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#### 4.3. Estimating the number of employees incurring avoidable health damages

In order to estimate the number of avoided health damages we first estimate the amount of avoided cumulative blood index ( $\mu\text{g}/\text{dL}$  years) associated with reducing blood lead levels to 10  $\mu\text{g}/\text{dL}$  for different periods of time and then we relate these reductions to the differences in cumulative blood index between comparison groups shown for the studies shown in Table 12.

This step requires several assumptions. We assume that:

1. Employees estimated to have BLL > 10  $\mu\text{g}/\text{dL}$  will, on average, have BLL = 15  $\mu\text{g}/\text{dL}$ .
2. Employees estimated to have BLL > 30  $\mu\text{g}/\text{dL}$  will, on average, have BLL = 35  $\mu\text{g}/\text{dL}$ .
3. The effect estimates described in Table 12 are linear in cumulative blood index years.
4. The number of employees entering and exiting each industry is constant.
5. Reduction in lead exposure has the same benefit for all employees of all tenures.

Assumptions 1 and 2 allow us to estimate the number of cumulative blood index years avoided, which are needed to relate avoided lead exposure to health outcomes. Assumption 3 allows us to relate different magnitudes of blood lead reductions to the estimated health effects and Assumption 4 allows us to estimate effects for different time periods. Assumption 5 allows us to treat the health benefits to employees from reduced lead exposure the same regardless of how many previous years of exposure they experienced.

In order to illustrate the process, we describe below how we estimate the number of avoided premature deaths associated with 10 years of reduced lead exposure for Construction employees with BLL = 15  $\mu\text{g}/\text{dL}$  prior to enactment of the proposed regulation:

- Because the proposed regulation is estimated to reduce BLLs to 10  $\mu\text{g}/\text{dL}$ , an employee estimated to have a BLL of 15  $\mu\text{g}/\text{dL}$  would experience a reduction of 5  $\mu\text{g}/\text{dL}$  each year.
- After 10 years each employee would experience a reduction of  $5 \times 10 = 50$   $\mu\text{g}/\text{dL}$  years.

- The difference between comparison groups in the all-cause mortality study (Weisskopf et al 2015) was 400 µg/dL years, which was found to be associated with a Hazard Ratio of 1.86. Therefore, relying on Assumption 3 above, we estimate a 50 µg/dL year reduction to be associated with a Hazard Ratio of  $1 + 0.86*(50/400) = 1.125$ .
- We estimate 14,422 employees in Construction with BLL = 15 µg/dL and the baseline mortality rate in California is 617 deaths per 100,000 so on average we would expect 89 deaths per year among this population.
- With a hazard ratio of 1.125, 89 deaths in the low lead comparison group is estimated be associated with 100 deaths in the high lead comparison groups.
- Therefore 10 years of reducing 14,422 Constructions employees' BLLs from 15 µg/dL to 10 µg/dL would avoid an estimated  $100 - 89 = 11$  deaths.

We follow this process for both Construction and General Industry employees for each health endpoint with supporting evidence from studies using the Normative Aging Study dataset . In addition to the assumptions noted above, we convert Odds Ratios to Relative Risk using the conversions presented in Table 3 of Viera (2008) so that we can easily assess the number of avoided cases. For Hypertension, an Odds Ratio of 1.5 and an incidence of approximately 30% is associated with a Relative Risk = 1.3. Similarly, for depression, an Odds Ratio of 3.62 and a prevalence of 20.6% is associated with a Relative Risk = 2.35.

**Table 13: Annual Baseline Rates for Health Endpoints Included in Benefits Estimates**

Health Endpoint	Base Rate in CA (per 100,000)	Source
Mortality (all-cause)	617	CDC <sup>4</sup>
Hypertension	28,500	CDC <sup>5</sup>
Heart-attack (non-fatal)	387	Office of Statewide Planning and Development <sup>6</sup>
Depression/ anxiety <sup>7</sup>	20,600	National Institute of Mental Health <sup>8</sup>

<sup>4</sup> <http://wonder.cdc.gov/ucd-icd10.html> (CDC 2018)

<sup>5</sup> <https://www.americashealthrankings.org/explore/annual/measure/Hypertension/state/CA>

<sup>6</sup> [http://www.cehtp.org/faq/heart\\_attack/heart\\_attack\\_who\\_is\\_at\\_risk#\\_faq\\_1](http://www.cehtp.org/faq/heart_attack/heart_attack_who_is_at_risk#_faq_1)

<sup>7</sup> We measure depression as persistent depressive disorder or anxiety disorder.

<sup>8</sup> <https://www.nimh.nih.gov/health/statistics/persistent-depressive-disorder-dysthymic-disorder.shtml>,  
<https://www.nimh.nih.gov/health/statistics/any-anxiety-disorder.shtml>

Table 13 shows the base rates for each quantified health benefit endpoint and Table 14 shows the estimated number of avoided cases following 10 years of lower exposures associated with the proposed regulation. We also estimate the number of avoided cases 1, 5, 20, 30, and 45 years after the proposed regulations were enacted (data not shown). The number of avoided cases depends on both the effect of lead exposure (Table 12) and the base rate (Table 13). Because depression has both a large effect and a high base rate, it has the highest estimated number of avoided cases with nearly 700.

