaust temperature, and stack exhaust exit velocity.

The OGV transit emissions are simulated as area sources using values from Tables 5.5 and 5.9 of the Starcrest inventory, which apportion emissions by county. A 1000ft (305m) shipping lane[2]

[1] NJDEP has not received SO2 calculations from Port Authority for the CASP strategies.
[2] Transportation Safety Board, Office of Marine Safety, http://www.ntsb.gov/publictn/2007/MAB0702.pdf, p5
[3] Boiler emissions were calculated assuming residual fuel oil with 30,444 ppm sulfur in 2006 and distillate fuel oil with 1,000 ppm sulfur in 2015

was assumed from the Lower New York Bay, through the Narrows and Kill van Kull, to Newark Bay. The dwelling emissions from ship auxiliary engines are simulated as individual point sources at the berths together with emissions from the ships' boilers. Because stack information was not available for individual engines, the average stack height (43 meters) obtained from the Port of Los Angeles Starcrest[3] inventory report was applied to all dwelling engines. The modeling parameters for each of the emission source categories are summarized in Table 4.

Commercial harborcraft (tugboat) emissions are generated in a similar fashion to the OGVs. The links are identical to those of OGVs, except that they only extend from the marine terminals to the Anchorage channel (between The Narrows and Upper New York Bay). Cargo handling equipment (CHE) emissions are simulated as area sources with the polygon features of the dispersion model.[4]

Table 4: Emission Source Model Parameters

Model parameter	**OGVs**	**Tugboats**	**CHE**	**Rail**	**Truck**	**OGV Dwelling**	**Wharf Cranes**
Release height (m)	50	6	2.1-11.5	5	3.7	Ht=43m Temp=618K Vel=16m/s Diam=0.5m	Ht= 38m Temp=644K Vel=20m/s Diam=0.1m
Shipping lane width (m)	305	305	-	-	-		
σ_{zo} (m)	7 (transit)	2.7	0.3-1.8	2.6	1.8		

Locomotive emissions for idling and line haul are simulated as area sources. The links were estimated by NJDEP staff and extended from Bay Avenue 3000m north to Port Street. The line haul link width is estimated to be 20m.

The on-terminal and off-terminal heavy-duty truck traffic is simulated as area sources; the link width is assumed to be 18m (two lanes in each direction – no allowance for wake width was made due to their slow traveling speeds). The nearby off-terminal truck emissions are represented as line sources along the marine terminal approach roads.

Starcrest provided the annual operating hours for the cargo handling equipment and locomotives. NJDEP staff temporally allocated all the emission sources at both marine terminals based on discussions with terminal operators. The assumptions for the temporal distribution of the emissions are listed in Table 5; further details are provided in Appendices B and C.

<u>Number of trucks</u> – Approximately 2.9 million visits per year were used in the modeling (11,960 trucks per operating day)[5]. The idle time used for each truck was 1.4 hours per day at the marine

[3] Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, ARB, 2006
[4] Emission release heights for CHE were not measured, but estimated during a DEP site visit
[5] Starcrest Consulting Group LLC, 2006 Baseline Multi-Facility Emissions Inventory, 2008, p85

terminals[6]. Emissions are also included from the trucks traveling on nearby roadways from the marine terminals to the two closest intersections with the New Jersey Turnpike (a total of 5.9 miles combined). Predicted impacts from marine terminal trucks travelling through the surrounding communities are presented in the Phase 3 report. Note: Some uncertainty remains regarding the accounting of on-terminal truck moves.

Background

PM-2.5 Monitor – The 98th percentile 24-hour concentration and annual PM2.5 background values are based on the average values measured at the Elizabeth Lab. monitor from 2008-2010. The monitor is located approximately three miles southwest of the marine terminal. By adding the 98th percentile background 24-hour concentration to the modeled impact we have adopted a more conservative approach since it assumes that this relatively high value occurred on the same day (in the worst case year) as the modeled impact.

Table 5: Temporal distribution of Diesel PM2.5 emissions at the Elizabeth Port Authority Marine Terminal/Port Newark

Category	Time Period	Hours Per Day	Days Per Year
Ocean-going vessel (OGV) Transit	Midnight – midnight	24	365
OGV Dwelling	Midnight – midnight	24	365
OGV - Tugboats	Midnight – midnight	24	365
Cargo handling Equipment	6am – 9am/6pm	3-12	365
Trucks	6am – 6pm	12	250
Locomotives	6am – 8pm	14	365

SO_2 Monitor – The 1-hour, 24-hour and annual SO_2 background values were also based on values measured at the Elizabeth Lab. monitor (2008-2010).

Receptors – Two receptor networks were used, both Cartesian grids. The inner receptor grid covers an area approximately 5 ½ x 5 ½ miles centered on the port and includes residences to the east in Bayonne, and residences to the south in Elizabeth (Figure 1). The regional grid (29 x 38 points) had a 2000m resolution, whereas the inner network (19 x 22 points) had a 500m resolution. Discrete receptors were also placed in Bayonne along the boundary with Newark Bay.

6 Starcrest Consulting Group LLC, 2006 Baseline Multi-Facility Emissions Inventory, 2008, p85

III. Future Impacts of the Marine Terminal's Diesel Emissions on Nearby Air Quality - Fine Particulate Model Predictions – PM-2.5 National Ambient Air Quality Standards (NAAQS)

The predicted concentrations for 2015 due to diesel emissions were compared to the PM-2.5 National Ambient Air Quality Standards (NAAQS). In Table 6, the maximum predicted annual PM-2.5 concentrations combined with representative PM-2.5 background levels (Elizabeth Lab) were compared to the existing PM-2.5 NAAQS.

Table 6 shows that the region's annual background levels are well below the annual NAAQS. The impact due to marine terminals emissions, when added to the monitored background levels, does not exceed the annual NAAQS. The impact of the marine terminal activities on residential areas is greatest in the western portion of the City of Bayonne but even here emissions from marine terminal activities do not exceed New Jersey's annual significant impact levels (SILs) for PM2.5. Impacts on other residential areas are even lower. Figure 2 shows the spatial distribution of the maximum annual PM-2.5 concentrations for both 2006 and 2015.

Table 7 shows the predicted eighth-high 24-hour concentrations with associated background levels compared to the existingPM-2.5 NAAQS. The eighth high modeled 24-hour concentration represents the 98th percentile concentration for that year. The 24-hour background levels at the monitor nearest to the marine terminal are well below the NAAQS.

Table 6: Maximum Predicted Annual PM2.5 Impacts for 2006 and 2015 near the Port of Newark and the Elizabeth Port Authority Marine Terminal due to Ship, Cargo Handling Equipment, Truck and Locomotive Emissions at the Marine Terminals

Location	2006 Maximum Predicted Impact of Port (µg/m^3)	2015 Maximum Predicted Impact of Port[a] (µg/m^3)	Significant Impact Level[b] (SIL) (µg/m^3)	Background Air Quality (µg/m^3)[c,d]	Total Concentration for 2015 (µg/m^3)	NAAQS (µg/m^3)
Bayonne	0.69	0.25	0.3	11.6	11.9	15.0
Elizabeth	0.22	0.03	0.3	11.6	11.6	15.0
Newark	0.10	0.04	0.3	11.6	11.6	15.0
Staten I.	0.34	0.15	0.3	11.6	11.8	15.0
Elizabeth Lab. Monitor	0.08	0.02	0.3	11.6	11.6	15.0
Jersey City	0.43	0.13	0.3	11.6	11.7	15.0

[a]NJDEP received comments regarding the age distribution used for the Port trucks. A separate model run was conducted assuming an older truck fleet (see Appendix A). This resulted in larger on-site impacts and a 0.04µg/m^3 increase at sensitive receptors across Newark Bay in Bayonne.
[b]The SIL is considered a de minimis pollutant impact. The PM-2.5 SILs were promulgated by USEPA in 2010 The PM-2.5 SILs represent approximately 2% of annual PM-2.5 NAAQS and 3% of the 24-hour PM-2.5 NAAQS.
[c]Average annual concentration measured at Elizabeth Lab from 2008 to 2010
[d]The 0.02 µg/m^3 is subtracted from the Elizabeth Lab. monitored value to avoid double counting the marine terminal's contribution.

Table 6: Maximum Predicted Annual PM2.5 Impacts for 2006 and 2015 near the Port of Newark and the Elizabeth Port Authority Marine Terminal due to Ship, Cargo Handling Equipment, Truck and Locomotive Emissions at the Marine Terminals

Location	2006 Maximum Predicted Impact of Port (µg/m^3)	2015 Maximum Predicted Impact of Port[a] (µg/m^3)	Significant Impact Level[b] (SIL) (µg/m^3)	Background Air Quality (µg/m^3)[c,d]	Total Concentration for 2015 (µg/m^3)	NAAQS (µg/m^3)
Bayonne	0.69	0.25	0.3	11.6	10.9	15.0
Elizabeth	0.22	0.03	0.3	11.6	10.3	15.0
Newark	0.10	0.04	0.3	11.6	10.6	15.0
Staten I.	0.34	0.15	0.3	11.6	10.4	15.0
Elizabeth Lab. Monitor	0.08	0.02	0.3	11.6	11.6	15.0
Jersey City	0.43	0.13	0.3	11.6	10.7	15.0

[a]NJDEP received comments regarding the age distribution used for the Port trucks, therefore a separate model run was conducted assuming an older truck fleet. See Appendix A for model year comparison. This resulted in larger on-site impacts and a 0.04µg/m^3 increase at sensitive receptors across Newark Bay in Bayonne.
[b]The PM 2.5 SIL was promulgated by USEPA in 2010. The PM-2.5 SILs represent approximately 2% of annual PM-2.5 NAAQS and 3% of the 24-hour PM-2.5 NAAQS.
[c]Average annual concentration measured at Elizabeth Lab from 2008 to 2010
[d]The 0.02 µg/m^3 is subtracted from the Elizabeth Lab. monitored value to avoid double counting the marine terminal's contribution.

There were no exceedances of the 24 hour SIL. Figure 3 shows the spatial distribution of the maximum eighth-high 24-hour PM-2.5 concentrations for both the baseline and future years. The marine terminals do not cause an exceedance of the 24 hour NAAQS.

Table 7: Maximum Predicted 24-Hour PM2.5 Impacts for 2006 and 2015 near the Port of Newark and the Elizabeth Port Authority Marine Terminal due to Ship, Cargo Handling Equipment, Truck and Locomotive Emissions

Location	2006 Maximum Predicted Impact of Port (µg/m^3)	2015 Maximum Predicted Impact of Port (µg/m^3)	SIL (µg/m^3)	Background Air Quality (µg/m^3)[a,b]	Total Concentration for 2015 (µg/m^3)	NAAQS (µg/m^3)
Bayonne	2.8	0.6	1.2	29.9	29.6	35.0
Elizabeth	1.4	0.2	1.2	29.9	27.5	35.0
Elizabeth Lab.	0.5	0.1	1.2	29.9	30.0	35.0

Monitor						
Newark	0.6	0.3	1.2	29.9	29.3	35.0
Staten Is.	2.2	0.5	1.2	29.9	27.8	35.0
Jersey City	1.6	0.4	1.2	29.9	29.4	35.0

[a]Average annual concentration measured at Elizabeth Lab. from 2008 to 2010.
[b]The 0.1 $\mu g/m^3$ is subtracted from the Elizabeth Lab. monitored value due to the Port's contribution.

NJDEP Risk Management Procedures for Facility-Wide Risk from Existing Sources[7]

Risk management guidelines are designed to interpret the results of risk assessments and determine which risks are generally considered high. The NJDEP has used risk management for about 20 years to make decisions about whether or not to issue a permit, based on risk, and to determine conditions that should be included in a permit, on a case-by-case basis, to minimize risk. More recently, NJDEP has used risk management as a tool to identify strategies to reduce risk from concentrated sources of diesel emissions from mobile sources, such as train yards, truck terminals, and with this evaluation, the mobile sources operating at or near the marine terminals at Port Newark and the Elizabeth Port Authority Marine Terminal. NJDEP uses the following risk management guidelines for facility-wide risk:

- Cancer risk greater than 1000 in a million – unacceptable risk. Take immediate action to reduce risk; pursue enforcement action for existing facilities.
- Cancer risk greater than 100 in a million but less than 1000 in a million - implement short-term risk minimization strategy.
- Cancer risk greater than 10 in a million but less than 100 in a million greater than 10 in a million - implement long-term risk minimization strategy.
- Cancer risk less than 10 in a million – negligible risk; a formal risk minimization strategy is not required but continue efforts to minimize risk.

Note: For individual, new and modified equipment, the NJDEP considers a risk of greater than 1 in a million to be significant, justifying risk minimization, and a risk greater than 100 in a million to be unacceptable.

Model Predictions – Carcinogenic and Non-Carcinogenic Health Effects

Table 8 lists the predicted incremental cancer risk due to the estimated emissions from ships, cargo handling equipment, locomotives and trucks. (It should be noted that emissions from the ship boilers are composed of non-diesel particulate matter, and are therefore not included in cancer risk.) The cancer risk values for all diesel emission sources range from about 6 in a million at the residential area in Elizabeth to the southwest to 69 in a million in the residential area in Bayonne to the east (see Figure 4) (in the baseline scenario the range was 30 to 150 in a million). While some of these areas are not currently used for residential purposes, Figure 4 can also be used as a general tool to show areas of potential cancer risk outside the boundary of the Port Newark and Elizabeth Port Authority Marine Terminal. According to NJDEP's Risk

[7] "Guidance on Risk Assessment for Air Contaminant Emissions, Technical Manual 1003," NJDEP, 2009 which provides information for carrying out a risk assessment in conjunction with applying for an air pollution control permit from a stationary source, http://www.state.nj.us/dep/aqpp/downloads/techman/1003.pdf.

Management Guidelines for the Air Quality Program, risks between 10-100 in a million justify pursuing long-term efforts to further reduce cancer risk from sources at the marine terminals. The incremental cancer risks predicted at residences in Bayonne, Newark, Jersey City and Staten Island fall into this category. When compared to the cancer risks predicted from baseline emissions, Figure 4 indicates that the area of risk in the 10 to 100 in a million category has shrunk but is still an area of concern. The incremental cancer risk is an estimate that assumes a lifetime exposure and uses a unit risk factor, which estimates the carcinogenic potency of a chemical. The unit risk factor incorporates conservative assumptions to account for uncertainty, as described in the following sections and discussed in greater depth in Appendix E.

Table 8: Predicted Incremental Cancer Risk at Residential Locations attributed to Diesel Particulate Emissions from OGV, Cargo Handling Equipment, Trucks and Locomotives Operating At or Near Port Newark and Elizabeth

Receptor	Diesel Annual Maximum Impact ($\mu g/m^3$) (2006)	Diesel Annual Maximum Impact ($\mu g/m^3$) (2015)	Diesel Unit Risk Factor [a] $(\mu g/m^3)^{-1}$	Incremental Cancer Risk [b] (2006)	Incremental Cancer Risk [b] (2015)
Bayonne	0.50	0.23	3 E-04	150	69
Elizabeth	0.14	0.02	3 E-04	42	6
Newark	0.10	0.03	3 E-04	30	9
Staten Island	0.21	0.14	3 E-04	63	42
Jersey City	0.26	0.12	3 E-04	78	36

a. Unit risk factor from California EPA (2002)
b. Assumes 70 year inhalation exposure; 69= 69 in a million risk

What are the uncertainties associated with the predicted risk?

