

State of California
Department of Cannabis Control
California Code of Regulations, Title 4, Division 19
Initial Statement of Reasons:
Pesticide Testing

INTRODUCTION

The Department of Cannabis Control (“Department” or “DCC”) is responsible for administering and enforcing the provisions of the Medicinal and Adult-Use Cannabis Regulation and Safety Act (MAUCRSA, Bus. & Prof. Code § 26000 et seq.), including the cultivation, manufacture, and testing of commercial cannabis and cannabis products.

BACKGROUND

The Department is specifically tasked with prioritizing the protection of the public in its regulatory activities (BPC §26011.5). MAUCRSA further specifies that the Department mandate only commercially feasible procedures, technology, or other requirements, and must not make compliance so onerous that the operation under a cannabis license is not worthy of being carried out in practice by a reasonably prudent businessperson (BPC §26013(c)).

Business and Professions Code section 26060(c) requires the Department of Pesticide Regulation (DPR) to develop guidelines for action levels for pesticide residues in harvested cannabis. Under Business and Professions Code section 26100(d)(2), DCC is responsible for establishing maximum allowable levels of contaminants and must consider guidelines set by DPR in establishing action levels for residual pesticides.

The Department’s residual pesticide action levels have not been updated since their initial adoption in 2017. Since that time, the Department has developed a more thorough understanding of how pesticides are used in commercial cannabis cultivation. The Department has also continued to work with DPR as they conduct research and analysis to better assess appropriate risk-based action levels for pesticide residues in cannabis goods.

In December 2024, DPR issued a memorandum (“Memo”) to the Department recommending updates to various existing action levels and inclusion of additional pesticides in the cannabis testing requirements. DPR’s updated recommendations reflect a conservative approach using health- and risk-based methodologies. (Memo, pp.1-3, 6, 11.) However, DPR explicitly acknowledged that some proposed action levels may be below the detection limit of current analytical testing equipment, and that

whether to implement these action levels is a policy decision to be made by DCC.
(Memo, p.11.)

PROBLEM STATEMENT

Laboratory testing of cannabis and cannabis products is an important aspect of a well-regulated cannabis industry. Medical patients and adult-use consumers must have access to products that are accurately labeled and free of dangerous contaminants and adulterants, including pesticide residues. Inhalation or ingestion of pesticides is unhealthy and can cause especially severe issues for medicinal consumers who are immunocompromised.

The Department is proposing to address three principal concerns in this rulemaking action. First, existing action levels for residual pesticides are outdated and do not reflect the most current analysis of risk. Second, assigning a pass/fail value of “non detect” for Category I pesticides provides opportunities for testing laboratories to manipulate test results and facilitate the harmful practice of lab shopping. Third, allowing multiple methods of establishing limits of detection (LOD) and limits of quantitation (LOQ) rather than one standardized method results in variability between testing laboratories and opens the door to “lab shopping.”

“Lab shopping” is an industry term of art referring to the practice of selecting a testing lab based on favorability of results, rather than accuracy of testing. Under existing law, every batch of cannabis goods must be tested before it may be sold at retail. Manufacturers and distributors may realize significant financial losses if a batch of goods fails regulatory compliance testing, ranging from costs of remediation or relabeling to total loss of the goods if destruction is required. There is substantial incentive, therefore, for a licensee to seek out testing laboratories with less stringent standards. Labs with less rigorous methods to conduct testing will draw customers away from scientifically rigorous labs, placing the labs most committed to public safety at a competitive disadvantage and potentially driving them out of business.

ANTICIPATED BENEFITS

The Department anticipates that this regulatory package will benefit consumers and the regulated market through updated pesticide action levels and more rigorous and scientifically valid requirements that will increase standardization between testing laboratories. Testing requirements that prioritize human health and that mandate scientifically rigorous testing practices support the Department’s goal of a safe, well-regulated market.