**Table 14: Estimated Number of Avoided Cases 10 Years after  
Proposed Regulation Implemented**

<b>Health Endpoint</b>	<b>Baseline # of Cases Expected for exposed employees</b>	<b>Estimated # of Avoided Cases: Construction</b>	<b>Estimated # of Avoided Cases: General Industry</b>	<b>Total Avoided Cases</b>
Mortality (all-cause)	246	11	20	31
Hypertension	11,134	106	223	329
Heart-attack (non-fatal)	154	3	7	10
Depression	8,199	223	468	691

#### 4.4. Monetizing avoided health damages

Broadly, there are two channels by which the proposed standard would generate benefits by lowering lead exposure levels faced by employees: (1) avoided morbidity and (2) avoided mortality. In order to monetize non-fatal health damages, we rely on Levin (2016), which includes estimates of costs associated with health damages from occupational lead exposure in the United States. Avoided morbidity costs can be divided into direct and indirect costs, where direct costs include spending associated with diagnosis, treatment, recovery and accommodation of a lead-

caused illness and indirect costs include productivity loss and personal time loss associated with a specific lead-caused illness. The Levin study develops a simple algorithm for monetizing both types of damages from health outcomes associated with high occupational lead exposure.

In order to value avoided premature deaths we rely on the EPA estimate of \$9.0M (in \$2017) for the Value of a Statistical Life (VSL). VSL is commonly used to measure the average person’s willingness to pay to avoid risk of death and there are well-established ranges of estimates used in regulatory impact assessments in the United States. The concept of a VSL represents the value of an average American life and therefore values a life saved of any person equally. An overview of both types of monetized damages is shown in Table 15 broken down by health outcome.

**Table 15: Overview of Direct and Indirect Monetized Health Damages (2017 \$)**

Damage	Direct per case cost	Indirect per case cost	Total per case cost
All-cause mortality	NA	NA	\$9,000,000 <sup>+</sup>
Hypertension	\$1,700	\$1,700	\$3,500*
Heart-Attack (non-fatal)	\$116,000	\$116,000	\$241,300*
Depression	\$4,000	\$8,000	\$12,500*

Source: \* Levin (2016) Table 3, \*EPA.

+ With the exception of all-cause mortality, all costs are annual.

#### 4.5. Results

We estimate that 41,000 employees have blood lead levels > 10 µg/dL and 1,200 of those employees have blood lead > 30 µg/dL. Given the baseline mortality rates for the general population, we would expect 253 deaths in a year for a population of that size. However, mortality rates for people exposed to high levels of lead are substantially higher (Weisskopf et al 2015). Moreover, the effects are cumulative so the longer the proposed regulation is in place, the more premature deaths are averted each year. Specifically, by reducing blood lead levels to



10 µg/dL we estimate that the regulation would help avoid 15 premature deaths in year 5, 31 premature deaths in year 10 and 59 premature deaths in year 20.<sup>9</sup>

**Table 16: Annual Estimated Avoided Deaths Per Year**

<b>Years after proposed regulation enacted</b>	<b>Construction</b>	<b>General Industry</b>	<b>Total</b>
1	1	2	3
5	5	10	15
10	11	20	31
20	19	40	59
30	29	60	89
45	43	90	133

Following the process outlined in the previous sections for each of the health endpoints, valuing avoided cases according to Table 15, we estimate annual health benefits from the proposed regulation to be \$27.9M in year 1 increasing each year until they reach \$1.3B per year by year 45. The selected estimated benefits are split between General Industry and Construction, roughly proportionately to the (exposure-adjusted) number of employees exposed to lead (65% General Industry, 35% Construction). By year 7 annual total benefits would have exceeded annual costs. The most valuable benefit is avoided premature deaths followed by depression, heart attacks, and hypertension, respectively.

**Table 17: Annual Estimated Avoided Health Costs Per Year (Millions 2017 \$)**

<b>Years after proposed regulation enacted</b>	<b>Construction</b>	<b>General Industry</b>	<b>Total*</b>
1	9.0	18.9	27.9
5	45.0	94.6	139.6

<sup>9</sup> These calculations assume that employees with BLL = 10 µg/dL would have the same mortality rate as the general population. However, there is some evidence that even exposure to lower levels of lead causes excess mortality.

10	90.1	189.2	279.3
20	180.1	378.4	558.6
30	270.2	567.7	837.8
45	405.3	851.5	1256.7

\*Includes value of avoided deaths, hypertension, depression/anxiety, and non-fatal heart attacks.

The value of the benefits estimated here is far greater than the estimated costs associated with the proposed regulation. Moreover, these benefits estimates represent only a fraction of the total potential benefits because we have not quantified many of the other health benefits likely to accrue from the proposed regulation.

#### 4.6. Non-Quantified Benefits

##### *Omitted Health Damages*

The present estimates do not attempt to quantify all benefits from the proposed regulation because while lead exposure is understood to cause these health damages, there have not been careful studies using the Normative Aging Study dataset to precisely quantify the relationship between cumulative lead exposure and incidence. Non-quantified health endpoints linked to lead, but without sufficient data to reliably estimate the number of avoided cases, include muscular pain, ocular disorder, nervous system disorder, panic disorder, dementia, male fertility damages, and female fertility damages, among others.