The estimates provided by risk assessments are not exact. They help scientists and the public evaluate and place into perspective the risks associated with emissions of toxic air pollutants. Due to uncertainties in each of the variables that go into a health risk assessment, there is uncertainty in estimating the risk to a specific individual or at a specific location. Because of the conservative nature of the risk assessment process, these assumptions typically overestimate the risk. The risk estimates provide guidance to agencies and emission sources to inform decisions on where to focus efforts to reduce exposure. Some of the more important uncertainties include the following:

- The predicted incremental cancer risk produced for this report assumes a continual lifetime inhalation exposure to the modeled diesel particulate concentration. This risk is most relevant for residential exposure and sensitive groups or populations, including schools, day care centers and hospitals in neighboring areas. Workers on the site of the emission sources used in this modeling are not exposed to the same levels of marine terminal-related diesel particulate emissions for 24 hours a day for a lifetime. Hence, the onsite risk levels in this report are informational for comparison to offsite risks, but are not directly relevant to the exposure and risk levels for the workers at the marine terminal.

- The cancer risk prediction also assumes that diesel emissions from marine terminal-related activities will remain constant for the next 70 years. Activity is expected to grow but the emissions rate will decline as engines are replaced or rebuilt to cleaner standards and other emission reduction strategies are implemented, such as cleaner fuel and idle reduction.
- USEPA has replaced the mobile source emissions model MOBILE6.2 with MOVES. According to USEPA estimates, this model predicts PM2.5 levels that are 2–4 times higher than the MOBILE6.2 model
- The unit risk factor used in estimating cancer risk is a value published and used by the California Air Resources Board. In order to be protective of public health, NJDEP uses this unit risk factor to estimate risk in the absence of a USEPA published unit risk factor. NJDEP acknowledges that the health studies upon which the number is based have limitations. (See Appendix E for further discussion.)
- The cancer and non-cancer risk predictions only include emissions from marine terminal-related activity in Port Newark and at the Elizabeth Port Authority Marine Terminal. Risk from exposure to background air contaminant levels from other sources is not included, and therefore the cumulative risk is not estimated.
- The model predictions presented here only include diesel emissions from Port Authority-owned terminals in New Jersey; other terminals have not been included. The recently acquired Global Marine Terminal in Bayonne has not been included, although it was purchased by the Port Authority of New York and New Jersey.
- Truck emissions include only idling and transit emissions from trucks while inside the marine terminal gates, and emissions from truck transit along the approach roads to the marine terminals. Truck diesel particulate emissions on the New Jersey Turnpike and most local roads are not included.
- Since the workers on industrial sites such as the marine terminal properties are typically present for about eight hours a day they are therefore exposed to the predicted levels of diesel particulate less than those living in nearby residences.

Culpability Analyses

Figures 9 to 13 present isopleth maps to illustrate the predicted cancer risk based on actual or potential residential exposure resulting from emissions from each source category. These figures are intended to allow the identification and prioritization of emission sources that can be targeted for risk reduction strategies. The maps show that with the ocean-going vessels, cargo-handling and truck emission sources the area of cancer risk is much reduced; the tugboat source remains almost the same because the Port Authority has not yet calculated emission benefits for most of the tugboat specific strategies in the Clean Air Strategy; the locomotive emissions increase between the baseline and future scenarios although these are only a fraction of the total marine terminal contribution. These figures do show that tugboats are primarily responsible for the cancer risks identified in nearby residential areas (Figure 4) although each of the other emission source categories has some contribution. Taken individually, tugboats had higher risk levels off-site justifying short-term risk minimization (100-1000 in a million). While not all of the off-site areas are currently used for residential purposes, the maps are a conservative approach to showing areas of actual and potential cancer risk.

Predicted Hazard Index (non-cancer risk) – The USEPA has an Integrated Risk Information System that provides estimates of the concentrations of specific pollutants that can be continuously inhaled over the duration of a lifetime without an appreciable risk of adverse non-cancerous health effects (referred to as a Reference Concentration). A source's impact divided by the reference concentration is the hazard index. A hazard index below 1 indicates a negligible health risk. The predicted exposure from marine terminal sources alone does not exceed a hazard index of 1 in any of the residential areas of Elizabeth, Bayonne, Newark, Staten Island or Jersey City. This is the same as the Phase 1 baseline modeling. Table 9 lists the predicted annual concentration of diesel particulates emitted from marine terminal operations and the calculated hazard index in these residential areas. Because diesel particulates from other sources in the region are not included in the modeling, no conclusion can be made whether the combined diesel concentration due to all sources exceeds the reference concentration in these neighborhoods.

Table 9: Predicted Hazard Index (non-cancer risk) at Residential Locations due to the Marine Terminals' OGV, Cargo Handling Equipment, Truck and Locomotive Diesel Particulate Emissions

Receptor	Annual Impact of Port ($\mu g/m^3$) (2006)	Annual Impact of Port ($\mu g/m^3$) (2015)	Reference Concentration ($\mu g/m^3$) [a, b]	Hazard Index[c] (2006)	Hazard Index[c] (2015)
Bayonne	0.50	0.23	5.0	0.10	0.05
Elizabeth	0.14	0.02	5.0	0.03	0.004
Newark	0.10	0.03	5.0	0.02	0.01
Staten Island	0.21	0.14	5.0	0.04	0.03
Jersey City	0.26	0.12	5.0	0.05	0.02

a. Estimate of a continuous inhalation exposure for a given duration to the human population that is likely to be without an appreciable risk of adverse non-cancerous health effects (from IRIS)
b. Assumes annual exposure
c. Hazard index below 1 indicates negligible incremental health risk.

IV. Impacts of Diesel Emissions From Operations at Port Newark and the Elizabeth Port Authority Marine Terminal on Nearby Air Quality: Model Predictions – SO_2 NAAQS

The predicted concentrations of SO_2 emissions were compared to the SO_2 NAAQS. In Tables 10, 11 and 12 the respective maximum predicted annual, 24-hour (eighth-high) and 1-hour (fourth-high) SO_2 concentrations combined with representative SO_2 background levels (Elizabeth Lab) are compared to the existing SO_2 NAAQS. The region's background levels are well below the NAAQS. Impacts from the port activities with background are not predicted to cause violations of the NAAQS. Figures 5, 6 and 7 show the spatial distribution of the maximum annual, 24-hour and 1-hour SO_2 concentrations, respectively. These figures dramatically demonstrate the predicted improvement in SO_2 levels across all time periods compared to the Phase 1 baseline.

Table 10: Maximum Predicted Annual SO_2 Impact of Emissions from Operations at Port Newark and the Elizabeth Port Authority Marine Terminal for 2006 and 2015

Location	(2006) Annual Impact ($\mu g/m^3$)	(2015) Annual Impact ($\mu g/m^3$)	SIL ($\mu g/m^3$)	Background Air Quality ($\mu g/m^3$)[a,b] (maximum)	(2015) Total Concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
Bayonne	5.4	0.3	1	7.6	7.9	80
Elizabeth	0.4	0.03	1	7.6	7.6	80
Elizabeth Lab. Monitor	0.9	0.05	1	7.6	7.7	80
Newark	1.1	0.07	1	7.6	7.7	80
Staten Is.	2.1	0.2	1	7.6	7.7	80
Jersey City	3.4	0.3	1	7.6	7.9	80

[a]The 0.05 $\mu g/m^3$ impact due to port activities is not subtracted from the Elizabeth Lab background

[b]Average annual concentrations measured from 2008 to 2010

Table 11: Maximum Predicted 24-hour SO_2 Impact of Emissions from Operations at Port Newark and the Elizabeth Port Authority Marine Terminal for 2006 and 2015

Location	2006 24-hour Impact (8^{th} highest) ($\mu g/m^3$)	2015 24-hour Impact (8^{th} highest) ($\mu g/m^3$)	SIL ($\mu g/m^3$)	Background Air Quality ($\mu g/m^3$)[a,b] (maximum) 2^{nd}-high	(2015) Total Concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
Bayonne	22.2	0.7	5	28.6	29.3	365
Elizabeth	2.8	0.2	5	28.6	28.8	365
Elizabeth Lab. monitor	4.6	0.2	5	28.6	28.8	365
Newark	6.4	0.4	5	28.6	29.0	365
Staten Is.	8.0	0.5	5	28.6	29.1	365
Jersey City	12.3	0.7	5	28.6	29.3	365

[a]The 0.2 $\mu g/m^3$ due to port activities is subtracted from the background

[b]Average annual concentration measured at Elizabeth Lab. from 2008 to 2010

Table 12: Maximum Predicted 1-hour SO_2 Impact of Emissions from Operations at Port Newark and the Elizabeth Port Authority Marine Terminal for 2006 and 2015

Location	2006 1-hr Impact (4th highest) (µg/m³)	2015 1-hr Impact (4th highest) (µg/m³)	SIL (µg/m³)	Background Air Quality (µg/m³)[a,b] (3yr average 99th percentile)	Total Concentration (µg/m³) (2015)	NAAQS (µg/m³)
Bayonne	80.6	3.3	7.8	89.7	93.0	196
Elizabeth	39.3	1.4	7.8	89.7	91.1	196
Elizabeth Lab. monitor	46.5	2.0	7.8	89.7	91.7	196
Newark	63.2	2.6	7.8	89.7	92.3	196
Staten Is.	73.4	3.2	7.8	89.7	92.9	196
Jersey City	50.0	2.6	7.8	89.7	92.3	196

[a]The 2.0 µg/m³ due to port activities is subtracted from the background

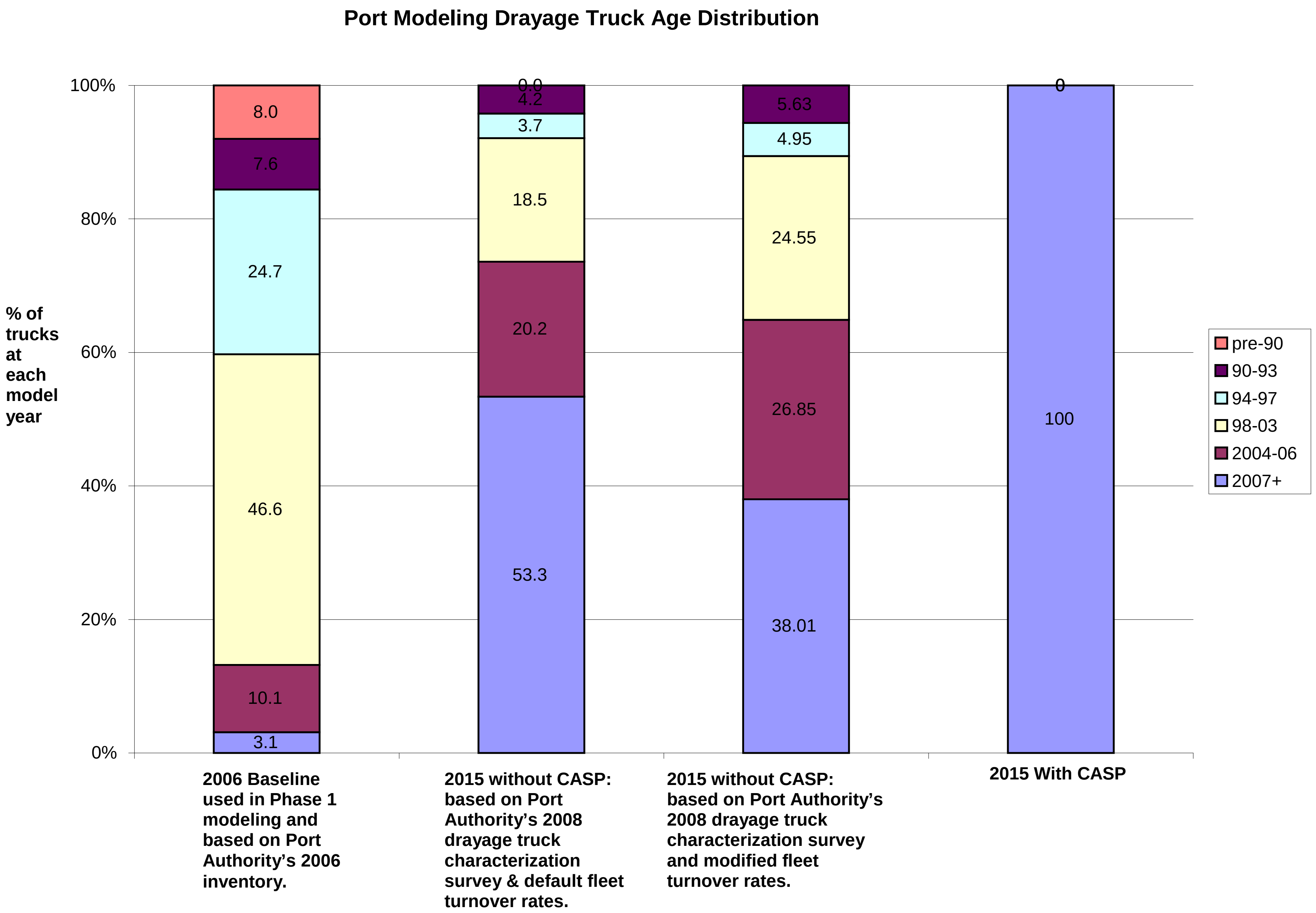
[b]Average annual concentration measured at Elizabeth Lab. from 2008 to 2010

V. Discussion of Results

The modeling predicts that:

- The predicted concentrations of fine particulates from marine terminal operations, not including background concentrations, are below the levels that would cause non-cancerous health effects. The Phase 1 baseline modeling showed the same result.
- The incremental cancer risk predicted at residences in Bayonne, Staten Island, Jersey City and Newark are reduced compared to the Phase 1 baseline, but are still between 10 and 100 in a million and therefore still justify long-term efforts to further reduce cancer risk. The incremental cancer risk at residences in the western part of Bayonne is of most concern. The prediction is that marine terminal related emissions result in a risk to a maximally exposed individual of about 69 chances in a million, assuming constant exposure to the highest predicted concentration for 70 years. With the Phase 1 baseline emissions this risk was 150 in a million.
- Emissions from marine terminal activities when added to background concentrations do not cause a violation of either the annual or 24-hour PM2.5 NAAQS at any modeled location, whereas in the Phase 1 baseline model predictions the marine terminal activities contributed significantly to a violation of the 24-hour PM2.5 NAAQS at all five modeled locations.
- Emissions from marine terminal activities are below New Jersey's significant impact levels (SIL's) for annual PM2.5 in all the surrounding communities in both the Phase 1 and Phase 2 scenarios.
- Emissions from marine terminal activities were above New Jersey's significant impact levels (SIL's) for 24-hour PM2.5 in some surrounding communities in the Phase 1 baseline but not in the Phase 2 future case.

- Marine terminal-related SO_2 emissions when added to the background concentrations do not violate the annual, 24-hour or 1-hour NAAQS or SIL and are significantly reduced from Phase 1 baseline levels.
- The culpability maps show that with the ocean-going vessels, cargo-handling and truck emission sources, the area of cancer risk is much reduced; the tugboat source remains almost the same because the Port Authority has not yet calculated emission benefits for most of the tugboat specific strategies in the Clean Air Strategy. Although the locomotive emissions increased between the baseline and future scenarios their overall contribution to the area of cancer risk was always small.