Consumers will benefit from reduced risk of pesticide exposure as a result of updated action levels. This is especially beneficial for medical cannabis patients who may be immunocompromised and face greater risk from exposure to residual pesticides due to underlying health conditions.

Increased standardization between licensed laboratories reduces the opportunities for lab shopping, which benefits both consumers and the regulated cannabis industry. Lab shopping results not only in skewed pesticide residue results, but also implicates the results of all tests that affect health and safety, including THC concentration, heavy metals, dangerous solvents, and molds. Removing opportunities for lab shopping results in more accurate and transparent test results leading to a safer cannabis market.

When cannabis and cannabis products sold in the legal market are reliably tested, accurately labeled, and shown to be free from contaminants, consumers have greater incentive to purchase through licensed retailers rather than risking their health on cannabis sold in the illicit market. Offering safe cannabis and cannabis products gives licensed businesses an advantage in the marketplace and incentivizes participation in the regulated cannabis market.

SPECIFIC PURPOSE OF, AND RATIONALE FOR, EACH PROPOSED AMENDMENT

Global Amendments

Use of “shall.”

Shall. This word runs afoul of several basic principles of good drafting. The first is that a word used repeatedly in a given context is presumed to bear the same meaning throughout. (Shall commonly shifts its meaning even in midsentence.) The second principle is strongly allied with the first: when a word takes on too many senses and cannot be confined to one sense in a given document, it becomes useless to the drafter. (Shall has as many as eight senses in drafted documents.) The third principle has been recognized in the literature on legal drafting since the mid-19th century: good drafting generally ought to be in the present tense, not the future. (Shall is commonly used as a future-tense modal verb.) In fact, the selfsame quality in shall—the fact that it is a chameleon-hued word—causes it to violate each of those principles.

(Garner, Garner on Language and Writing (2009) p. 174.)

The Department is removing the word “shall” from its regulations for the reasons described above and to eliminate any potential for misinterpretation due to inconsistent or incautious drafting. These are non-substantive changes under CCR, title 1, section 100(a)(4). In every instance of its usage to indicate or impose a mandatory requirement, “shall” is being replaced with “must.” In every instance of its usage to disallow or prohibit an action, “shall not” is being replaced with “may not.” The meaning of each provision being amended as described is not being altered by the change in verbiage. In other words, existing mandatory provisions are not being made permissive or optional, and existing prohibitions remain in effect.

Chapter 10. Testing Laboratories

Amend §15719. Residual Pesticides Testing.

Existing subsection (b) is amended to remove requirements regarding Category I pesticides because each pesticide listed in the consolidated table (discussed below) is being assigned a numerically quantifiable action level and the distinction between Category I and Category II pesticides is no longer relevant.

Existing subsection (c) is amended to remove the LOQ requirement for Category I pesticides because each pesticide listed in the consolidated table (discussed below) is being assigned a numerically quantifiable action level and the distinction between Category I and Category II pesticides is no longer relevant. This subsection is further amended to require licensed laboratories to establish an LOQ for each pesticide in the consolidated table. The LOQ, defined in section 15700(kk) as the minimum concentration of an analyte in a specific matrix that can be reliably quantified, is critical for ensuring that a given test is capable of accurately reporting the amount of a substance. The Department determined that requiring laboratories to be able to accurately quantify the presence of each pesticide at half of that pesticide's respective action level will ensure that testing results are accurate. The Department considered requiring LOQs between 50-100% of the action level, which would be easier for laboratories to achieve, but determined that due to existing allowable margins for error in accuracy and recovery, allowing higher LOQs may result in samples passing pesticide testing despite the presence of pesticides above the stated action levels. Requiring laboratories to establish LOQs at or below 50% of action levels eliminates this potential danger.

Existing subsection (d) is amended to refer only to the pesticide action levels in the consolidated table (discussed below). Subsections (d)(1) and (d)(2) are repealed. This is necessary because each pesticide listed in the consolidated table is being assigned a numerically quantifiable action level and the distinction between Category I and Category II pesticides is no longer relevant.