##### *Possible health damages with insufficient evidence to support causal linkages with lead*

In addition to the health damages *known* to be associated with lead that we are unable to quantify, other health damages are *suspected* to be associated with lead exposure including cancer and chronic kidney disease. However, the causal links between lead and these outcomes are not well enough established to merit inclusion in this SRIA.

##### *Benefits below regulation threshold*

We assume the reduced exposure levels under the proposed regulation will be exactly equal to the maximum allowable amount. In other words, we assume lead concentrations are not reduced below their maximum allowable concentrations due to the regulation being enacted. If the revised regulations result in lead exposure levels lower than the maximum allowable limit, then additional benefits would come from larger reductions than we model here.

#### *Benefits to non-employees*

By lowering workplace exposure the proposed regulation will also lead to reduced “takehome” exposure for non-employees. When employees are exposed to lead over the course of the workday, small lead particles accumulate on exposed skin, hair, clothing and equipment. In many cases (unless the employee changes and showers prior to returning home) these lead particles are transported home and the employee’s family is exposed to elevated levels of lead. Reducing levels of lead exposure in the workplace will therefore also reduce exposure of infants and children by reducing the amount of lead transported home from the workplace. However, while we acknowledge this additional benefit, limited information is available regarding the potential magnitude. It is expected to be relatively small compared to benefits accrued by exposed employees and is not quantified in this analysis.

## 5. Macroeconomic Impacts

### 5.1. Methodology

The economy-wide impacts of the revisions to the occupational lead safety regulations are evaluated using the BEAR forecasting model. The BEAR model is a dynamic computable general equilibrium (CGE) model of the California economy. The model explicitly represents demand, supply, and resource allocation across the California economy, estimating economic outcomes over the period 2016-2030. For this SRIA, the BEAR model is aggregated to 60 economic sectors.

The current version of the BEAR model is calibrated using 2015 IMPLAN data. Both the baseline and policy scenarios use the Department of Finance conforming forecast from June 2017. The conforming forecast includes official assumptions about future GDP growth for the State's economy and population.

### 5.2. Scenarios

The estimated macroeconomic impact of the regulation is based on expected changes in compliance costs and health expenditures for the various sectors identified in sections 3 and 4. The main scenario, *Proposed*, represents the expected macroeconomic impact of increasing compliance costs and health benefits from 2018-2030. While the compliance costs of the proposed regulations are expected to remain constant after the second year of implementation, the benefits of the proposed regulation will continue to increase as the workforce exposed to lead turns over. While this turnover process is assumed in section 4 to take approximately 45 years, the macroeconomic analysis only forecasts out to 2030. In this sense, the macroeconomic results presented here are likely to show only the medium-term effects of the proposed regulation, and to be conservative in terms of long term net benefits.

### 5.3. Inputs to the Assessment

The main inputs into the macroeconomic analysis are the sector-specific compliance costs of the proposed regulation over time and the reduction in health expenditures that can be expected as lead-induced health effects decline over time.

To model compliance costs, we match the 6-digit NAICS codes where lead-exposed employees have been identified to the relevant BEAR sector. There are two types of costs calculated in section 3: extra costs that employers must pay on intermediate goods and services (e.g. additional lab tests or engineering controls) and time costs that employers must pay for employees' lost time while undergoing testing, training MRP, etc. For each affected sector, we calculate the total compliance costs in each category of intermediate inputs and labor payments.

A summary of the direct costs and avoided health expenditures, which serve as the inputs to the BEAR model, is given in Table 18. The estimates shown are for a sample fully-implemented year (2025). Year 1 inputs into the model will be different as will health expenditure savings, which increase over time. All monetary inputs are in real \$2015 and no discounting adjustments have been made.

Table 18: Macroeconomic Model Inputs by Sector for a Representative Year (\$ million)

<b>BEAR Sector</b>	<b>Labor Costs</b>	<b>Materials Costs</b>	<b>Health Expenditures</b>
Hydroelectric Power Generation	0.01	0.58	-0.19
Fossil fuel Electric Power Generation	0.07	3.43	-1.10
Electric Power Transmission and Distribution	0.10	2.91	-1.61
Non-Electric Power Utilities	0.11	5.26	-5.37
Non-residential Construction	0.43	6.21	-5.26
Residential Construction	22.47	18.09	-45.14
Other Construction	1.34	13.66	-8.67

Non-Ferrous Metal Manufacturing	0.56	0.73	-1.20
Primary Metal Manufacturing	4.69	4.54	-14.81
Ferrous Metals Processing	22.61	29.29	-50.24
Electronics Manufacturing	1.28	1.16	-0.84
Electrical Equipment and Appliance Manufacturing	1.61	0.94	-9.99
Aircraft Manufacturing	1.50	1.89	-3.29
Wholesale Trade	18.38	22.71	-45.20
Information and Communications Services	8.08	1.88	-11.79
Professional Services	1.07	0.96	0.00
Hospitality Services	10.35	1.46	-16.84
Other Services	2.83	0.81	-1.89
Public Services	7.41	6.25	0.00