Port Modeling Drayage Truck Age Distribution
100%
80%
60%
40%
20%
0%
% of trucks at each model year
8.0
7.6
24.7
46.6
10.1
3.1
0.0
4.2
3.7
18.5
20.2
53.3
5.63
4.95
24.55
26.85
38.01
0
100
pre-90
90-93
94-97
98-03
2004-06
2007+
2006 Baseline used in Phase 1 modeling and based on Port Authority's 2006 inventory.
2015 without CASP: based on Port Authority's 2008 drayage truck characterization survey & default fleet turnover rates.
2015 without CASP: based on Port Authority's 2008 drayage truck characterization survey and modified fleet turnover rates.
2015 With CASP

APPENDIX B: ASSUMPTIONS MADE CONCERNING PM2.5 EMISSIONS[A]										
Main Source Type	**Subcategory**	**Location/Source Type**	**Stack Height (m)**	**Annual Emission rate (tpy)**	**Emission rate (g/s)**	**Value used in model ($g/s/m^2$) if area source, g/s if point source**	**Hours of operation (Annual)**	**Approx. hours of operation (daily)[b]**	**Reference for stack height**	**Notes**
CMV	OGV – Transit	1000ft. channel from 3 mile mark to Port; Area	50	17.1 or 16.99	0.49	3.84E-08	8760	24[c]	Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report, 2006, CalEPA, ARB James Corbett, pers. comm.. Feb. 2009	Breakdown of OGV into dwelling, transit and boilers from Table 5.5; breakdown of county emissions from Table 5.9 including Starcrest email dated 9/9/09
CMV	OGV - Dwelling	Dwelling at two points next to Maher and PNCT Terminals Point	43 SZINIT=7	14.6	0.42	0.20 PN 0.22 PE	8760	24[c]	As above	As above
CMV	OGV – Boilers	As above, Transit Dwelling:	As above	0.69 6.86	0.02 0.19	1.55E-09 0.08 PN 0.11 PE	8760	24[c]	As above	As above
CMV	OGV- Tugboats	1000ft. channel from The Narrows to Port; Area	6	9.13	0.26	5.59E-08	8760	24[c]	Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report, 2006, CalEPA, ARB	
CHE	Straddle	Port-wide Area	11.5	3.36	0.10	1.08E-08	3578	6am-4pm[c]	Field trip estimate at Maher terminal (02/10/09)	CHE emissions were split into each type of equipment by allocating county emissions (see Tables 2.1 and 2.3 of 2006 inventory) The total emission was divided proportionally for each port by area (88% PE, 11% PN)
CHE	Tractor	Port-wide Area	2.9	2.24	0.06	1.08E-09	1783	6am-11am[c]	As above	As above
CHE	Fork lift	Port-wide Area	2.1	0.40	0.01	2.68E-10	1481	6am-10am[c]	As above	As above

Main Source Type	Subcategory	Location/Source Type	Stack Height (m)	Annual Emission rate (tpy)	Emission rate (g/s)	Value used in model (g/s/m^2) if area source, g/s if point source	Hours of operation (Annual)	Approx. hours of operation (daily)[b]	Reference for stack height	Notes
CHE	Top Loader	Port-wide Area	3.15	0.43	0.01	5.48E-10	2829	6am-2pm[c]	Average value taken from Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report, 2006, CalEPA, ARB	As above
CHE	Container Handler	Port-wide Area	3.15	0.20	0.01	2.04E-10	2205	6am-12pm[c]	Average value taken from ARB report above	As above
CHE	Other Primary Equipment	Port-wide Area	3.15	0.22	0.01	2.71E-10	2674	6am-1pm[c]	Average value taken from ARB report above	As above (average hours from Table 2.12 – not including cranes)
CHE	Ancillary	Port-wide Area	3.15	0.18	0.01	8.50E-11	1067	6am-9am[c]	Average value taken from ARB report above	As above (average hours from Table 2.18)
CHE	Rubber-tired Gantry Crane	Port-wide Area	19.2	0.47	0.01	1.04E-07	4596	6am-6pm[c]	Field trip estimate at Maher terminal (02/10/09)	Contact with each terminal confirmed their use at APM only
CHE	Other Crane	Port-wide Area	38	0.37	0.01	0.008	1799	6am-11am[c]	As above	Stack parameters were estimated during a DEP site visit
LOCO	Switch (idling)	ExpressRail between Maher and APM terminals Area	4.6	8.14	0.23	2.95E-07	5110 (estimate from M. Dower)	6am-8pm[c]	Diesel Particulate Matter Health Risk Assessment for the West Oakland Community, 2008, ARB, CalEPA Appendix B	
LOCO	Line Haul	Area	4.6	0.35	0.01	9.79E-08	As above	6am-8pm[c]	Diesel Particulate Matter Health Risk Assessment for the West Oakland Community, 2008, ARB, CalEPA Appendix B	

Main Source Type	Subcategory	Location/Source Type	Stack Height (m)	Annual Emission rate (tpy)	Emission rate (g/s)	Value used in model (g/s/m^2) if area source, g/s if point source	Hours of operation (Annual)	Approx. hours of operation (daily)[b]	Reference for stack height	Notes
					24-hour	**Annual**				
Trucks	Idle	APM, Maher,PNCT Area	3.66	1.25	0.1 divided amongst the three terminals by area: 2.74E-07 g/s/m^2 (APM) 2.74 E-07 g/s/ m^2 (Maher) 2.74E-07 g/s/ m^2 (PNCT)	0.07 divided amongst the three terminals by area: 1.88E-07 g/s/m^2 (APM) 1.88 E-07 g/s/ m^2 (Maher) 1.88E-07 g/s/ m^2 (PNCT)	250 days	6am-6pm[d]		Port Authority of New York and New Jersey, 2006 Baseline multi-Facility Emissions Inventory, November 2008, p87
Trucks	On-terminal	Port-wide Area	3.66	0.12	0.01 Divided amongst the two Ports 2.65E-11 g/s/m^2 (Elizabeth) 2.65E-11 g/s/ m^2 (Newark)	0.002 Divided amongst the two Ports 3.16E-10 g/s/m^2 (Elizabeth) 3.16 E-10 g/s/ m^2 (Newark)	250 days	6am-6pm[d]		Proportional tpy divided by area; see spreadsheet Port truck emission calculations.xls; Emission rate from Port Authority of New York and New Jersey, 2006 Baseline multi-Facility Emissions Inventory, November 2008, p87
Trucks	Off-terminal	From the Port gates to the New Jersey Turnpike intersections 13A and 14. Area	3.66	1.56	Annual 0.04	Varying according to link length and width	250 days	6am-6pm[d]		

[a] Elizabeth Port Authority Marine Terminal = PE, Port Newark = PN
[b] Starting hour to Ending hour
[c] Based on 365 days per year;
[d]Based on 250 working days per year;

Ref A: Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report, CalEPA, ARB (2006)

Unitary emission rates for CHE were calculated for both ports based on the total area (3639210.657 meters^2).
Notes: Urban population used was 2,395,758 with a roughness length of 1.0m.

APPENDIXC: ASSUMPTIONS MADE CONCERNING SO2 EMISSIONS[A]										
Main Source Type	**Subcategory**	**Location/ Source Type**	**Stack Height (m)**	**Annual Emission rate (tpy)**	**Emission rate (g/s)**	**Value used in model ((g/s/m^2) if area source, g/s if point source)**	**Hours of operation (Annual)**	**Approx. hours of operation (daily)[b]**	**Reference for stack height**	**Notes**
CMV	OGV - Transit	1000ft. channel from 3 mile mark to Port; Area	50	113.2	3.25	2.54E-07	8760	24[c]	Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report, 2006, CalEPA, ARB James Corbett, pers. comm.. Feb. 2009	Breakdown of OGV into dwelling and transit from Table 5.5; breakdown of county emissions from Table 5.9
CMV	OGV - Dwelling	Dwelling at two points next to Maher and PNCT Terminals Point	43 SZINIT=7	120.5	3.37	0.20 PN 0.22 PE	8760	24[c]	As above	As above
CMV	OGV – Boilers	As above, Transit Dwelling:	As above	11.2 112.1	0.32 3.22	2.53E-08 0.08 PN 0.11 PE	8760	24[c]	As above	As above
CMV	OGV -Tugboats	1000ft. channel from The Narrows to Port; Area	6	0.62	0.01**	3.79E-09	8760	24[c]	Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report, 2006, CalEPA, ARB	
CHE	Straddle	Port-wide Area	11.5	0.73	0.02	2.36E-09	3578	6am-4pm[c]	Field trip estimate at Maher terminal (02/10/09)	CHE emissions were split into each type of equipment by allocating county emissions (see Tables 2.1 and 2.3 of 2006 inventory) The total emission was divided proportionally for each port by area (88% PE, 11% PN)

Main Source Type	Subcategory	Location/ Source Type	Stack Height (m)	Annual Emission rate (tpy)	Emission rate (g/s)	Value used in model (g/s/m^3) if area source, g/s if point source	Hours of operation (Annual)	Approx. hours of operation (daily) [b]	Reference for stack height	Notes
LOCO	Switch (idling)	ExpressRail between Maher and APM terminals Area	4.6	0.78	0.02	3.80E-08	Estimate from PA 2006 inventory 34,744; 11 shifts	6am-8pmc	Diesel Particulate Matter Health Risk Assessment for the West Oakland Community, 2008, ARB, CalEPA Appendix B	
LOCO	Line Haul	Volume	4.6	0.05	0.001	1.40E-08	As above	6am-8pmc	Diesel Particulate Matter Health Risk Assessment for the West Oakland Community, 2008, ARB, CalEPA Appendix B	
					24-hour	**Annual**				
Trucks	Idle	APM, Maher,PNCT Area	3.66	0.11	0.01 divided amongst the three terminals by area: 2.41E-08 g/s/m^2 (APM) 2.41E-08 g/s/m^2 (Maher) 2.41E-08 g/s/m^2 (PNCT)	0.01 divided amongst the three terminals by area: 1.71E-08 g/s/m^2 (APM) 1.71 E-08 g/s/ m^2 (Maher) 1.71E-08 g/s/m^2 (PNCT)	250 days	6am-6pm	Trucks	Trucks
Trucks	On-terminal	Port-wide Area	3.66	0.05	N/A	N/A	250 days	6am-6pmd		Proportional tpy divided by area; see spreadsheet Port truck emission calculations.xls;
Trucks	Off-terminal	From the Port gates to the New Jersey Turnpike intersections 13A and 14. Area	3.66	0.31	Annual 0.01	Varying according to link length and width	250 days	6am-6pmd	Trucks	Off-terminal

[a] Elizabeth Port Authority Marine Terminal = PE, Port Newark = PN
[b] Starting hour to Ending hour
[c] Based on 365 days per year;

[d]Based on 250 working days per year;

Ref A: Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report, CalEPA, ARB (2006)

Unitary emission rates for CHE were calculated for both ports based on the total area (3639210.657 meters^2).
Notes: Urban population used was 2,395,758 with a roughness length of 1.0m.

Appendix D – Excerpted from Port Authority of NY/NJ's Clean Air Strategy Plan

OCEANGOING VESSELS

Implemented Actions		Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
OGV (a). The Port Authority is working with the Port of Rotterdam to develop an Environmental Ship Index (ESI) as a means of establishing criteria for evaluating and recognizing clean ships.		Not quantifiable	Not included in modeling because not quantified.

Committed Actions	Estimated Period of Implementation	Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
OGV(b). Establish a year-round vessel speed incentive program for ships approaching the harbor. The Port Authority program would cover the portion of the year (May 1 through October 31) that does not fall under the National Oceanic and Atmospheric Administration (NOAA)'s seasonal management restrictions for the mid-Atlantic area.	2009 – 2012	11.6% /19.1% /6.6%	Modeled 2.3 tpy reduction
OGV(c). Develop an incentive program for OGVs to switch to low sulfur fuel when in the Port of New York and New Jersey. This incentive would likely be funding to help cover the cost differential between the use of low sulfur fuel and conventional bunker fuel while in port. Incentive payments would apply to main and auxiliary engine consumption and approximate 50% of the cost differential between heavy fuel oil and marine gas oil at .2% sulfur content for main engine and 50% for auxiliary engines. A1 To qualify for the incentive, vessels must also participate in the vessel speed reduction program.	2009 – 2012	54.4%/ 11.58%/ 0.00%	Included reductions in 2015 projection
OGV(d). Develop a Clean Ship/Green Flag program, using the ESI mentioned above, to recognize ships that use vessel speed reduction and clean engine technology to reduce their air emissions.	2009 – 2014	Implementation details needed prior to calculation	Not included in modeling because no details
OGV(e). Install shore-power ("cold ironing") capability at the Brooklyn Cruise Terminal.	2009 – 2011	1.87%/ 2.58%/ 0.38%	Not included in modeling because not a NJ facility
OGV(f). Continue/expand international partnership with the Port of Rotterdam, and other ports if opportunities exist, working to implement "clean ship" and other related programs/projects.	2009 – 2014	Not quantifiable	Not included in modeling because not quantified

OGV(g). Support the establishment of a North American Emissions Control Area, led by EPA R2 helping to advance the agency work needed to submit and support the ECA application process.	2009	Not quantifiable	Not included in modeling because not quantified
OGV(h). NYCEDC to seek to repeal the New York State tax exemption for bunker fuel.	2009	Not quantifiable	Not included in modeling because not quantified

Future Actions			
OGV(i). Install shore-power capability at the NYCEDC's Manhattan Cruise Terminal and in conjunction with all new terminal developments.			
OGV(j). Implement pilot projects for bonnets and other promising new technologies.			
OGV(k). Seek to establish a New York State tax exemption for low-sulfur fuel.			

CARGO HANDLING EQUIPMENT

Implemented Actions		Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
CHE(a). Completed switchover to use of Ultra Low Sulfur Diesel (ULSD) fuel in all CHE.		9% PM / 97% SO_x	Already in 2006 baseline.
CHE(b). Installed and evaluated active diesel particulate filters (DPF) on yard tractors.		No plans to quantify	Already in 2006 baseline
CHE(c). Currently using CNG, propane, or electric-powered forklifts in warehouses.		No plans to quantify	Already in 2006 baseline
CHE(d). Instituted Idle Reduction Program at all marine container terminals restricting idling times of diesel powered cargo handling equipment through the use of automatic shutoff devices and electric plug-in technology.		25% /25% /25%	Not in place in 2006 for Phase 1 baseline; modeled 6 tpy reduction
CHE(e). Completed installation of 39 out of 53 electric cranes and modernization of all CHE at container terminals to models meeting EPA's 2004 on-road emissions standards.		30% /48/30% /30%	39 electric cranes already in 2006 baseline

Committed Actions	Estimated Period of Implementation	Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
CHE(f). Sponsor pilot projects to test hydraulic and electric hybrid yard hostlers.	2009-2011	.34%/ .17%/ .02%	Modeled 0.54 tpy reduction
CHE(g). Install new engines with DPF on two wharf cranes Port Authority owns at Red Hook Container Terminal in Brooklyn and on two on-road stick cranes at the ASI facility at Port Newark.	2010	2.25% / 0.76% / 0.00%	Modeled 0.8 tpy reduction

CHE(h). Accelerate modernization/upgrade/decommission up to 300 pieces of CHE, including 50 pieces of equipment with the oldest engines at all Port-Authority leased terminals to meet EPA's 2007 on-road standards.	2009 - 2014	10.3% / 11.8% / 0.00%	Modeled 2.1 tpy reduction
CHE(i). Replace up to one-third of the CHE fleet at all Port-Authority leased terminals with alternative powered equipment, including, but not limited to, diesel electric, hydraulic hybrid, and CNG, where technologically feasible.	2009 - 2016	26.3% / 14.6% / 0.00%	Modeled 6.5 tpy reduction
CHE(j). Determine the causes of on-terminal idling by CHE and work to strengthen the Idle Reduction Program by implementing actions which reduce or eliminate those causes, where feasible.	2009	Not quantifiable	Not included in modeling because not quantified
CHE(k). Decommission or electrify eleven diesel cranes at Port Newark and Port Elizabeth. Create an incentive program to retire and dismantle a minimum of two diesel powered cranes. Install/upgrade electrical power infrastructure to support new electric wharf cranes for the remaining balance (nine cranes).	2009 - 2014	3.5% / 2.7% / 0.38%	Modeled 0.54 tpy reduction

Future Actions
CHE (l). Install wind turbines as alternative energy source on Port Authority facilities.
CHE(m). Consider actions to address cold weather idling. Start with a pilot program to work through technical issues.
CHE(n). Replacement/upgrade of all remaining CHE not covered under CHE actions (h) and (i) above using the best available technologies at the time of replacement.