Existing subsection (e) is non-substantively reworded and relocated to appear before the consolidated pesticide table.

Finally, the two existing tables in section 15719 are being consolidated. The consolidated table includes the names of all pesticides required to be tested (column 1) and each pesticide's respective CAS number (column 2), action level for inhalable cannabis and cannabis products (column 3), and action level for non-inhalable cannabis products (column 4). Column 1 includes all 66 pesticides (Category I + Category II) listed in the existing tables, plus 11 additional pesticides for which DPR recommended testing and provided action levels. (Memo, Table 4, pp.15-19.) Further, DPR revised the action levels for 31 of the 66 existing pesticides. (Memo, p.20.) The Department defers to DPR's subject matter expertise regarding pesticide exposure and accordingly relies on and incorporates the justifications provided in the Memo regarding the need to test

for these 77 pesticides and to establish or revise their respective action levels, as applicable.

Column 1 also includes three pesticides (Fenobucarb (BPMC), Isoprocarb (MIPC), and Procymidone) for which DPR recommended testing but did not provide action levels. (Memo, Table 2, p.10.) DPR instead recommended that DCC prohibit the sale or distribution of cannabis with “any detectable residue of these pesticides.” (Memo, p.10.) One of DPR’s recommendations is to eliminate the “two-category system” in section 15719 in favor of establishing specific action levels for each pesticide. (Memo, p.11.) DPR explains that inherent in “detect/non-detect” testing is an increased chance of disparity between testing laboratories, as one laboratory may use analytical equipment that is less precise than another. (Id.) As previously stated, DPR recommended specific numerical action levels for 77 of the 80 pesticides for which the Department should require testing. However, the remaining three pesticides are essentially recommended to be treated as “Category I” pesticides. The Department considered postponing inclusion of these three pesticides in section 15719 until DPR provides numerical action levels but instead determined it necessary to include them now in furtherance of protecting public health. The Department believes it is reasonable and logical to establish these action levels using existing Category I testing requirements as a guide. Accordingly, since Category I pesticides currently have a required LOQ of 0.1 ppm, the Department is proposing to set the action level for these three pesticides at 0.1 ppm.

Amend §15731. Limits of Detection (LOD) and Limits of Quantitation (LOQ) for Quantitative Analyses.

Existing subsections (a) and (b) provide three optional methods of calculating the LOD and LOQ, respectively, for a given chemical analysis. When these options were adopted in 2017, California’s commercial cannabis industry, including laboratory testing of cannabis and cannabis products, was in its infancy. At that time, options for calculating limits of detection and quantitation were considered necessary because there was insufficient evidence to support the adoption of one uniform, robust method. However, over the past eight years the Department has come to realize that the broad scope of the existing rule leads to variability in test results and increased disparity in the testing industry.

For example, the Department has determined that the calculation options in existing subsections (a)(1) and (b)(1) do not consider a test method’s total performance, and that signal-to-noise ratio analysis is better employed in verifying the accuracy of LOD and LOQ values calculated pursuant to subsections (a)(2) and (b)(2), respectively. Similarly, existing subsections (a)(3) and (b)(3) reference federal “guidelines” that were useful tools available and loosely adaptable to the burgeoning commercial cannabis testing industry in 2017 but not designed or intended to be applied to cannabis testing. In general, these guidance documents provide examples and recommendations in lieu of specific calculations or laboratory test procedures. The downside to offering broad guidelines and recommending best practices is that it allows for wide variation in

laboratory operating procedures, which is antithetical to the Department's goals of standardizing and efficiently regulating all licensed cannabis testing activity in the state.

Another concern stemming from existing section 15731 is that some licensed laboratories use less rigorous methods of calculating LODs and LOQs. This practice represents a potential threat to public health from exposure to elevated levels of residual pesticides in cannabis goods.