#### 5.4. Results

This section presents the expected macroeconomic impacts of the proposed regulation. Table 19 shows the key macroeconomic indicators: real gross state product (GSP), employment, real output, investment, and household income. Several observations of the macroeconomic aggregates are worth of emphasis. First, despite the large estimated direct costs (section 3) and benefits (section 4), the macroeconomic impacts of the regulatory revisions are expected to be quite small. This is due to the fact that the compliance costs and reduction in health expenditures are have offsetting impacts over the assessment period. Generally speaking, costs dominate in the early years and benefits dwarf these in the long term.<sup>10</sup> There will also be macroeconomic adjustments in production and unemployment across sectors that will average out in the macroeconomic aggregates presented below. Some sectors (e.g. compliance services and products) may see increased employment and output, while other sectors may see lower unemployment and output as they internalize higher compliance cost impacts. In later years, the

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<sup>10</sup> Given that we are only evaluating about half the long-term (full career) health improvement (to 2045), the dominance of benefits to California employees and their families is even more dramatic.

trends in macroeconomic indicators is largely reversed as the effects of higher health expenditure savings surpasses compliance costs. In 2030, the final year of our analysis period, real GSP is estimated to be \$2.40 million higher than the baseline, small in percentage terms but important to the industries and employees involved. Similar impacts are also observed in other macro indicators, such as real output, investment, and household income.

The second observation is that in the early years of the proposed regulation, employment and the macroeconomic income and expenditure indicators move in opposite directions. Total employment actually increases for the early years of the proposed regulations. This is likely due to the nature of the employment composition in sectors that are affected by higher compliance costs. Compliance may adversely impact some jobs in covered industries, but at the same time stimulates employment in (generally smaller and more labor intensive) sectors providing compliance equipment and services. Finally, health related savings will be diverted from medical care to other consumption, about 70% of which is services in California. This expenditure shifting offers strong, job-intensive long-term stimulus from the regulation. Moreover, services are primarily in-state in their direct and indirect employment impact – these jobs cannot be outsourced.

**Table 19: Economy-wide Impacts of Occupational Lead Standards**  
(billion \$ difference from baseline, 2015\$ unless otherwise noted)

	<b>2018</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
Real GSP	-0.26	-0.42	-0.02	2.40
Employment (1,000 FTE)	0.09	0.25	0.24	3.08
Real Output	-0.28	-0.51	0.23	4.36
Investment	-0.12	-0.1	0.42	1.84
Household Income	-0.04	-0.08	-0.02	0.75

Table 20 decomposes the total change in real business output into sector-specific changes in real enterprise output. The effects of the proposed regulation on sectoral output are varied

across both sectors and years. In the early years of the proposed regulations, when compliance costs are significantly larger than health benefits, all sectors of the economy see very small reductions in trend output.<sup>11</sup> This trend is reversed as health expenditures exceed compliance costs later in the analysis period.

**Table 20: Decomposition of Industry Output**  
(billion \$ difference from baseline, million 2015\$)

Sector	2018	2020	2025	2030
AgForestry	0.01	0	-0.02	-0.06
Mining	0	0	0	0.02
Utilities	-0.01	-0.03	-0.04	-0.01
Construction	-0.06	-0.07	0.14	0.83
Manufacturing	-0.14	-0.21	0.12	1.46
Wholesale Trade	-0.06	-0.08	0.08	0.69
Retail Trade	0	-0.01	0.01	0.16
Transportation	-0.01	-0.01	0.01	0.14
Services	-0.01	-0.08	-0.05	1.16
Government	0	-0.01	-0.02	-0.02

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<sup>11</sup> It should be emphasized that reducing trend output by these amounts means, in every case, that these sectors will continue growing over time, but at negligibly slower rates in some years because of net compliance costs. Since baseline (trend) annual growth in California is assumed to exceed 2%, the largest effect above indicates that this growth would be slightly lower growth in the most impacted year. Thus, current employment would never decline (no jobs are lost) even in growth moderates.



## 6. Fiscal Impacts

This section details the expected fiscal impact of the proposed revisions to the occupational lead regulations. There are two dimensions to the fiscal impact considered here. First, a number of lead-exposed employees are employed in state and local governments. Table 21 shows that there are an estimated 72,439 local government employees and 41,038 state government employees exposed to lead. The vast majority of these employees are in law enforcement. There will be compliance costs, borne by local and state agencies, associated with reducing the lead exposure of those employees.

Table 21: Estimated Total Exposed Employees by Private/Public Sector

2-digit NAICS Code	Sector	Private Sector EEs	Local Gov't EEs	State Gov't EEs	Total Exposed Employees
<b>Section 1532.1 (Construction)</b>					
22	Utilities	1,005	1,160	0	2,165
23	Construction	72,725	1,808	110	74,643
53	Real Estate and Rental and Leasing	2,168	11	0	2,179
56	Admin/Support/Waste Mgt and Remediation Services	4,762	0	0	4,762
92	Public Administration	0	1,119	0	1,119
	<b>Total Exposed Employees (1532.1)</b>	<b>80,660</b>	<b>4,098</b>	<b>110</b>	<b>84,868</b>
<b>Section 5198 (General Industry)</b>					
31-33	Manufacturing	15,614	0	0	15,614
42	Wholesale Trade	9,090	0	0	9,090
51	Information	644	0	0	644
54	Professional, Scientific, and Technical Services	814	0	0	814
56	Admin/Support/Waste Mgt and Remediation Services	5,590	0	0	5,590
71	Arts, Entertainment, and Recreation	846	893	26	1,764