HEAVY DUTY DIESEL VEHICLES

Implemented Actions		Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
Trucks(a). Initiated NY/NJ Roadway enhancement program to increase roadway capacity and reduce congestion.		Not quantifiable	Not included in modeling because not quantified.
Trucks(b). Terminal operators installed electric gates, relocated gates, and extended gate hours at both ends, where feasible, to reduce truck congestion and idling emissions at terminals.		No plans to quantify	Not included in modeling because not quantified
Trucks(c). NYCEDC negotiated a mandate in its lease with Phoenix Beverages at Pier 11 Red Hook to convert its entire fleet of trucks (100 trucks) to CNG within 7 years.		To be calculated by September 2010	Not included in modeling because not quantified and not a NJ facility

Trucks(d). Currently using Portfields initiative to promote development of warehouse and distribution centers on abandoned, contaminated industrial sites located near the Port which would reduce truck vehicle miles traveled and their associated emissions.		To be calculated by September 2010	Not included in modeling because not quantified

Committed Actions	Estimated Period of Implementation	Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
Trucks(e). Create and implement a $2M Emission Reduction Fund for port truck owners to finance acquisition of newer, lower emitting vehicles, with $750K in Port Authority funding to match an EPA grant of $750K combined with $500K from a micro-lender.	2009 – 2012	1.10%/0.00%/0.00%	Modeled Port Authority's proposed truck ban which prohibits pre-2007 trucks from calling on port facilities as of January 2017.
Trucks(f). Work with shippers and vessel operators to establish a SmartWay-type partnership with vessel operators and shippers that would enhance business to truckers that use vehicles equipped with SmartWay air emission and fuel efficiency upgrades. Upgrades may include the installation of diesel particulate filters (DPFs) and/or a diesel oxidation catalyst (DOC).	2009 – 2010	32.15% / 0.00% / 0.00%	Modeled Port Authority's proposed truck ban which prohibits pre-2007 trucks from calling on port facilities as of January 2017.
Trucks(g). Develop a program to phase out older trucks serving Port Authority marine terminal facilities based on model year. To advance this action: Establish a truck working group by June 2009 to work out implementation details, including funding, tracking mechanisms and structure and timing for denying Port access. Implement a Truck Replacement Program to provide incentives and financing to replace pre-1994 trucks with 2004 or newer vehicles.	2010 – 2017	23.73% (8.01% on terminal and 15.72% off terminal) / 6.1% / 0.4%	Modeled Port Authority's proposed truck ban which prohibits pre-2007 trucks from calling on port facilities as of January 2017.
Trucks(g). Develop an appointment system for trucks serving the terminals, including a fast lane at the gate for newer (2004 or younger) vehicles, in order to decrease total truck turnaround time.	2010	Implementation details needed prior to calculation	Not included in modeling because no details.
Trucks(h). Conduct a study of freight movement, modal splits, and short sea shipping, led by NYCEDC.	2009	Not quantifiable	Not included in modeling because not quantified.
Trucks(i). Develop public-private partnerships for retrofits and/or alternative fuels.	2009 – 2014	Not quantifiable	Not included in modeling because not quantified

Future Actions
Trucks(k). Develop near-Port truck parking areas with plug-in electrification technology to reduce idling emissions. Consider including rest stop amenities as part of the parking area to encourage use.
Trucks(l). Assess the feasibility of creating a new exit ramp or Port-only lane off of the New Jersey Turnpike between exits 13a and 14a for Port truck traffic.
Trucks(m). Work with shipping lines to change the operating rules for chassis pool so they are more effective.
Trucks(n). Install plug-ins for refrigerated containers (reefers) at New York City marine terminals and Hunts Point, led by New York City.

RAIL

Implemented Actions	Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
Rail (a). Invested over $600M in ExpressRail expansion. Established on-dock rail at all container terminals. Achieved 358,000 rail lifts in 2007, displacing over 537,000 truck trips. Capacity when complete: 1.2M rail lifts/year; displacing over 1.8M truck trips.	To be calculated by April 2010	Partially in place in 2006 but not included in modeling because not quantified
Rail (b). NYCEDC installed Kim Hot Start anti-idling device on-dock switcher locomotive at New York Container Terminal.	To be calculated by April 2010	Not in place in 2006, but not included in modeling because not quantified
Rail (c). Currently using ground air system in place of on-board air compressor (which is powered by vehicle's diesel generator) to provide locomotive's compressed air needs.	To be calculated by April 2010	Partially in place in 2006, but not included in modeling because not quantified
Rail (d). Expanded rail capacity by extending and modernizing the Staten Island Railroad, with resource support from NYCEDC.	To be calculated by April 2010	Not in place in 2006, but not included in modeling because not quantified and not a NJ facility

Rail (e). NYSA created a rail incentive program in July 2007 with investments of over $40M to-date.		Included in rail(a) above	Not in place in 2006, but not included in modeling because not quantified and not a NJ facility
Rail (f). NYCEDC negotiated lease agreement at South Brooklyn Marine Terminal with Axis which includes financial incentives for moving goods by rail or barge.		To be calculated by September 2010	Not in place in 2006, but not included in modeling because no details and not a NJ facility

Committed Actions	Estimated Period of Implementation	Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
Rail (g). Retrofit/replace up to three switching locomotives serving the Port with GenSets, particulate filters, and possibly selective catalytic reduction (SCR) technology for NO_x reduction. Administrative support by New Jersey DEP and funding from Supplemental Environmental Project, negotiated by NJDEP.	2009 – 2011	12.7% / 10.8% / 1.7%	Modeled 1.03 tpy reduction
Rail (h). Reconfigure two switching locomotive engines with GenSets. The railways, CSX and Norfolk Southern, would provide 20% percent of the costs; an additional 20% would come from the Port Authority, and 60% would be provided by a grant from the Congestion Mitigation Air Quality (CMAQ) program.	2010 – 2011	9.5% / 12.99% / 1.32%	Modeled 0.77 tpy reduction
Rail (i). Implement a switch to ULSD fuel in switcher locomotives serving the Port and in cargo handling equipment at intermodal yards, prior to EPA's 2012 off-road engine standards taking effect.	2009 – 2012	2.2% / 2.2% / 0.00%	Included reductions in 2015 projection
Rail (j). Implement operational procedures to shut down locomotive engines when not in use and outside temperatures permit.	2009	Implementation details needed prior to calculation	Not included in modeling because no details and not quantified.
Rail (k). Extend and modernize rail lines to and in South Brooklyn Marine Terminal and the Port Jersey Peninsula to increase efficiency, led by NYCEDC.	2009 – 2011	Not quantifiable	Not included in modeling because not quantified.
Rail (l). Install anti-idling technology in switcher locomotive engines at the Port of Newark and Elizabeth Marine Terminal.	2009 – 2010	3.3% / 3.0% / 1.1%	Modeled 0.27 tpy
Rail (m). Begin evaluation of alternative powered (hybrid, CNG or all-electric) lifting equipment at intermodal yards.	2011 – 2014	Not quantifiable	Not included in modeling because not quantified.

Future Actions
Rail (n). Consider a long term, operational change of increasing the amount of cargo leaving the Port on rail versus truck. This includes increasing short-haul rail capabilities.
Rail (o). Implement efficiency improvements, such as the electrification of lift equipment and use of alternative powered (hybrid, CNG or all-electric) lifting equipment, at intermodal yards close to the port.
Rail (p). Reduce dependency on trucks by enhancing use of rail and barge, such as through Express Rail expansion, development of short haul rail lines and implementation of short sea shipping.

HARBORCRAFT

Implemented Actions		Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions
HC (a). Began switchover to ULSD in all harbor craft, including Staten Island Ferries.		To be calculated by September 2010	Not in place in 2006 but not included in modeling because not quantified
HC (b). Completed engine retrofits on four Staten Island public ferries and engine replacements on fifteen tugs operating in NY/NJ Harbor as part of the Harbor Deepening Project Air Offset Program.		18.2% Nox (calculated based on emission reductions in excess of those requried by the Harbor Deepening Project Air Offset Program. PM & GHG reductions are not tracked under the program.	Not in place in 2006 but not included in modeling because no PM reductions quantified
HC (c). Currently implementing a Marine Vessel Engine Replacement Program, lead by New York City DOT, to upgrade to Tier I, II, or III marine engines.		To be calculated by September 2010	Not in place in 2006, but not included in modeling because not quantified

Committed Actions	Estimated Period of Implementation	Estimated Emission Reductions PM/Nox/GHG	NJDEP modeling assumptions

HC (d). Revitalize the cross-harbor rail barge and convert the locomotive switcher engines supporting the operation to GenSet configuration and implement use of ULSD in both the locomotive and the harbor tug assigned to move the rail barge.	2009 – 2014	Implementation details needed prior to calculation	Not included in modeling because not quantified
HC (e). Install diesel oxidation catalysts on private ferries, led by New York City under a federal grant	2009 – 2014	To be calculated by April 2010	Not included in modeling because not quantified.
HC (f). Accelerate the use of ULSD fuel in harbor craft in advance of EPA's 2012 non-road diesel standards. Work with suppliers to ensure ULSD, with additives, is available. Work with suppliers to add more fueling sites or a central fueling depot in the New York/ New Jersey Harbor.	2009 – 2011	5.0% / 5.0% / 0.0%	Included reductions in 2015 projection.
HC (g). Adopt measures to increase fuel efficiency in harbor craft: Vessel speed reduction; Vessel assignment planning to reduce transit length; Use Automatic Identification System (AIS) to monitor incoming vessel speeds and plan just in time arrival; and Identify places—as part of New York City Economic Development Corporation's Phase II Maritime Support Study—where tugs can tie up and shut down engines between assignments in same general location.	2009 – 2011	Implementation details needed prior to calculation	Not included in modeling because not quantified
HC (h). Investigate and test post-combustion controls and after-treatment technologies for tugs.	2010 – 2012	Not quantifiable	Not included in modeling because not quantified
HC (i). Raise awareness about reducing emissions and influence new purchases to include equipment up to highest emission standards. EPA Region 2 commitment to conduct outreach to harbor craft owners and operators via the National Clean Diesel Campaign, the Northeast Diesel Collaborative (NEDC), and the NEDC Goods Movement Workgroup	2009 – 2010	Not quantifiable	Not included in modeling because not quantified
HC (j). Expand marine vessel engine replacement or engine retrofit program (MERP) to private ferries, tugs and other harbor craft, as an effort separate from the Harbor Deepening Project Air Offset Program. Initial goal of replacing eleven engines.o Work to relax the requirement to stay in the harbor a large percent of the time.	2009 – 2014	Implementation details needed prior to calculation	Not included in modeling because not quantified

Future Actions

HC (k). Explore options for reducing the cost of cleaner/alternative fuels for harbor craft, including obtaining bulk suppliers and working to reform tax laws to waive taxes on fuel consumed in New York waters.

HC (l). Install strong-arm dockers on ferries, which will enable them to shut off their engines while picking up or discharging passengers at dock.
HC (m). Develop dockside electrification for tugs, where feasible.
HC (n). Implement a hybrid ferry and tug pilot program, building off of New York EDC feasibility studies of a hybrid tug for cross-harbor rail operations.
HC (o). Use anti-fouling hull coatings on marine vessels to reduce drag and improve fuel efficiency.

FIGURE 1: MODEL RECEPTOR INNER GRID AND LOCATION OF RESIDENTIAL NEIGHBORHOODS NEAR TO THE PORT

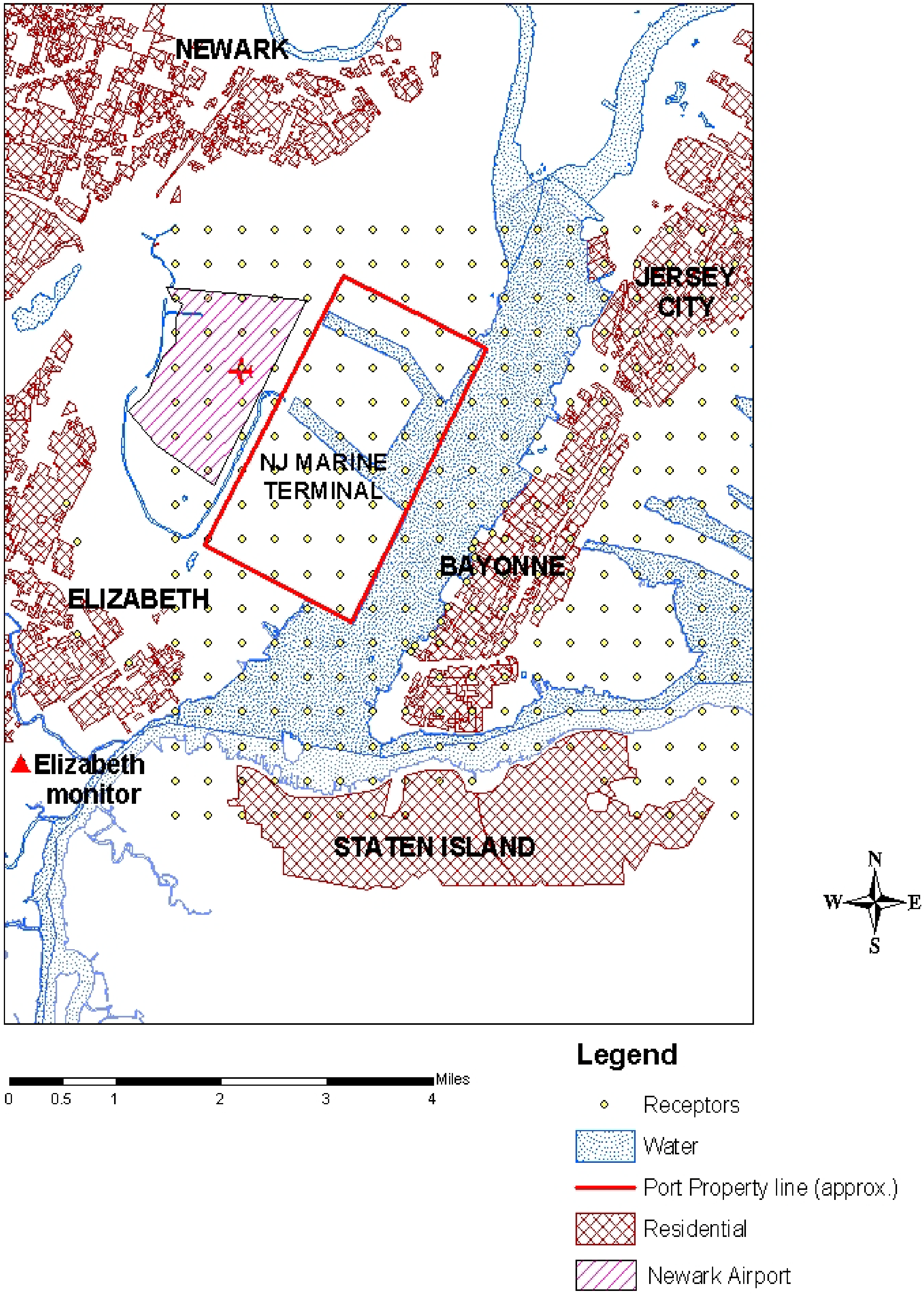


FIGURE 2: MAXIMUM PREDICTED ANNUAL PM2.5 CONCENTRATIONS IN 2006 AND 2015 DUE TO ALL PORT ACTIVITIES (not including background)