Anecdotally, the Department has received stakeholder feedback echoing these concerns and requesting the adoption of standardized LOD and LOQ calculations. The Department is accordingly amending this section to ensure consistency and fairness in the industry by establishing one method of calculating an LOD, one method of calculating an LOQ, and additional verification requirements for both calculations.

Amended subsection (a) incorporates existing subsection (a)(2) to clearly require use of a single calculation for determining the LOD. The calculation is based on the test method's total performance, including the process of extraction of the analytes from a given matrix. The calculation is scientifically rigorous because it uses a statistical measure of the test method's total variability to determine the concentrations at which the test method will be able to detect a given analyte with 95% confidence. The calculation uses the statistical difference of the signals, as demonstrated by the required seven spiked blank samples and standard deviation, to predict the LOD concentration with 95% probability that analytes at the calculated concentration will be detected.

New subsection (b) establishes additional ongoing acceptance criteria requirements for LODs based on whether the chemical analysis is chromatographic. The Department is requiring an additional verification that the calculated LOD values meet a minimum signal-to-noise ratio of 3:1 because the generally accepted definition of a detectable signal in analytical chemistry is a signal that is distinguishable from noise in a ratio of 3:1. It is important that the LOD values that have been determined by the laboratory in the LOD calculation are reviewed against the signals produced by the instrument to ensure the values are achievable with the chosen instrumentation. In chromatographic analyses, signals from instrumentation are graphically represented as peaks that must be verified by visually comparing them to the noise at their respective heights. In non-chromatographic analyses, signals are displayed as numerical values and therefore must be verified by software analysis or mathematical calculation. The failure to maintain a signal-to-noise ratio of 3:1 at the LOD significantly impairs the ability of the laboratory to report when an analyte is present and undermines the accuracy of the test method. Regular attention from laboratory staff is needed to maintain the required ratio, which is the basis for determining whether an analyte is present or not, both at the initial LOD determination and subsequently.

New subsection (c) incorporates existing subsection (b)(2) to clearly require use of a single calculation for determining the LOQ. The calculation is based on the test method's total performance, including the process of extraction of the analytes from a given matrix. The calculation is scientifically rigorous because it uses a statistical

measure of the test method's total variability to determine the concentrations at which the test method will be able to measure a given analyte with 95% confidence. The calculation uses the statistical difference of the signals, as demonstrated by the required seven spiked blank samples and standard deviation, to predict the LOQ concentration with 95% probability that analytes at the calculated concentration are measurable.

New subsection (d) establishes additional ongoing acceptance criteria requirements for LODs based on whether the chemical analysis is chromatographic. The Department is requiring an additional verification that the calculated LOQ values meet a minimum signal-to-noise ratio of 10:1 because the generally accepted definition of a measurable signal in analytical chemistry is a signal that is distinguishable from noise in a ratio of 10:1. It is important that the LOQ values that have been determined by the laboratory in the LOQ calculation are reviewed against the signals produced by the instrument to ensure the values are achievable with the chosen instrumentation. In chromatographic analyses, signals from instrumentation are graphically represented as peaks that must be verified by visually comparing them to the noise at their respective heights. In non-chromatographic analyses, signals are displayed as numerical values and therefore must be verified by software analysis or mathematical calculation. The failure to maintain a signal-to-noise ratio of 10:1 at the LOQ significantly impairs the ability of the laboratory to report when an analyte is measured and undermines the accuracy of the test method. Regular attention from laboratory staff is needed to maintain the required ratio, which is the basis for determining whether an analyte is measurable or not, both at the initial LOQ determination and subsequently.

TECHNICAL, THEORETICAL, AND/OR EMPIRICAL STUDIES, REPORTS, OR DOCUMENTS

1. Department of Pesticide Regulation Memorandum, Recommended Revisions to the Pesticide Action Levels for Testing Cannabis Products in California, December 18, 2024.