81	Other Services (except Public Administration)	690	0	0	690
92	Public Administration	0	67,448	40,903	108,351
<b>Total Exposed Employees (5198)</b>		<b>33,288</b>	<b>68,341</b>	<b>40,928</b>	<b>142,557</b>
<b>Total Exposed Employees</b>		<b>113,948</b>	<b>72,439</b>	<b>41,038</b>	<b>227,425</b>

The additional compliance costs to local and state governments are shown in Table 22. We estimate that the proposed regulations will cost local governments approximately \$11.3 million and \$9.7 million per year in years 1 and 2+, respectively. Just under half of this is expected to be associated with local police departments coming into compliance with more stringent occupational lead standards. Utilities and Construction employees employed by local governments account for most of the rest of the additional cost. The proposed regulations are expected to cost the California state government approximately \$2.8 million and \$2.7 million per year in years 1 and 2+, respectively. Eighty-six percent (86%) of this cost is associated with state law enforcement agencies.

**Table 22: Estimated Additional Public Sector Compliance Costs**

2- Digit NAICS Code	Sector	Total Public Sector Cost		Local Government Cost		State Government Cost	
		Year 1	Year 2+	Year 1	Year 2+	Year 1	Year 2+
<b>Section 1532.1 (Construction)</b>							
22	Utilities	\$3,187,425	\$3,187,425	\$3,187,425	\$3,187,425	\$0	\$0
23	Construction	\$2,457,155	\$1,669,455	\$2,103,268	\$1,309,793	\$353,887	\$359,662
53	Real Estate and Rental and Leasing	\$12,029	\$8,767	\$12,029	\$8,767	\$0	\$0
56	Admin/Support/Waste Mgt Services	\$0	\$0	\$0	\$0	\$0	\$0
92	Public Administration	\$1,097,238	\$678,154	\$1,097,238	\$678,154	\$0	\$0
	<b>Total Cost (1532.1)</b>	\$6,753,847	\$5,543,801	\$6,399,960	\$5,184,139	\$353,887	\$359,662
<b>Section 5198 (General Industry)</b>							
31-33	Manufacturing	\$0	\$0	\$0	\$0	\$0	\$0
42	Wholesale Trade	\$0	\$0	\$0	\$0	\$0	\$0
51	Information	\$0	\$0	\$0	\$0	\$0	\$0
54	Professional, Scientific, and Technical Services	\$0	\$0	\$0	\$0	\$0	\$0
56	Admin/Support/Waste Mgt Services	\$0	\$0	\$0	\$0	\$0	\$0
71	Arts, Entertainment, and Recreation	\$788,134	\$577,196	\$766,171	\$561,111	\$21,964	\$16,085
81	Other Services (except Public Administration)	\$0	\$0	\$0	\$0	\$0	\$0
92	Public Administration	\$6,525,032	\$6,263,876	\$4,101,403	\$3,937,540	\$2,423,629	\$2,326,336
	<b>Total Cost (5198)</b>	\$7,313,166	\$6,841,072	\$4,867,574	\$4,498,651	\$2,445,593	\$2,342,422
	<b>Total Cost</b>	\$14,067,013	\$12,384,874	\$11,267,534	\$9,682,790	\$2,799,480	\$2,702,084

DOSH, the government agency that would enforce the proposed revisions, does not anticipate any fiscal impact to the agency as a result of the proposed revisions.

## 7. Analysis of Regulatory Alternatives

In addition to the proposed regulatory revisions to the Title 8 occupational lead standards, we analyze the impacts of two regulatory alternatives. One of the regulatory alternatives is more stringent than the proposed regulation and other regulatory alternative is less stringent.

For the more stringent regulatory alternative, we assume that the permissible exposure limit is set at 2  $\mu\text{g}/\text{m}^3$ , rather than the proposed level of 10  $\mu\text{g}/\text{m}^3$ . This change would both increase the compliance costs for regulated entities and potentially increase employee benefits by reducing even low-level occupational exposure to lead. The additional compliance actions required under the lower PEL, compared to baseline requirements, are shown in Table 23.

**Table 23: Compliance Requirements Under the More Stringent Regulatory Alternative**

Control Requirement	Airborne Exposure Level ( $\mu\text{g}/\text{m}^3$ )					
	<0.5	0.5 -2	2 - 30	30 - 50	50 - 500	>500
Air Monitoring		X	X			
Engineering Controls			X	X	X <sup>1</sup>	X <sup>1</sup>
Respiratory Protection			X	X	X <sup>2</sup>	X <sup>3</sup>
Personal Protective Equipment		X	X	X		
Hygiene- Advanced			X	X		
Hygiene - basic	X	X	X	X		
Medical Surveillance		X	X	X	X	X
Medical Work Removal				X		
Training - Comprehensive		X	X	X		

<sup>1</sup> Upgraded engineering controls

<sup>2</sup> ½ full mask, ½ half mask respirator

<sup>3</sup> Supplied air respirators

For the less stringent regulatory alternative, we assume that the current occupational lead requirements remain as they are. There would be no additional compliance costs beyond what firms are already required to do under existing regulations. However, there would also be no additional benefits for California employees working in occupations with lead exposure.