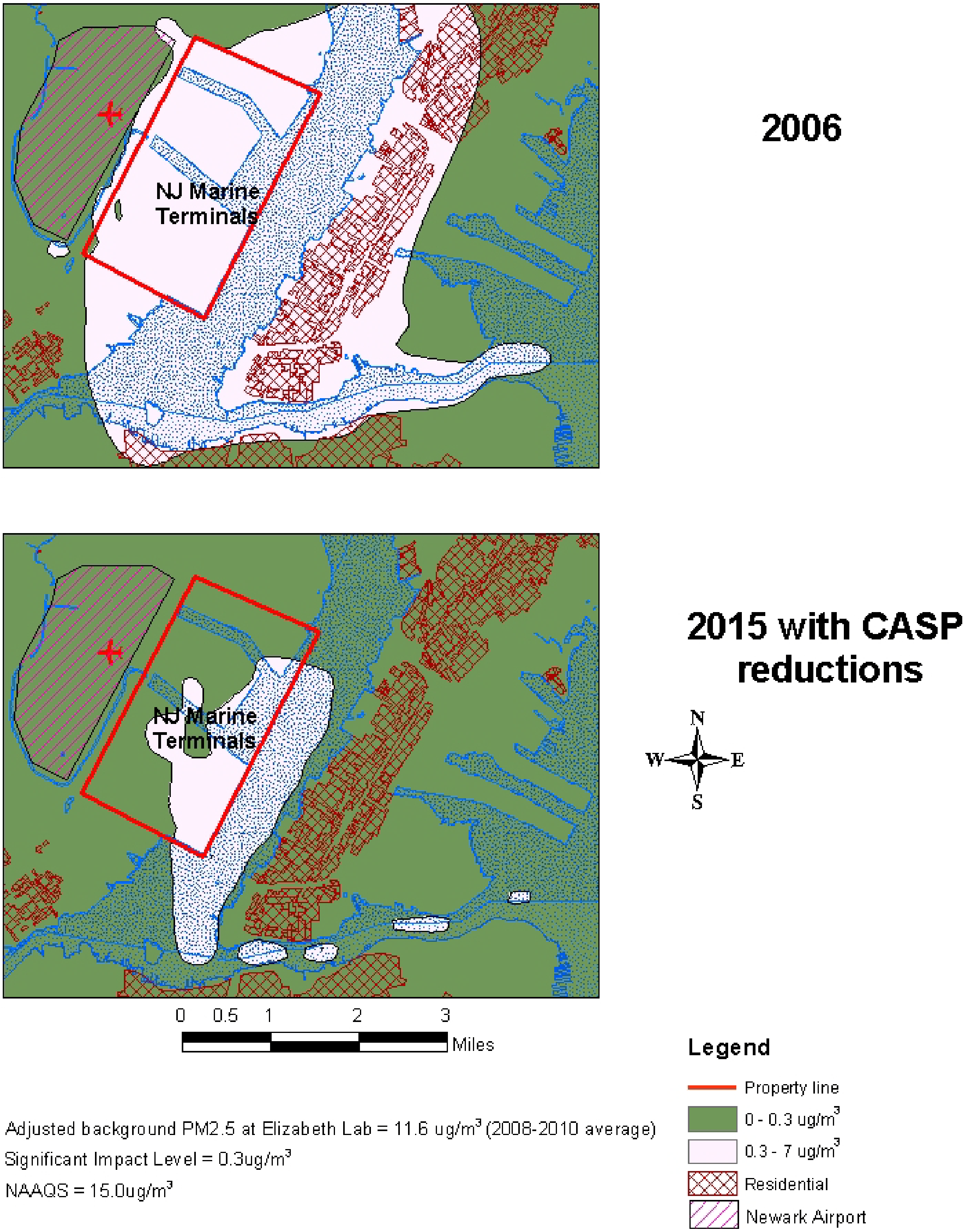


FIGURE 3: MAXIMUM PREDICTED 24-HOUR PM2.5 CONCENTRATIONS IN 2006 AND 2015 DUE TO ALL PORT ACTIVITIES (not including background)

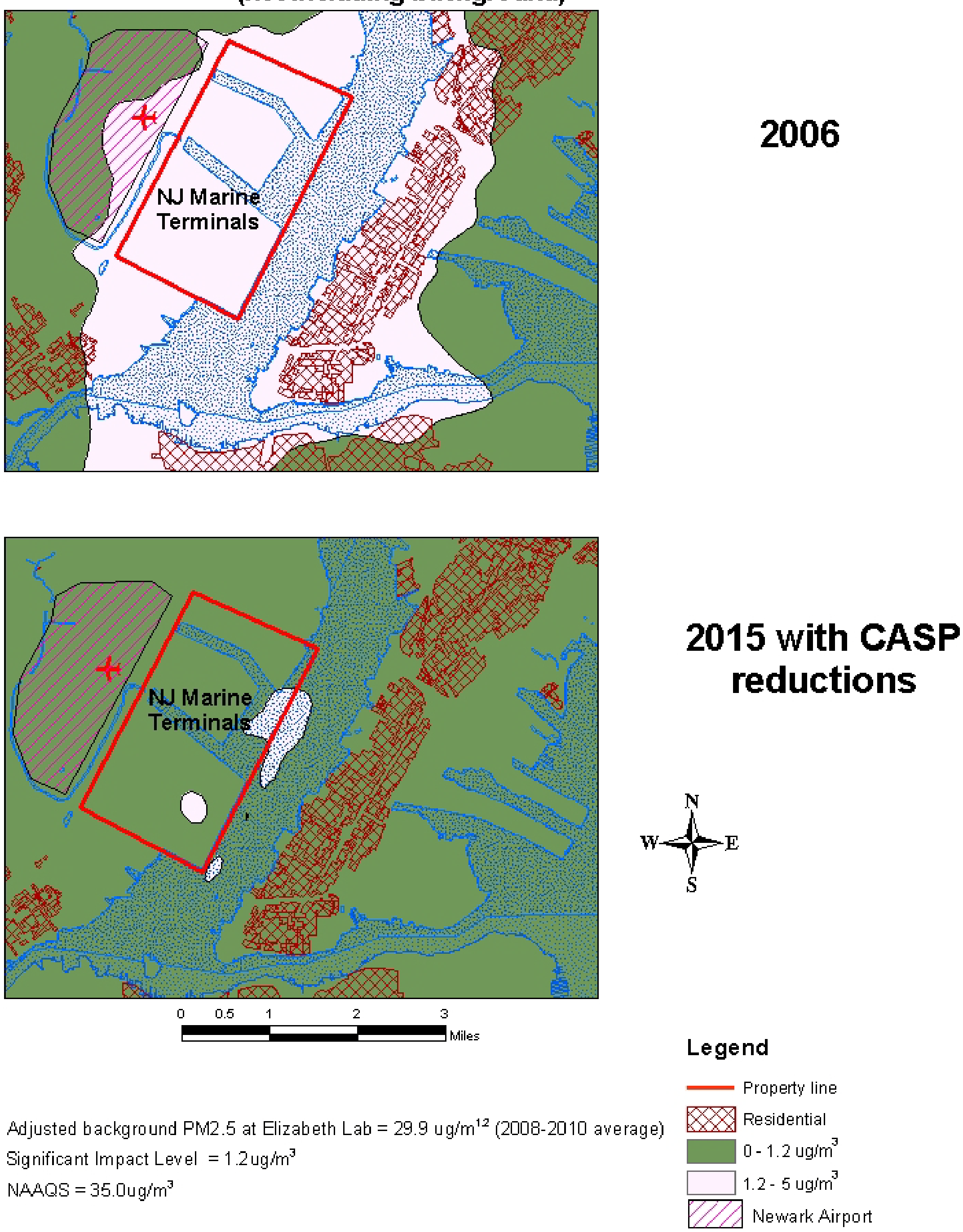


FIGURE 4: MAXIMUM PREDICTED 70-YEAR LIFETIME CANCER RISK DUE TO FUTURE PORT-RELATED DIESEL PARTICULATE EMISSIONS IN 2006 AND 2015 (not including background)

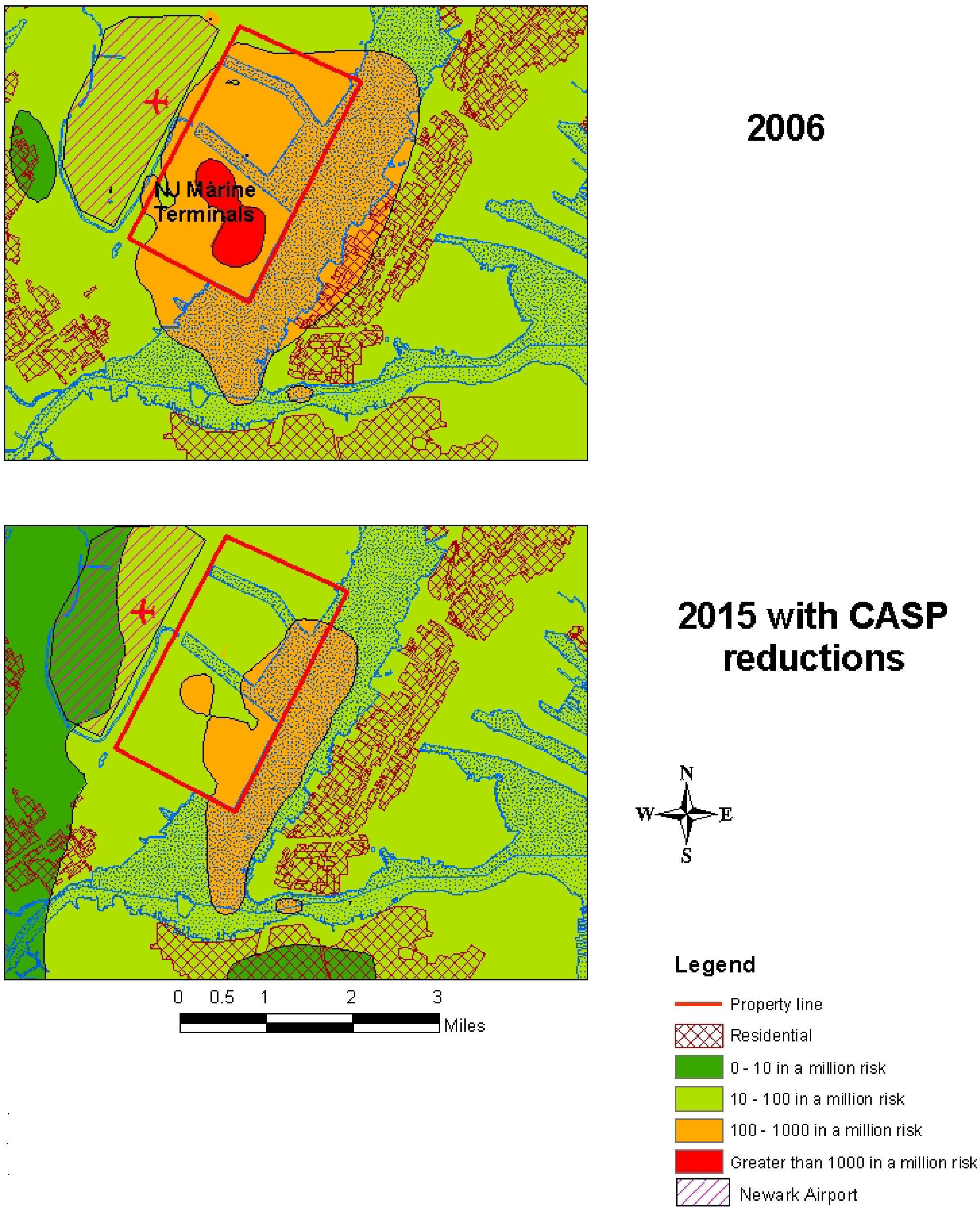


FIGURE 5: MAXIMUM PREDICTED ANNUAL SO2 CONCENTRATIONS IN 2006 AND 2015 DUE TO ALL PORT ACTIVITIES (not including background)

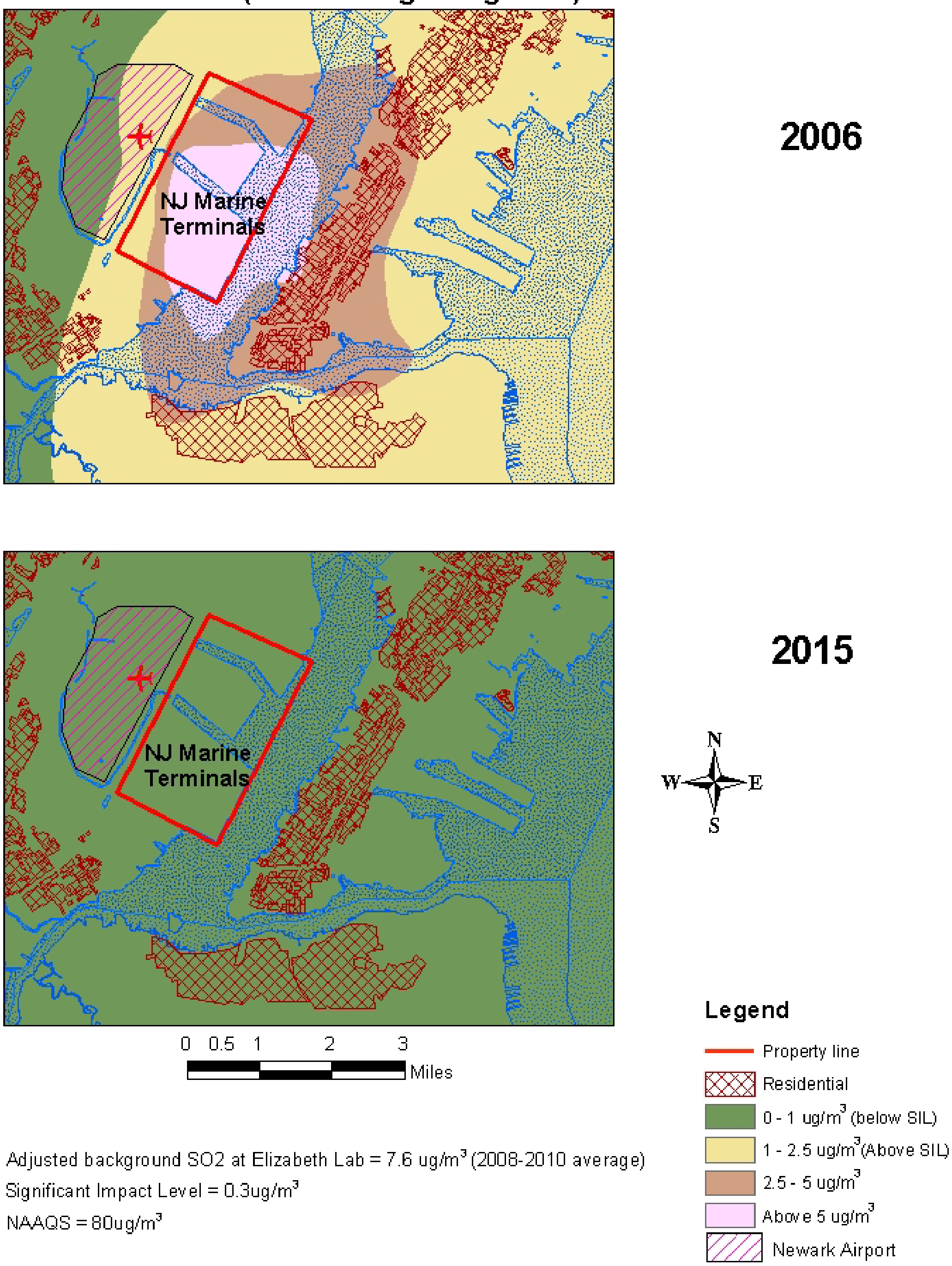


FIGURE 6: MAXIMUM PREDICTED 24-HOUR SO2 CONCENTRATIONS IN 2006 AND 2015 DUE TO ALL PORT ACTIVITIES (not including background)