STANDARDIZED REGULATORY IMPACT ANALYSIS

The Standardized Regulatory Impact Analysis ("SRIA") for this proposed action was performed by ERA Economics, LLC and is included as Attachment 1 to this statement of reasons.

CONSIDERATION OF ALTERNATIVES

The Department considered requiring laboratories to obtain ISO accreditation to test the 14 new pesticides and reaccreditation to test only those of the existing 66 pesticides that have revised action limits lower than the previous action limit of 0.1 µg/g. This alternative was rejected because the primary goals of this proposed action are to prevent licensed laboratories from falsifying or manipulating pesticide residue test results and ensure that products that reach consumers are safe for consumption. This alternative proposal would focus on the 14 new pesticides while maintaining the status

quo for nearly all of the 66 existing pesticides, and as identified and discussed at length in this statement of reasons, maintaining the status quo ignores DPR's recommendations and is inadequate to regulate laboratories and protect consumers.

ATTACHMENT 1
STANDARDIZED REGULATORY IMPACT ANALYSIS

Standardized Regulatory Impact Analysis

2025 Laboratory Package

Prepared by:

ERA Economics, LLC

Prepared for:

Department of Cannabis Control

May 2025

ERA Economics
Environment • Resources • Agriculture

Table of Contents

1. Introduction.....	7
1.1 Statement of Need for the Proposed Regulation	9
1.2 Major Regulation Determination.....	10
1.3 Public Outreach and Input.....	10
1.4 Report Organization	11
2. Analytic Approach and Data.....	11
2.1 Overview of Economic and Fiscal Impacts.....	11
2.2 Direct Effects.....	13
2.3 Market Effects	13
2.4 Fiscal Impacts.....	14
2.5 Indirect and Induced Impacts	14
3. Cannabis Industry Baseline Overview.....	15
3.1 Cannabis Supply.....	15
3.2 Wholesale Prices	17
3.3 Cannabis Demand.....	17
3.4 Licensed Market Share of Total Consumption.....	20
3.5 Description of Laboratory Testing	21
3.6 Laboratory Licenses	22
3.7 Laboratory Testing Failure Rates	23
3.7.1 Lower Bound Supply Shift	24
3.7.2 Upper Bound Supply Shift.....	25
3.8 Baseline Cost of Laboratory Testing.....	26
4. Economic and Fiscal Impacts: Proposed Regulations	28
4.1 Direct Economic Benefits	29
4.2 Direct Industry Costs.....	29
4.2.1 §15719. Residual Pesticides Testing.....	30
4.2.2 Costs of Compliance.....	32
4.3 Market Supply and Demand Effects	35
4.4 Indirect and Induced Effects.....	41
4.5 Economic Impacts Summary.....	44

4.5.1	Employment (Job) and Income Estimated Effects.....	44
4.5.2	Gross State Product.....	44
4.5.3	Creation or Elimination of Businesses.....	44
4.5.4	Expansion of Businesses.....	45
4.5.5	Competitive Advantages or Disadvantages	45
4.5.6	Investment in the State and Taxes	46
4.5.7	Incentives for Innovation	46
4.5.8	Estimated Effects on a Typical Business and Small Business.....	46
4.5.9	Other Economic Impacts to Businesses, Individuals, Worker Safety, and the State's Environment	47
4.6	Department Fiscal Costs.....	48
4.6.1	Other State and Local Public Agencies Fiscal Costs	48
4.7	Impact Summary	48
5.	Economic and Fiscal Impacts: Proposed Alternatives.....	48
5.1	Economic and Fiscal Impacts of Regulation Alternative 1	49
5.1.1	Alternative 1 Direct Economic Benefits	49
5.1.2	Alternative 1 Direct Economic Costs	49
5.1.3	Alternative 1 Market Effects.....	50
5.1.4	Alternative 1 Indirect and Induced Effects	52
5.2	Alternative 1 Economic Impacts Summary.....	53
5.2.1	Employment (Job) Estimated Effects	53
5.2.2	Gross State Product.....	53
5.2.3	Creation or Elimination of Businesses.....	53
5.2.4	Expansion of Businesses.....	53
5.2.5	Competitive Advantages or Disadvantages	53
5.2.6	Investment in the State and Taxes	53
5.2.7	Incentives for Innovation	54
5.2.8	Estimated Effects on a Typical Business and Small Business.....	54
5.2.9	Other Economic Impacts to Businesses, Individuals, Worker Safety, and the State's Environment	54
5.2.10	Department Fiscal Costs	55