## 7.1. Summary of Direct Costs and Direct Benefits

A summary of the direct costs and benefits for the more stringent and less stringent regulatory alternative are described below.

### *More Stringent Regulatory Alternative*

Compliance costs for the more stringent regulatory alternative, with a lower PEL, are shown in Table 24 (for Construction) and Table 25 (for General Industry). The total compliance costs for Construction are nearly identical to the compliance costs under the proposed regulation. This is due to the fact that most exposure employees in Construction had exposure levels less than 10 ug/m<sup>3</sup> so a lower PEL would not capture many additional employees. However, in General Industry, the compliance costs nearly double from \$144 million (year 1) and \$111 million (year 2+) under the proposed regulation to \$281 million (year 1) and \$203 million (year 2+) with the lower PEL. This is driven almost entirely by the fact that thousands of law enforcement employees would be required to adopt more stringent control requirements than would be required under the proposed regulatory changes.

**Table 24 : Summary of Additional Compliance Costs for Lower PEL in Construction (\$2017)**

<b>Cost Component</b>	<b>Year 1</b>	<b>Year 2+</b>
Air Monitoring	\$4,033,646	\$2,175,011
Engineering Controls	\$6,214,218	\$6,666,374
Respiratory Protection	\$3,130,275	\$3,240,515
Personal Protective Equipment	\$1,243,819	\$1,243,819
Hygiene (lunchroom, showers, change rooms)	\$6,801,272	\$6,801,272
Hygiene - basic	\$12,151,886	\$12,151,886
Medical Surveillance	\$66,452,139	\$47,680,091
Medical Removal Program	\$0	\$0
Training - Comprehensive	\$4,431,073	\$4,431,073
<b>Total Compliance Cost - Construction (1532.1)</b>	<b>\$104,458,328</b>	<b>\$84,390,041</b>

**Table 25: Summary of Additional Compliance Costs for Lower PEL in General Industry (\$2017)**

<b>Cost Component</b>	<b>Year 1</b>	<b>Year 2+</b>
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Air Monitoring	\$55,470,495	\$14,666,867
Engineering Controls	\$37,728,683	\$38,195,216
Respiratory Protection	\$1,124,288	\$1,004,941
Personal Protective Equipment	\$5,590,355	\$5,590,355
Hygiene - Advanced	\$55,785,858	\$55,785,858
Hygiene - Basic	\$22,009,542	\$22,009,542
Medical Surveillance	\$29,592,965	\$12,215,519
Medical Removal Program	\$19,931,341	\$0
Training - Comprehensive	\$53,604,343	\$53,604,343
<b>Total Compliance Cost - General Industry (5198)</b>	<b>\$280,837,869</b>	<b>\$203,072,639</b>

Reducing the permissible exposure limit to 2  $\mu\text{g}/\text{m}^3$  would generate all of the same benefits as reducing the permissible exposure limit to 10  $\mu\text{g}/\text{m}^3$  as well as further benefits from the additional reduction below 10  $\mu\text{g}/\text{m}^3$ . The benefits of reduction below 10  $\mu\text{g}/\text{m}^3$  depend on the health risks of low-level lead exposure and these remain unclear. While exposure to small amounts of lead was previously thought to present minimal health risk, recent work by Lanphear et al 2018 suggests that even low-level environmental lead exposure may increase the risk of cardiovascular disease mortality. While this new finding suggests substantial benefits would result from the additional reduction in exposure, most studies do not attempt to quantify the health benefits from reductions in exposure below these levels and so there is insufficient evidence to quantify the magnitude of these benefits.

#### *Less Stringent Regulatory Alternative*

The less stringent regulatory alternative, where the current regulatory requirements remain in effect, would produce no additional benefits to employees in California. There would also be no additional compliance cost for regulated entities. However, there is an opportunity cost of the less stringent regulatory alternative, which are the foregone employee benefits from reducing occupational lead exposure. Relative to the proposed regulation, these opportunity costs are quite large, as shown in Table 17, starting at approximately \$28 million in year 1 and increasing to over \$1.2 billion after 45 years.

## 7.2. Macroeconomic Impacts

In addition to the direct costs and benefits discussed above, we also analyzed the macroeconomic impacts of the more stringent regulatory alternative.<sup>12</sup> Table 26 summarizes the macroeconomic impacts of the more stringent regulatory alternative and provides a comparison to the expected macroeconomic impact of the proposed regulation. Across all key macroeconomic indicators, the lower PEL has larger adverse effects on the economy in the early years of implementation and more muted positive impacts on the economy in later years.