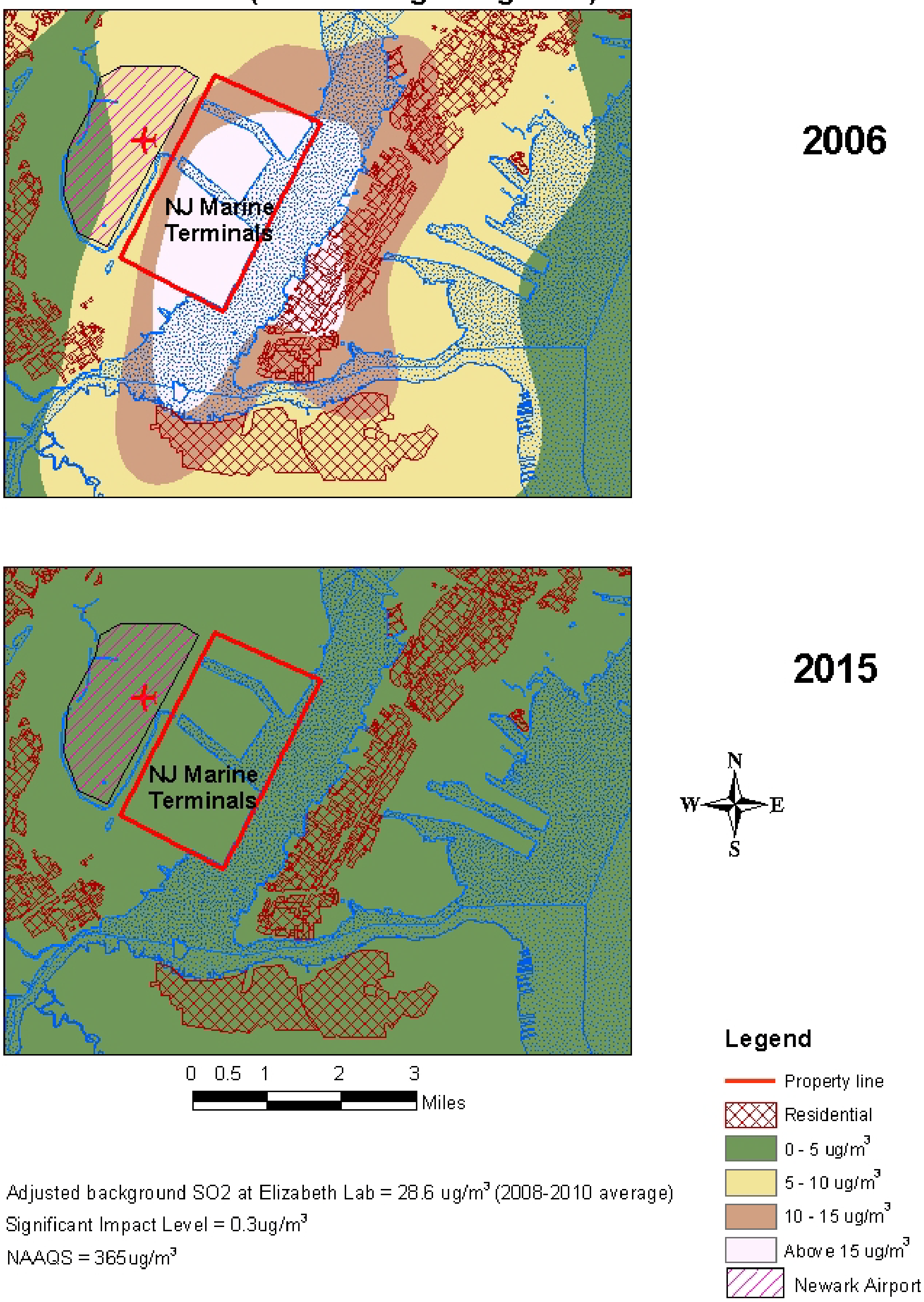
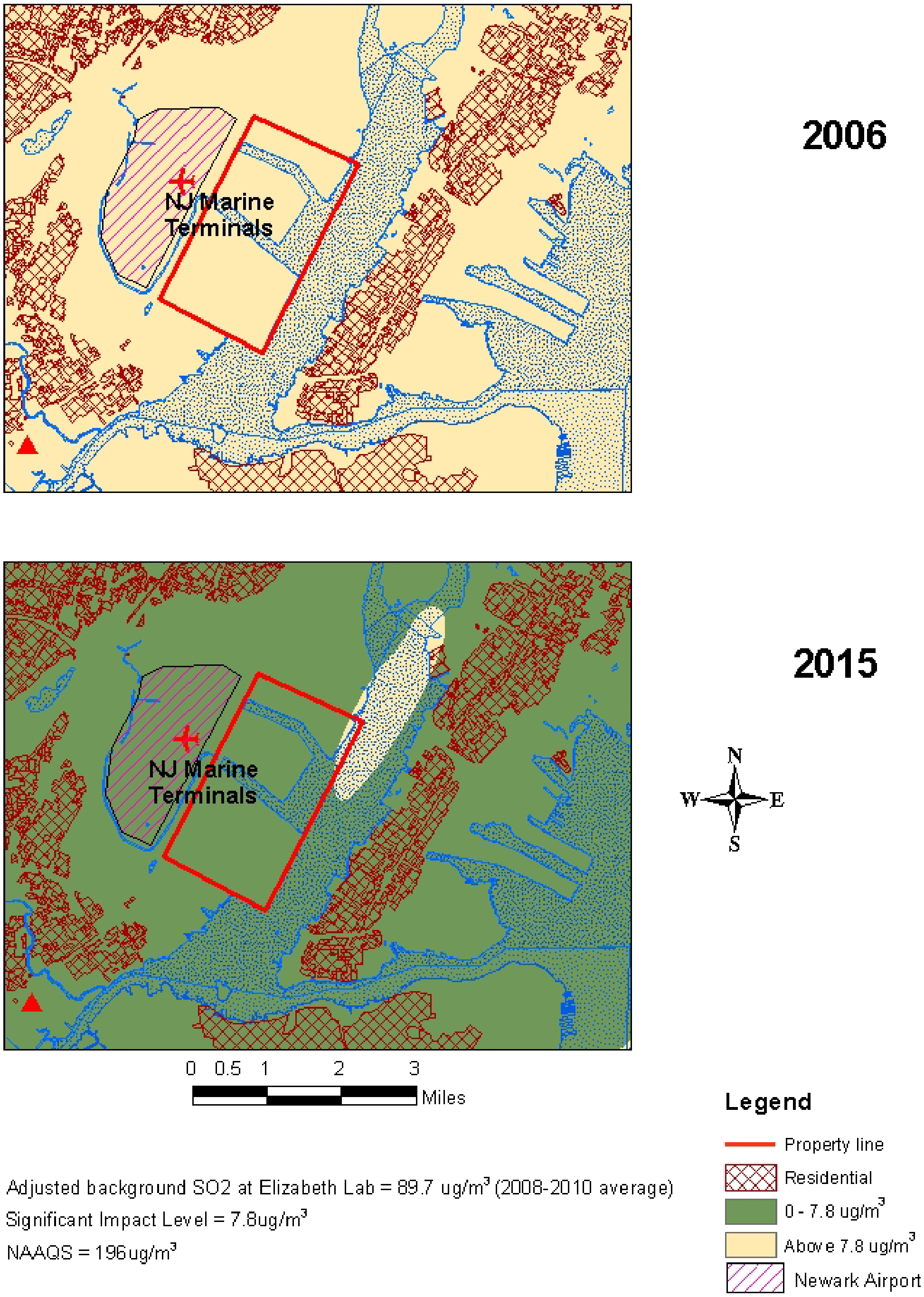


FIGURE 7: MAXIMUM PREDICTED 1-HOUR SO2 CONCENTRATIONS IN 2006 AND 2015 DUE TO ALL PORT ACTIVITIES (not including background)



Adjusted background SO2 at Elizabeth Lab = 89.7 ug/m³ (2008-2010 average)
Significant Impact Level = 7.8ug/m³
NAAQS = 196ug/m³

FIGURE 8: MAXIMUM PREDICTED 70-YEAR LIFETIME CANCER RISK DUE TO OCEAN-GOING VESSELS (DWELLING AND TRANSIT) NEAR THE PORT: A comparison of baseline and future years (not including background)

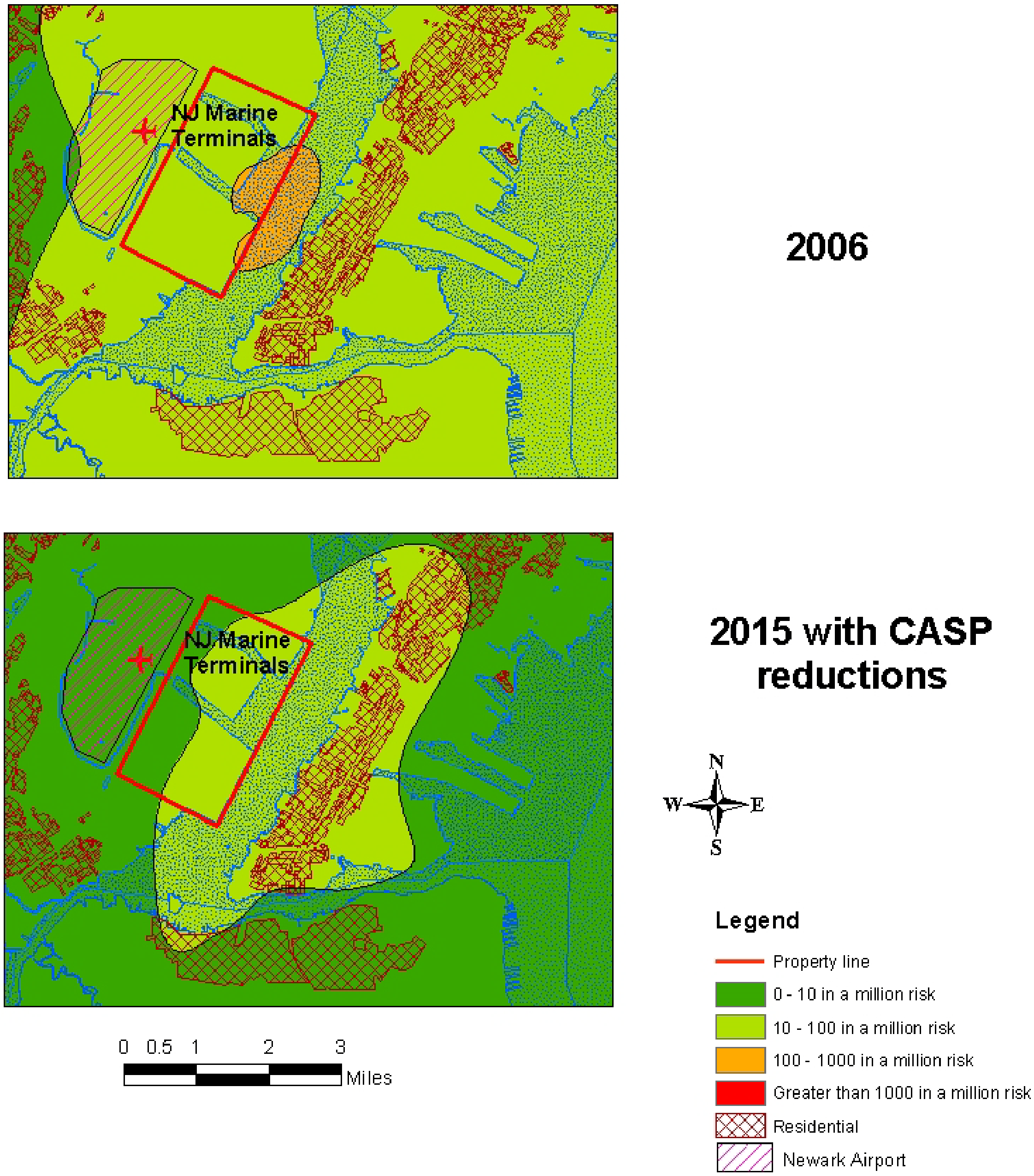


FIGURE 9: MAXIMUM PREDICTED 70-YEAR LIFETIME CANCER RISK DUE TO TUGBOATS NEAR THE PORT: A comparison of baseline and future years (not including background)

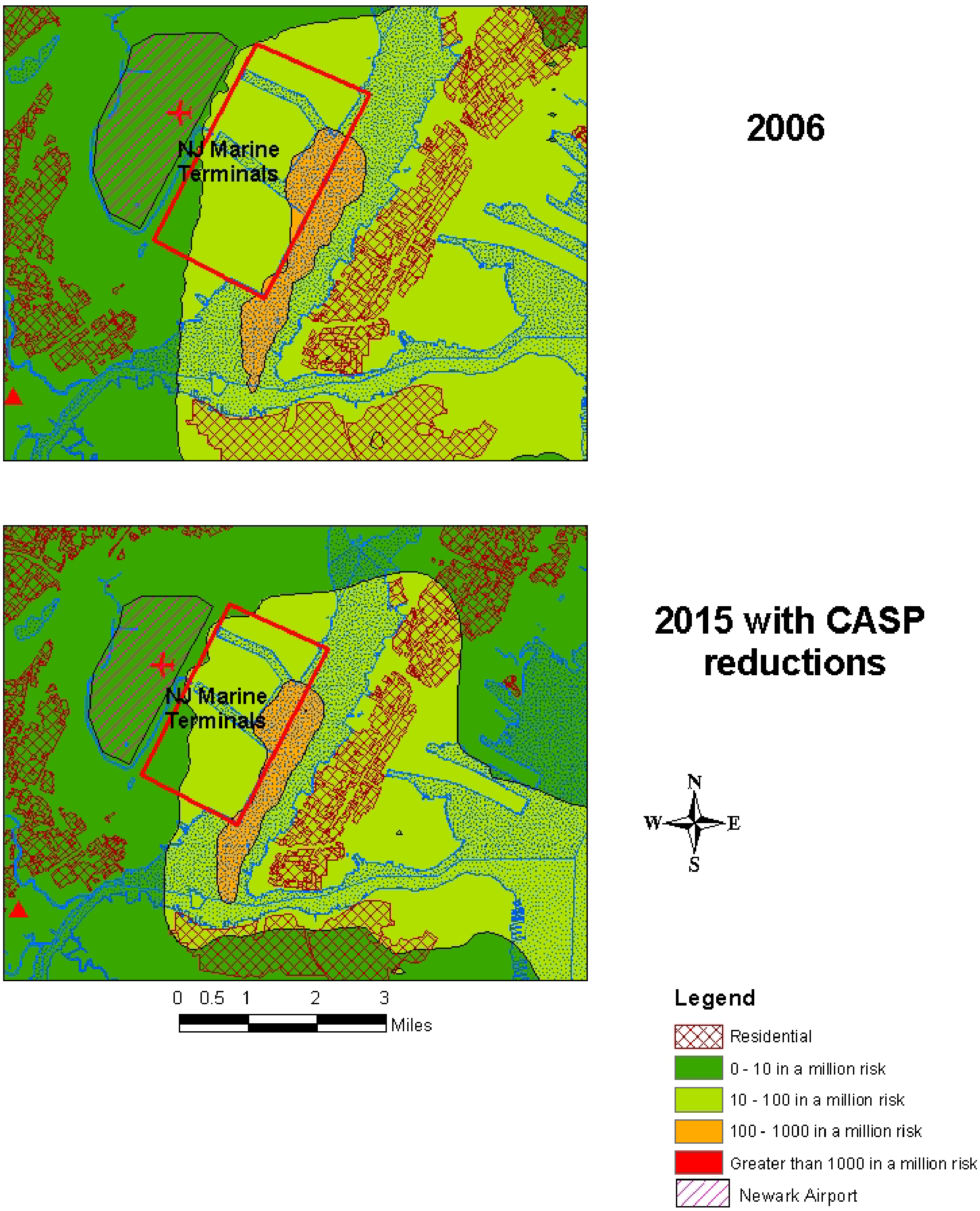


FIGURE 10: MAXIMUM PREDICTED 70-YEAR LIFETIME CANCER RISK DUE TO CARGO HANDLING EQUIPMENT NEAR THE PORT: A comparison of baseline and future years (not including background)