5.2.11	Other State and Local Public Agencies Fiscal Costs	55
5.2.12	Impact Summary for Alternative 1	55
5.2.13	Basis for Rejecting Alternative 1	55
5.3	Economic and Fiscal Impacts: Proposed Alternative 2.....	55
6.	References.....	57

List of Tables

Table 1. Estimated Licensed Cannabis Production, by Year and Medicinal and Adult Use Markets	16
Table 2. California Total Cannabis Consumption Estimates, 2019 – 2024.....	20
Table 3. Licensed Cultivation Share of California Cannabis Demand, Adjusted for Underreporting.....	21
Table 4. Expected Decrease in Cannabis Supply from Increased Failure Rate.....	24
Table 5. Laboratory Failure Rates by Product Type, 2024.....	24
Table 6. Average Annual Laboratory Costs (Example Average Medium-Sized Lab)	26
Table 7. Estimated Annual Laboratory Totals, 2024.....	27
Table 8. Total Direct Costs per Laboratory and Total Industry Costs.....	29
Table 9. Equilibrium Displacement Model Parameters	39
Table 10. First-Year Annualized Costs Per Laboratory.....	40
Table 11. EDM Analysis Market Effects Selected Results	41
Table 12. Changes in Surplus and Retailer Revenue for Licensed Market	41
Table 13. IMPLAN Results	43
Table 14. Total Economic Impact Summary	48
Table 15. Total Direct Costs per Laboratory and Total Industry Costs.....	49
Table 16. First-Year Annualized Costs Per Laboratory.....	51
Table 17. EDM Analysis Market Effects Selected Results	51
Table 18. Changes in Surplus and Retailer Revenue for Licensed Market	51
Table 19. IMPLAN Results	52
Table 20. Total Economic Impact Summary	55

List of Figures

Figure 1. Quarterly Wholesale Price Index (2018 = \$100) by Cultivation Method, 2015–2024 .	17
Figure 2. NSDUH Prevalence of Past-Year Cannabis Consumption, Unadjusted	19
Figure 3. California Per Capita Consumption Estimates, Adjusted for Underreporting	19
Figure 4. Change in active testing laboratory licenses, 2019 to 2024	23

1. Introduction

Since the passage of the Medicinal and Adult-Use Cannabis Regulation and Safety Act (MAUCRSA) in 2017, the California licensed cannabis industry has grown into the largest regulated market in the world. The retail value of sales exceeded \$4.6 billion in 2024, despite the licensed industry competing against a persistent illicit market. The licensed market regulations include the cannabis supply chain from seed to production, distribution, manufacturing, laboratory testing, and final retail sales. Laws and regulations governing California's industry have continued to evolve in response to better data, innovations, and evolving market conditions. The Department of Cannabis Control (Department) is the main regulatory agency for the California licensed market and continually adjusts regulations in response to new laws and industry conditions.

One area of concern for regulating the licensed market supply chain is product safety, including lab testing and pesticide residues. All licensed cannabis and cannabis products are tested to meet safety standards. However, potential variation in lab standards and methods has raised concerns about consistent testing for products that reach the licensed market. In response, the Department, in consultation with other state agencies, has evaluated options for standardizing testing methodologies, adjusting detection limits for pesticide residue, and ensuring uniform compliance across laboratories in California's licensed cannabis supply chain.