**Table 26 : Economy-Wide Impacts of Occupational Lead Standards – More Stringent Regulatory Alternative** (billion \$ difference from baseline, \$2015 unless otherwise noted)

	2018		2020		2025		2030	
	Proposed	Lower PEL	Proposed	Lower PEL	Proposed	Lower PEL	Proposed	Lower PEL
Real GSP	-0.26	-0.4	-0.42	-0.6	-0.02	-0.86	2.40	0.34
Employment (1,000 FTE)	0.09	-0.09	0.25	-0.11	0.24	-2.46	3.08	-3.86
Real Output	-0.28	-0.37	-0.51	-0.75	0.23	-0.95	4.36	1.37
Investment	-0.12	-0.23	-0.1	-0.34	0.42	-0.29	1.84	0.57
Household Income	-0.04	-0.11	-0.08	-0.16	-0.02	-0.44	0.75	-0.35

## 7.3. Comparison to Proposed Regulatory Revisions

This analysis considered two regulatory alternatives: a more stringent alternative that delivers potential additional employee benefits from even less exposure to occupational lead, but at a significantly higher cost, and a less stringent alternative that considers keeping occupational lead standards as they currently are. The more stringent regulatory alternative can be rejected because the additional benefits, which are difficult to quantify, come at nearly double the cost of

<sup>12</sup> A macroeconomic analysis of the less stringent alternative is not necessary since so additional compliance costs would be imposed on regulated entities. Therefore, no macroeconomic impacts would be expected.

the proposed regulation. The less stringent regulatory alternative can be rejected for not delivering adequate benefits, given the known risks to lead exposure, to employees in California.

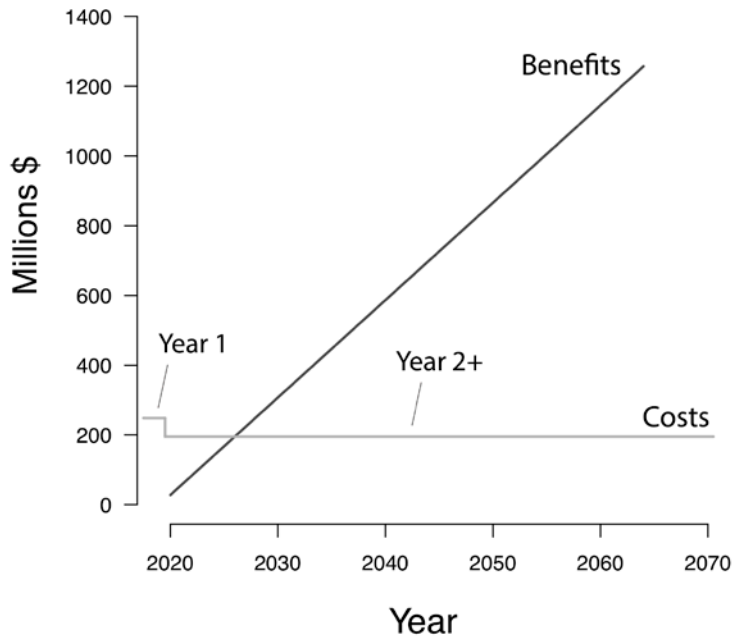


## 8. Interpretation of Economic Results

The Department of Industrial Relations' proposal to revise its occupational lead standards for Construction and General Industry is expected to give rise to compliance costs for industries where employees are currently exposed to lead, but reforming decades-old exposure safety standards will confer health benefits on current and future California employees and their families that far exceed these costs. Compliance costs reflect the need to update 40+ year-old exposure and health intervention standards, providing employees with enhanced protections to reduce exposure (e.g. engineering controls, respiratory protection, hygiene and personal protective equipment), while strengthening employee training, air monitoring, medical surveillance, and medical intervention requirements. These costs are expected to accrue to the sectors whose employees are exposed to lead, and ultimately would be passed along to consumers of products in these industries. The benefits of the proposed regulation include reductions in morbidity and mortality associated with lower levels of lifetime air and oral exposure to lead, a material whose toxicity occurs at much lower levels than had long been indicated. Employees in a large swath of California industries will experience and share health benefits from reduced exposure to lead. In addition, lead exposures to household members of employees from take-home lead would be reduced, resulting in additional health benefits.

As the full, long-term benefits of the proposed regulatory revisions are realized, the annual benefit-cost ratios for this regulation are quite high and sustained, with benefits expected be substantially larger than compliance costs. However, compliance costs begin to accrue immediately while the health benefits manifest themselves over time (Figure 3). The estimated aggregate breakeven point under the assumptions of this assessment would occur approximately within the first 7 years after the proposed revisions come into effect. It should also be recalled that the benefit estimates used in this study are not comprehensive and that total benefits are expected to be substantially higher.

Figure 3 Annual Costs vs. Benefits Over Time



Our macroeconomic results show the proposed revisions will likely have a negligible impact on the overall California economy, measured in terms of Gross State Product, employment, real business output, and household income. Because lead-exposed employees are spread across the diverse activities, the impacts of the regulation are not concentrated in any particular sector. The exception is in the early years of regulatory implementation when the construction and manufacturing sectors have high compliance costs, which reduces sectoral output. Even in sectors that show positive net compliance cost in some years, however, the impact is never high enough to reduce absolute output or jobs. All sectors remain growth and employment positive in every year, even if growth is moderated slightly by the need to improve employee health and safety.

## 9. References

Centers for Disease Control and Prevention (2016), National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. Disease Indicators Data [online]. 2016. <https://nccd.cdc.gov/cdi>.