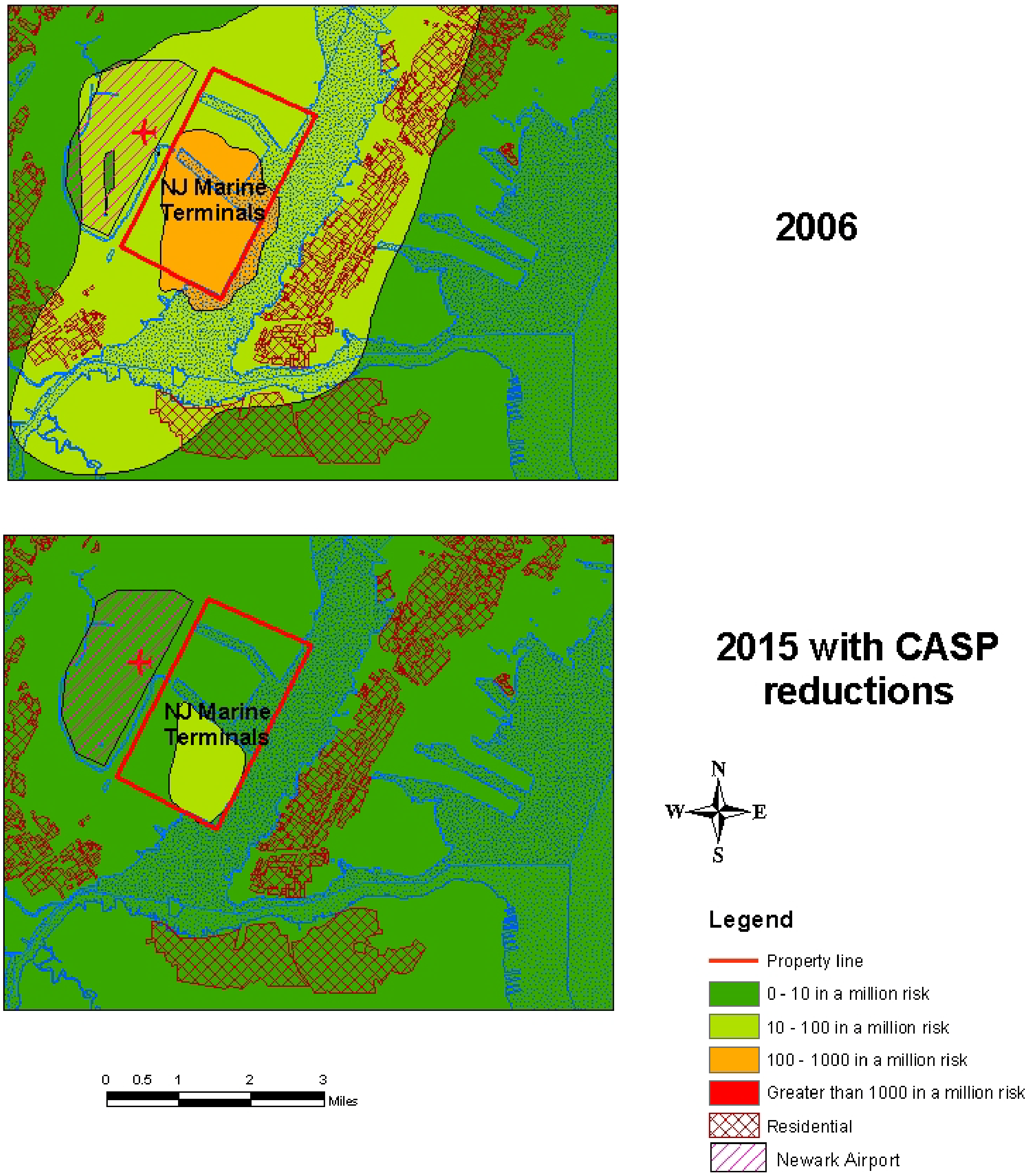


FIGURE 11: MAXIMUM PREDICTED 70-YEAR LIFETIME CANCER RISK DUE TO LOCOMOTIVES NEAR THE PORT: A comparison of baseline and future years (not including background)

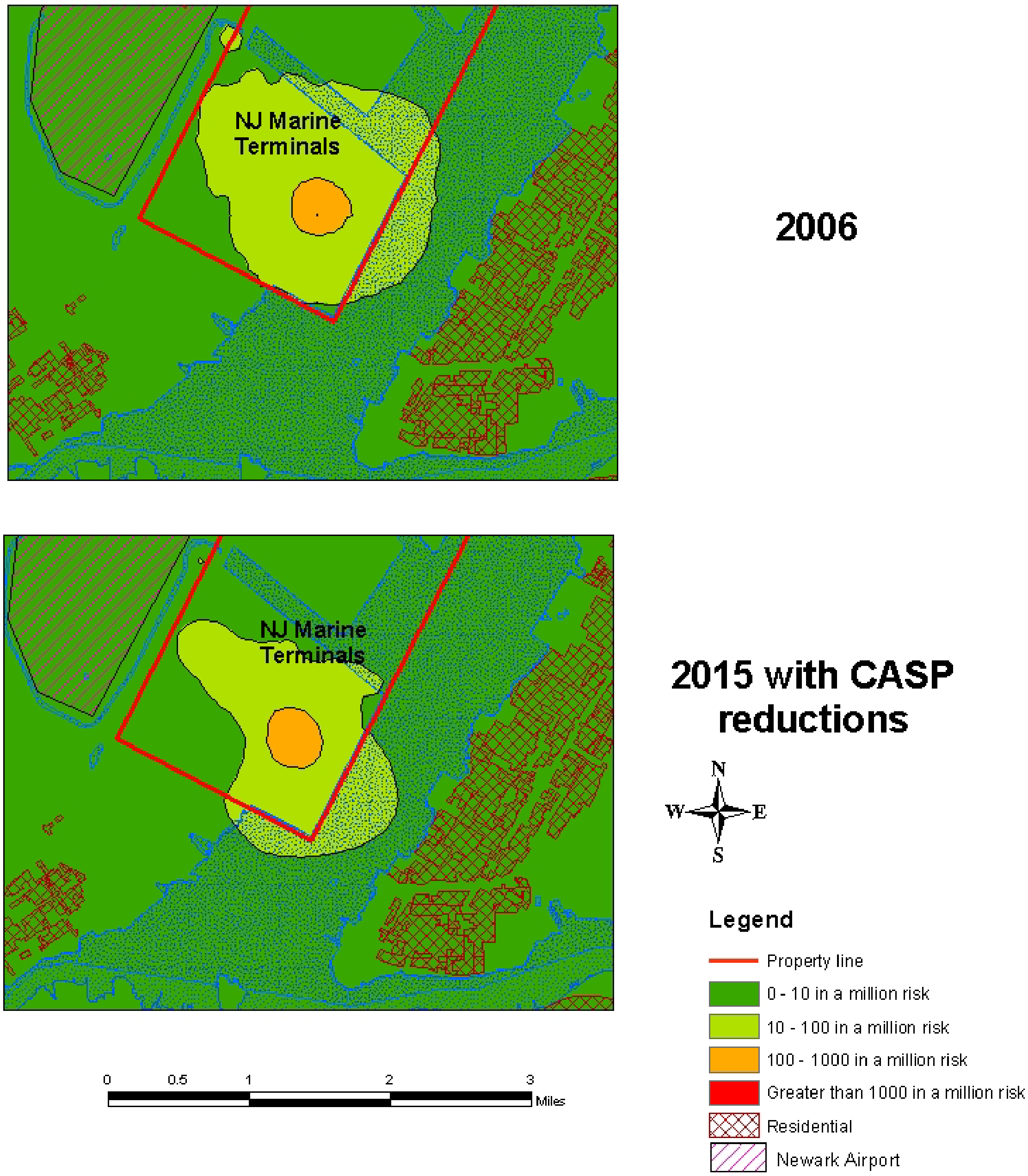
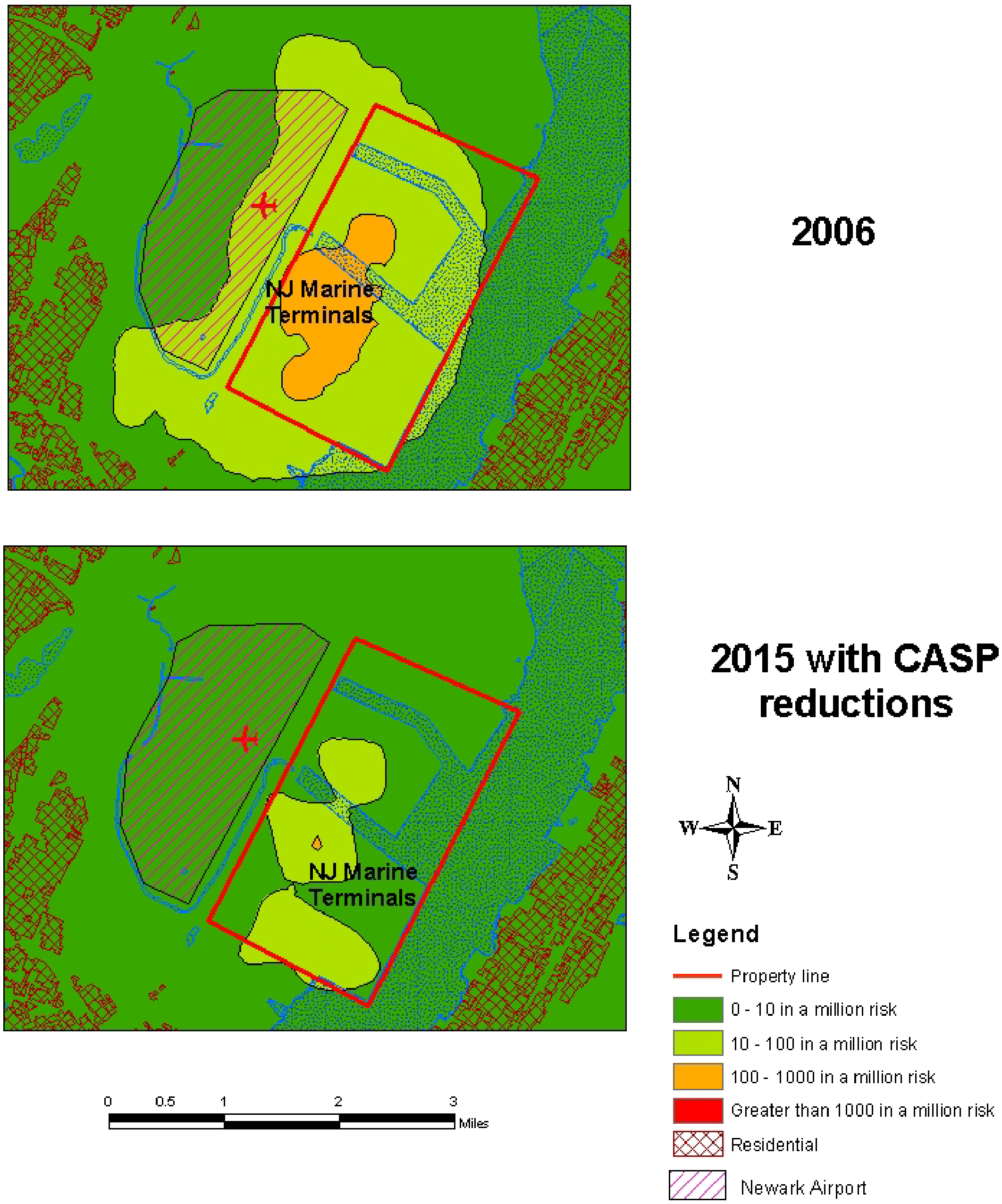


FIGURE 12: MAXIMUM PREDICTED 70-YEAR LIFETIME CANCER RISK DUE TO TRUCKS AT THE PORT AND ON ROADS LEADING TO THE PORT: A comparison of baseline and future years (not including background)



Appendix E

Use of California's Unit Risk Factor for Diesel Exhaust in Risk Assessment

New Jersey Department of Environmental Protection
Division of Air Quality
Bureau of Technical Services
9/30/2009

Executive Summary

Introduction & Background

The NJDEP Division of Air Quality (DAQ) has been using unit risk factors (URF) to evaluate cancer risk from emission sources since the late 1980s. The URF is a numerical dose-response factor that characterizes the relationship between the exposure to a substance, or dose, and the increased risk in developing cancer. These are developed from the review of toxicological and epidemiological studies by various governmental agencies and are published after a thorough review. Two primary sources of URF numbers are the USEPA's Integrated Risk Information System (IRIS) and the California Office of Environmental Health Hazard Assessment (OEHHA). Other sources of numerical dose responses may be used that meet the peer review criteria or have been evaluated in a public participation process. This document provides the reader with a summary of issues associated with diesel exhaust particulate matter emissions and the uncertainties inherent in the URF.

California's Position

California has listed diesel exhaust as a "Toxic Air Contaminant" (TAC) subject to risk assessment and risk management under California's Toxics Air Contaminant Program (Health & Safety Code section 39660). The process of adding a substance to the list of TACs is rigorous, involves public input, and approval by a Scientific Review Panel. The California Scientific Review Panel concluded that a reasonable estimate of the cancer unit risk is 3E-4/(ug/m^3).

USEPA's Position

In the *Health Assessment Document for Diesel Engine Exhaust* (May 2002), USEPA concludes that Diesel Exhaust (DE) is "likely to be carcinogenic to humans by inhalation," and that this hazard applies to environmental exposures. However, the document states, "human exposure-response data (for DE) are considered too uncertain to derive a confident quantitative estimate of cancer unit risk, and with the chronic rat inhalation studies not being predictive for environmental levels of exposure, EPA has not developed a quantitative estimate of cancer unit risk."

New Jersey's Position

The DAQ recognizes that there is always uncertainty in trying to quantify risk from exposure to a carcinogen. This is particularly true for exposure to DE. Emissions vary based on type, size, and age of engines, fuel type and operating conditions. Engines have become more efficient and less polluting, and are expected to continue this trend in the future. The DAQ also recognizes the scientific uncertainties associated with epidemiological and toxicological studies. The DAQ has reviewed the California and USEPA documentation describing how each agency arrived at their conclusion. What is clear is that the potential exposure to DE is relatively high, there is consensus it is probably carcinogenic, and that studies have shown there to be a dose-response relationship. The DAQ agrees that it meets the criteria of an air contaminant, and the risk should be evaluated in accordance with 7:27-8.5(c). The DAQ finds that in order to conduct an Air Quality Impact Analysis the best numerical value to determine risk is to use the California URF of 3E-4/(ug/m^3).

Technical Summary

Exposure

The 1996 National Air Toxics Assessment (NATA), released in 2002, was the first attempt by the USEPA to quantify the magnitude of exposure to diesel particulate matter (PM). It included estimates of ambient concentrations of diesel PM, averaged at the state, county, and census tract level. These concentrations were all attributed to emissions from mobile sources, both on-road and off-road. The contribution from stationary sources and even "non-point" sources was not included. It did not address diesel PM cancer risk.

The California Air Resources Board (CARB) estimated that the average annual ambient concentration of DE in California is 1.54 ug/m^3 (both indoor & outdoor).

In New Jersey, the estimated statewide annual average ambient concentrations of diesel PM are decreasing somewhat. It was modeled by the USEPA in the 1999 NATA to be 2 ug/m^3 (ranging from 0.82 in Cape May County to 4.65 Hudson County). The 2002 NATA modeled average ambient concentration of for NJ was 1.6 ug/m^3 (ranging from 0.7 in Cape May County to 3 in Hudson County).

Using the California URF to estimate cancer risk, a statewide exposure to diesel particulate at a concentration of 1.6 ug/m^3 gives a risk of 475 in a million.

The overall risk of developing cancer in the U.S. over a lifetime from all exposures, including air pollution, is 1 in 2 for males and 1 in 3 for females, and the risk for lung cancer is about 1 in 15. In other words, the risk for males is 500,000 in a million, the risk for females is 333,000 in a million, and the risk for lung cancer is 70,000 in a million.