The Department of Pesticide Regulation (DPR) regulates pesticides in California. It provides recommendations to the Department of Cannabis Control regarding the use of pesticides on cannabis, as required by Business and Professions Code (BPC) sec. 26100 (d)(2). On February 4, 2025, DPR released an updated list of pesticides reviewed for use on cannabis in California¹, and additional recommended action levels (i.e., detectable pesticide residue levels) for testing cannabis products. This is part of DPR's ongoing efforts to align with the state's regulatory requirements under Business and Professions Code (BPC) section 26060 et seq. By providing health-based recommendations, DPR aims to ensure that pesticide residue levels in cannabis products meet California health and environmental safety standards. The updated recommendations reflect the latest toxicological data, advancements in analytical methods, and changes in regulatory guidance. The Department has worked with DPR to implement its updated guidance for pesticide use in California cannabis.

This Standardized Regulatory Impact Analysis (SRIA) provides economic and fiscal analyses of the Department of Cannabis Control's (Department) proposed regulatory changes to implement DPR's recommendations and modify Department regulations for laboratory standards and methods.

¹ https://www.cdpr.ca.gov/wp-content/uploads/2025/02/pesticide_products_reviewed_for_use_on_cannabis.pdf

The Department has drafted revised regulatory language for Title 4 of the California Code of Regulations, Chapter 6 – Testing Laboratories Section 15719 - Residual Pesticides Testing to enact DPR’s recommended pesticide action levels. Separate revised action levels are proposed for inhalable and non-inhalable cannabis products for each of the 66 pesticides currently required for residue testing, along with newly established action levels for 14 additional pesticides. The revised action levels are coupled with changes to Limits of Quantification (LOQ), which is the lowest concentration that a laboratory can quantitatively detect.

The proposed laboratory regulations would enhance cannabis product safety by modifying pesticide residue testing standards and laboratory practices. These regulations would increase compliance costs for testing laboratories, potentially leading to higher capital and operating costs. This would cause market adjustments as these costs are transmitted through the cannabis industry supply chain, affecting lab testing costs, wholesale prices, and ultimately retail cannabis product prices in the licensed market. This also affects, and is affected by, competition from the illicit market.

The economic impacts of the proposed regulations were quantified by establishing the direct compliance costs to labs and other affected market segments. An economic model of the California illicit and licensed industries is then applied to evaluate the impact of these changes on the resulting market equilibrium, including changes in product prices. Lastly, an economic input-output (so-called “multiplier”) model is applied to assess indirect and induced economic effects in related industries. The total economic impacts (costs, benefits, and direct, indirect, and induced effects) are reported.

The economic analysis of these changes is based on the best available information for the California cannabis market, economic parameters, and laboratory testing methods and costs. Data for the licensed cannabis industry are limited, and official data regarding the illicit market are nonexistent. Therefore, the economic parameters that characterize the market for regulated and illicit cannabis are estimated based on the best available data. The methods are summarized and, where appropriate, sensitivity analyses are prepared to illustrate the range of potential economic outcomes. Despite data limitations, the findings of this economic impact analysis (e.g., major regulation determination and general magnitude of economic and fiscal impacts) are robust across the range of sensitivity scenarios. All of the costs included in this analysis are itemized so that the reader can understand the individual and total cost of the proposed regulations, and impacts identified in the California Administrative Procedure Act.

The California cannabis market is different than other conventional agriculture industries because cannabis is produced and sold widely in both the licensed market as well as the unregulated, illicit market. Accordingly, this economic impact analysis considers that cannabis businesses—from cultivation through final retail—operate in a market where consumer demand is partially met through the unregulated, illicit cannabis market. Cannabis products sold in the licensed and illicit markets are differentiated by quality, and the proposed regulations serve to

further improve the safety of licensed products relative to illicit products. Therefore, regulatory changes have important effects for both the licensed and illicit markets. To isolate the market effects of regulatory changes for producers and consumers in the licensed market, the relationship between the licensed and illicit markets is incorporated in the economic analysis framework.