Cheng, Y., Schwartz, J., Sparrow, D., Aro, A., Weiss, S.T., and H. Hu (2001). "Bone Lead and Blood Lead Levels in Relation to Baseline Blood Pressure and the Prospective Development of Hypertension The Normative Aging Study", *American Journal of Epidemiology*, Volume 153, Issue 2, 15 January 2001, Pages 164–171, <https://doi.org/10.1093/aje/153.2.164>

Environmental Protection Agency (2013). Integrated Science Assessment (ISA) for Lead. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-10/075F.

Kosnett, M.J., Wedeen, R.P., Rothenberg, S. J., Hipkins, K.L., Materna, B.L., Schwartz, B.S., Hu, H., and Woolf, A. (2007). "Recommendations for Medical Management of Adult Lead Exposure." *Environmental Health Perspectives*, Volume 115(3), Pages 463-471.

Lanphear, B. P. , S. Rauch, P. Auinger, R. W. Allen, and R. W. Hornung (2018). "Low-level lead exposure and mortality in us adults: a population-based cohort study". *The Lancet Public Health*, 2018.

Levin, R. (2016). "The attributable annual health costs of U.S. occupational lead poisoning", *International Journal of Occupational and Environmental Health*, 22:2, 107-120, DOI: 10.1080/10773525.2016.1173945

Hu H, Aro A, Payton M, et al (1996). "The Relationship of Bone and Blood Lead to Hypertension: The Normative Aging Study". *JAMA*. 1996; 275 (15):1171–1176. doi:10.1001/jama.1996.03530390037031

HUD (2017). "Economic Analysis of the Proposed Rule on Lead-Based Paint: Requirements for notification, evaluation, and reduction of lead-based paint hazards in federally owned residential property and housing receiving federal assistance; Response to elevated blood lead levels". Office of Lead Hazard Control and Healthy Homes. U.S. Department of Housing and Urban Development. January 3, 2017.

Jain, N., Potula, V., Schwartz, J., Vokonas, P., Sparrow, D., Wright, R., Nie, H., and H. Hu. (2007). "Lead Levels and Ischemic Heart Disease in a Prospective Study of Middle-Aged and Elderly Men:

the VA Normative Aging Study”. *Environmental Health Perspectives* Vol 115 (6), pages 871-875, June 2007.

OSHA (2007) “Regulatory Review of 29 CFR 1926.62: Lead in Construction.” Occupational Safety and Health Administration. U.S. Department of Labor. Available at <https://www.osha.gov/dea/lookback/lead-construction-review.html>

OSHA (2013) “Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis, Occupational Exposure to Crystalline Silica.” Occupational Safety and Health Administration. U.S. Department of Labor.

OSHA (2016). “Final Economic Analysis and Final Regulatory Flexibility Analysis: Supporting Document for the Final Rule for Occupational Exposure to Beryllium. Chapter 6 – Benefits and Net Benefits”. Occupational Safety and Health Administration. U.S. Department of Labor. 2016.

Rhodes, D., Sprio, A., Aro, A., and Hu, H. (2003). “Relationship of Bone and Blood Lead Levels to Psychiatric Symptoms: The Normative Aging Study”. *Journal of Occupational and Environmental Medicine*. 45 (11) pgs 1144-1151.

Viera, Anthony (2008). “Odds ratios and risk ratios: what’s the difference and why does it matter?”. *Southern Medical Journal*, 101 (7) 730-734.

Weisskopf, M. G., Sparrow, D., Hu, H., & Power, M. C. (2015). “Biased Exposure–Health Effect Estimates from Selection in Cohort Studies: Are Environmental Studies at Particular Risk?” *Environmental Health Perspectives*, 123(11), 1113–1122. <http://doi.org/10.1289/ehp.1408888>











used to calculate the NAICS-specific cost of employees being medically removed under the proposed standards. (See A.1.2.)

## A2. Appendix References

CDPH-OLPPP “California Painters Project: Helping Small Business Work Safely With Lead”, February 1998.

CalEPA-OEHHA “Estimating Workplace Air and Worker Blood Lead Concentration using an Updated Physiologically-based Pharmacokinetic (PBPK) Model”, October 2013.

Koh et al., “Lead exposure in US worksites: A literature review and development of an occupational lead exposure database from the published literature,” *Am J Ind Med.* 2015; 58(6): 605-616.

Koh et al., “Combining Lead Exposure Measurements and Experts’ Judgement Through a Bayesian Framework”, *Annals of Work Exposures and Health*, 2017, Vol. 61, No. 9, 1054-1075.

Kromhout et al., “A Comprehensive Evaluation of Within- And Between- Worker Components of Occupational Exposure to Chemical Agents”, *Ann. Occup. Hyg.*, 1993, Vol 37, No. 3, pp 253-270.

Locke et al., “Evaluating Predictors of Lead Exposure for Activities Disturbing Materials Painted With or Containing Lead Using Historic Published Data From U.S. Workplaces”, *Am J Ind Med.* 2017; 60:189-197.

National Research Council, “Potential Health Risks to DOD Firing-Range Personnel from Recurrent Lead Exposure”, Washington, DC: The National Academies Press, 2013.

<https://doi.org/10.17226/18249>.