Carcinogenicity of Diesel PM

There seems to be consensus that DE is human carcinogen. USEPA classifies it as "likely to be carcinogenic to humans by inhalation." The International Agency for Research on Cancer (IARC) classifies it a Group 2A carcinogen, "probably carcinogenic to humans." Numerous epidemiological studies have reported an increased cancer risk, particularly lung cancer, in populations that have been exposed to high levels of DE, such as truckers and railroad workers. Animal studies have also shown a positive association.

DE contains many gaseous and particulate compounds that are considered to be carcinogens, including known human carcinogens benzene, arsenic, and nickel. A number of hydrocarbons and PAHs, which are classified as "possibly" or "probably" carcinogenic, are adsorbed onto the particles.

It has been surmised that the total carcinogenic effect estimated for the many carcinogens identified in DE does not account for the carcinogenic effect of the whole DE. However, several animal studies have found tumors only from exposure to diesel PM. This and other considerations led California to have the particle mass serve as a surrogate measure for the whole DE exposure. Virtually all DE PM is less than 2.5 um in size.

Quantifying Cancer Risk

Unit risk is defined as the probability of contracting cancer from a lifetime (70-year) exposure to a unit concentration (1 ug/m^3) of a specific compound. A unit risk factor (URF) allows for the estimation of an increase in cancer risk in relation to exposure to an ambient air concentration. The unit risk factor yields a health risk expressed fractionally as "the chance" in a million, or 100,000, etc. of developing cancer. In the DAQ, URFs are used to estimate the magnitude of the cancer risk which may be attributable to a specific source of emissions.

To develop a URF, exposure (concentration) data is related (fitted linearly) to a specific health outcome, such as lung cancer. In general, the greater the exposure, the higher the cancer incidence, resulting in a potency slope. The confidence, and associated uncertainty, of this relationship is evaluated with statistical models that fill in data gaps, often at the lower end of the exposure range.

California's Process

California has listed diesel exhaust as a "Toxic Air Contaminant" (TAC) under California's Toxics Air Contaminant Program (Health & Safety Code section 39660). The listing process involves the production of technical support documents, conferences, public workshops, public hearings, public comment periods, and approval by a Scientific Review Panel.

Documentation of the process of listing DE as a TAC (and development of the associated URF) can be found at www.arb.ca.gov/regact/diesltac/diesltac.htm. This includes the California Environmental Protection Agency (CalEPA) "Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant" (Part A: Exposure Assessment, April 22, 1998; Part B: Health Risk Assessment for Diesel Exhaust, May 1998; and comments and responses from three comment periods, (June 1994, May 1997, and February 1998). A summary on development of the URF can be found in the *Air Toxics Hot Spots Program Risk Assessment Guidelines, Part II – Technical Support Document for Describing Available Cancer Potency Factors*, CalEPA, December 2005, in the chapter titled "Particulate Matter from Diesel-Fueled Engines."

Development of the California URF

Human epidemiological studies (usually occupational) and animal studies can be used to develop a URF. Epidemiological studies are often retrospective, in that they look back at past exposure and relate that to health outcomes that appear later. Actual measured exposures are often not available. The advantage of animal studies is that they allow for animals to be exposed to specific measured concentrations for a specific amount of time, with specific health outcomes observed. Extrapolating those results to humans is a major source of uncertainty.

The unit risks ultimately derived by California's Office of Environmental Health Hazard Assessment (OEHHA) for the general population were derived from two case studies of railroad workers. Included in the studies was the assumption that the mass concentration of particles governs the risk of DE, regardless of the particular type of diesel engine or fuel. The DE URFs are in units of "per ug/m^3 of diesel particulate matter."

California primarily used two studies in development of its URF:

- Garshick E, Schenker M, Munoz A, Segel M, Smith T, Woskie S, Hammond S and Speizer F. 1987. A case-control study of lung cancer and DE exposure in railroad workers. Am Rev Respir Dis 135:1242-1248.
- Garshick E, Schenker M, Munoz A, Segel M, Smith T, Woskie S, Hammond S and Speizer F. 1988. A retrospective cohort study of lung cancer and DE exposure in railroad workers. Am Rev Respir Dis 137:820-825.

These two studies are among a number that establish excess relative risk for lung cancer among workers exposed to DE. According to OEHHA, these two studies were specifically selected for the quantitative risk assessment because of their general excellence, their apparent finding of a relationship of cancer rate to duration of exposure, and because of the availability of measurements of DE among such railroad workers from the early 1980s in other studies. The case-control study had better information on smoking rates, while the cohort study had smaller confidence intervals of risk estimates. Neither study contained direct measurements of exposure concentrations over time. The resulting risk entails uncertainties due mostly to the limited exposure information and to the choice of models and data used in the analysis.

The effective dose was estimated to be cumulative atmospheric exposure to DE. Since direct measurements of exposure concentrations over the follow-up time of the study were not available, the exposure history had to be reconstructed. This was done using personal exposure measurements on railroad workers just after the end of the follow-up period in the study, historical data on dieselization of locomotives in the U.S., and other information. Also, data from a different study was used that estimated exposure to respirable PM for different job groups. Adjustments were made using estimated national average concentrations of PM, and for the PM attributable to environmental tobacco smoke.

For the cohort study, assumptions were made about nationwide concentrations breathed by workers. A linear rise in train dieselization was incorporated, producing a linear rise of the national average exposure concentrations around trains. Overall average cumulative exposure for the cohort for each year of follow-up (1959-1980) was quantified. There was an adjustment (intermittency correction) for non-continuous exposure. A calculation was made of the relationship between relative risk of lung cancer from DE exposure divided by the background incidence of lung cancer in the general population. Relative risks were fitted linearly to the duration of exposure, resulting in a slope. The unit risk was reported as the 95% upper confidence limit of the mathematical model.

The result that OEHHA gives is actually a range of lifetime unit risks, from 1.3E-4 to 2.4E-3/(ug/m^3), concluding that "the more scientifically valid unit risk values are near the lower end of the range." The California Scientific Review Panel concluded that a reasonable estimate of the cancer unit risk is 3E-4/(ug/m^3).

Comparisons With Other Data

A meta-analysis (a systematic combination of the results of numerous studies that generates a quantitative summary of variability) of 30 studies was used to bracket the carcinogenic potency of DE. None of the studies in the meta-analysis provided direct measurements of exposure concentration; this had to be reconstructed. The range of plausible exposures for the various populations in the studies ranged from 5 to 500 ug/m^3, resulting in risk ranging from 1.3E-4/ug/m^3 to 1.3E-2/ug/m^3. These were the extreme bounds of probable exposures. The 90% confidence interval range of the risks was calculated to be 1.6E-4 to 1.2E-3 per ug/m^3.

Available rat studies were not directly used to develop the range of URFs because of the uncertainties of extrapolating from rats to humans. However, URF values were calculated for comparison with the results of the human data. Rat data ranges were slightly within or below the bottom of the range of values based on human data.

Recognized Uncertainties Associated with the California Derived URF

Some of the significant issues in using these studies for development of a URF include:
- Lack of knowledge of actual exposure history, including possible exposure to unknown confounders;
- Historical reconstruction of exposure based on another study's exposure data for railway workers and the rate of dieselization for US railroads;
- Representativeness of railroad workers for the general population;
- Choice of analytical model.

There was considerable uncertainty in the slope in the relationship between cumulative exposure to DE & lung cancer. The 1988 cohort study states that the lack of a positive slope between cumulative exposures does not imply the study is negative, but is due to weakness in exposure assignment, changing exposures over time, and the lack of exposure data pre-1959.

There was a debate over inclusion of workers assumed to be "unexposed" to DE (clerks, signalmen) and the assumption that their exposure is background-level, and equivalent to zero. This assumption influences the slope, giving a positive result when set at zero and compared to those workers exposed to locomotive exhaust.

The studies did not include exposure prior to 1959, which could have added 10 to 15 years to exposure. This could bias the slope upward by attributing cancer incidence to the shorter exposure period. High estimates of exposure influence the estimated potency downward. Lower exposure concentrations would indicate a higher potency.

The duration of follow-up of exposed workers was relatively short. The latency for most human carcinogens is generally 20 years or more.

There were numerous programs and models available to analyze and interpret data. Their selection is discussed in detail in the OEHHA documents, and in their responses to comments.

Improvements in engines will have led to a decline in exposure to PM from the 1970s to the 1980s. Patterns of exposure would have changed because of a decline in emissions from newer engines. This could not be accounted for in the analysis.

Responses to the Issues

OEHHA: OEHHA believes that their use of a large range of risk estimates encompasses the uncertainty introduced by the limited exposure information. They state that the overall magnitude of the associated uncertainty is not unduly large. The greater than usual uncertainty in the exposure estimates is substantially offset by the much smaller than usual range of extrapolation from the occupational exposures of interest to ambient levels of concern. The extrapolation range was about 50 to 100 from the occupational exposure levels to ambient levels. OEHHA's range of risks attempts to scope out the uncertainty. The use of human data obviates the large uncertainty of extrapolating from animal data. Relative to other identified toxic air contaminants, OEHHA felt that there was a large amount of data to work with, including both noncancer and cancer studies, animal and human studies. There is less uncertainty about the range of risks from DE than about the range of risks from other identified California toxic air contaminants.

OEHHA actually presented a range of risks based on a range of exposure estimates. These exposure estimates included those provided by engine manufacturers (the high end of the range) and those estimated from lower range study data. OEHHA considered that the range could not be much broader than estimated (40 - 500 ug/m^3 with a likelier level of 50 - 240 ug/m^3). OEHHA acknowledged the uncertainty in the exposure estimates in the document, but concluded that their range of reconstructed doses is reasonable.

STAPPA/ALAPCO (now NACAA) used CalEPA's recommended URF of 3E-4/(ug/m^3) in its report on "Cancer Risk from Diesel Particulate: National and Metropolitan Area Estimates for the United States" (March 15, 2000).

Study Author's (Garshick) Comments: Eric Garshick, the primary author of the studies used in OEHHA's risk assessment, submitted comments during the public review period on how the data from his studies was used. He does stand by his study as showing an association between DE exposure and lung cancer risk in railroad workers. However, he stated that "[I]t is not possible to use the human epidemiologic data that was reanalyzed to assign a unit risk with confidence due to the uncertainty of the exposure data." OEHHA acknowledged that, given limitations in the available exposure information, it was not possible to derive a single unit risk value with confidence. However, OEHHA developed a range of upper bound unit risk values based upon a wide range of plausible exposure patterns. OEHHA also revised its analyses to include more recent information provided by the Engine Manufacturers Association with respect to diesel engine emissions and the potential magnitude of the past exposures of railroad workers.

USEPA Position and Arguments: In the *Health Assessment Document for Diesel Engine Exhaust* (May 2002), USEPA concludes that DE is "likely to be carcinogenic to humans by inhalation," and that this hazard applies to environmental exposures. However, the document also states that the DE "human exposure-response data are considered too uncertain to derive a confident quantitative estimate of cancer unit risk, and with the chronic rat inhalation studies not being predictive for environmental levels of exposure, EPA has not developed a quantitative estimate of cancer unit risk."

Kenny Crump Analysis & Comments: Crump, an independent consultant who also represents the automotive industry, was involved in analyzing data for USEPA to develop a quantitative risk assessment. In comments to OEHHA, he argued that his analysis of the cohort study shows no evidence to support an exposure-response trend. Relative risk of lung cancer decreased with increasing duration of exposure. OEHHA says there is no statistical support for these claims. They state that Crump's analyses did not use the clerks and signalmen as a control group, as they were assigned in the Garshick papers. Rather, they were treated as exposed to DE. OEHHA believes that this is a major reason that Crump does not get statistically significant exposure-response slopes in his exposure-response analyses. They disagreed with Crump's conclusions that there is no association between DE exposure and cancer because he could not find a positive dose-response trend in his analysis. Their analysis of evidence from 30 epidemiological studies indicated that DE exposure to workers is associated with an increased risk of lung cancer and that this risk is still significant after controlling as best as possible for smoking. OEHHA's meta-analysis indicates a significant exposure duration-response trend.

Miscellaneous Technical Arguments

Selection of Model: OEHHA chose a linear non-threshold model to estimate human cancer risk from DE on the theory that carcinogenesis is a result of DNA mutation from the constituents of DE. Animal and cellular studies demonstrate that DE is mutagenic. There may be other mechanisms working in concert with each other. DE is not treated as a threshold carcinogen, because there is insufficient data supporting a threshold hypothesized mechanism such as that involving lung overload.

Causal Relationship: OEHHA has stated that a causal relationship between DE exposure and human lung cancer risk is reasonable and very likely based on analysis of the epidemiological studies in the literature of exposed workers. OEHHA assessed causal inference using standard criteria. These criteria included: 1) the consistency of the findings; 2) the strength of the associations; 3) the possibility that the findings were due to bias; 4) the probability that the findings were due to chance; 5) evidence of exposure- response relationships; 6) temporality of the associations; and 7) biological plausibility of the associations. The great majority of the epidemiological studies find an association. The small magnitude of the relative risk increases the potential for confounding. However, the number and diversity of the occupations studied, and the various analyses of sources of confounding (e.g., smoking, ETS exposure, recall bias, informational bias) do not indicate that confounding or chance accounts for the observed results. While limited exposure information was available, based upon duration of exposure there was evidence of an exposure response trend.

Biological plausibility: Although this is not required for causal inference, there is biological evidence to support the association: 1) DE contains many mutagens; 2) DE causes lung cancer in animal studies; 3) DE contains many substances which occur in other complex mixtures which are respiratory carcinogens in humans; and 4) DE contains known and probable human carcinogens.

OEHHA has not shown a mechanism or even established the existence of a causal link between ambient exposures to DE and lung cancer in humans. Studies examining the association of long-term ambient exposures to DE and the incidence of lung cancer have not been done. Therefore, OEHHA has principally relied upon the available occupational exposure studies to assess the potential cancer risk. Because the range of extrapolation from the occupational exposures to the ambient exposures of concern is not large, it adds confidence to the extrapolation of findings at occupational exposures to ambient levels of exposure. With respect to the possible mechanisms of carcinogenesis, OEHHA has reviewed them, including evidence bearing on the genotoxicity of DE. The related evidence includes the presence of known genotoxins and carcinogens in DE, the bioavailability of various DE constituents, and the effects of DE or its constituents in various in vitro and in vivo test systems for genotoxicity.

Newer engines: There is very little information on the specific constituents of PM in new vs. old engines or using new vs. old fuels. Preliminary information indicates a reduction in PM, but the chemical composition of the exhaust appears to be similar between new and old exhaust. However, because distributed electrical generation may become more prevalent, the number of stationary diesel sources may increase and subsequent exposure to emissions may be increasing.

New Information: New studies will contribute to a future re-evaluation of a URF for DE. One of the most recent studies is "Lung Cancer and Vehicle Exhaust in Trucking Industry Workers" (October 2008; Eric Garshick, F. Laden, J.E. Hart, B. Rosner, M. E. Davis, E.A. Eisen, T.J. Smith. Environmental Health Perspectives, 116:1327-1332). The study established a large retrospective cohort of trucking company workers to assess the association of lung cancer mortality and measures of vehicle exhaust exposure. Adjusting for age and a healthy-worker survivor effect, lung cancer hazard ratios were elevated in workers with jobs associated with regular exposure to vehicle exhaust. Mortality risk increased linearly with years of employment and was similar across job categories despite different current and historical patterns of exhaust-related PM from diesel trucks, city and highway traffic, and loading dock operations. Smoking behavior did not explain variations in lung cancer risk. The authors concluded that trucking industry workers who have had regular exposure to vehicle exhaust from diesel and other types of vehicles on highways, city streets, and loading docks have an elevated risk of lung cancer with increasing years of work.