1.1 Statement of Need for the Proposed Regulation

Following passage of MAUCRSA, DPR provided the Department (then the Bureau of Cannabis Control) an initial proposed list of action levels for 66 pesticides. These pesticides were adopted in regulation as required testing for each batch of cannabis and cannabis products. Pesticides on this list were either designated as Category I (highest level of hazard) or Category II (moderate risk). Pesticides not included on this list are not necessarily allowable for use, but residue testing is not explicitly required for these. Category I pesticides required an LOQ of 0.1 µg/gram and any detection of the pesticide resulted in a failed test; Category II pesticides permitted detection and had variable action limits depending on their relative risk.

There was a lack of analytical data at the time these levels were established. Since the initial recommendations and regulations in 2017, new scientific data on pesticide toxicity and residue levels have emerged, and DPR has reassessed the risk of pesticide residues found in cannabis. These efforts are ongoing, and additional recommendations may be developed in the future. Additionally, changes in federal and state risk assessment methodologies and advancements in lab testing technologies have highlighted the need for more precise and health-based action levels. To accomplish this, DPR has recommended moving away from the Category I/Category II system to allow for a health-based approach for all action levels. That is, instead of having no permissible detection for Category I pesticides, LOQs and action limits are established depending on the relative risk of the pesticide.

In addition to establishing new action levels, the proposed regulations redefine LOQs for each pesticide. The LOQ is the detectable concentration of an analyte (pesticide compound). The LOQ established in 2017 of 0.1 µg/gram allowed some laboratories to avoid accurately quantifying pesticide residues found in samples. As a result, products which should have failed testing for pesticide residues instead may have reached consumers. This also inadvertently created an incentive for some distributors to potentially engage in “lab-shopping”² to increase the likelihood that their products pass testing. Similarly, some laboratories may have an incentive to pass tests to ensure distributors repeat as customers instead of turning to competitor laboratories with higher passed testing rates. Establishing lower LOQs prevents laboratories and

² “Lab-shopping” refers to the practice of sending samples to multiple labs in order to obtain the most favorable result.

distributors from falsely passing pesticide residue testing and ensures products that reach the market meet consistent minimum standards based on the current science and data.

1.2 Major Regulation Determination

Department laboratory regulations would exceed the \$50 million annual economic impact threshold. The 12-month period in which the economic impact of the proposed regulation would exceed \$50 million is defined as the 12 months following full implementation of the proposed regulations. The precise date of full implementation is unknown at this time. The total 12-month economic impact of regulatory costs, measured as changes in direct costs, labor income, value-added, and the value of output, would equal \$358 million across all affected sectors. This includes total statewide costs to businesses and individuals of \$222 million, total statewide benefits of \$136 million, the elimination of 1,144 jobs related to retail sector impacts, and the creation of 304 jobs related to laboratory sector impacts. Additional, potentially offsetting, human and environmental benefits were not possible to quantify.

1.3 Public Outreach and Input

The economic analysis leverages data, economic models, and information developed for prior rulemaking that has been initiated by the Department. This includes economic data and models that were developed for a SRIA prepared in 2017 and have been updated for various regulations and fiscal and economic assessments developed since.

ERA Economics and the Department conducted targeted outreach in preparing this analysis. This included outreach to researchers, stakeholders, and industry experts to understand current market conditions affecting testing laboratories and distributors. This also included assessing the potential effect of components of the regulations on businesses and individuals (e.g., compliance time and associated costs), and discussing potential benefits. The following groups were contacted to support the development of the analysis:

- Laboratories and other industry professionals to review current market conditions, update cost of production information, verify industry data, and receive general insights on industry trends, challenges, and changes.
- Researchers to discuss industry trends and feedback from other outreach/survey efforts.
- Department staff to assess potential effects on laboratories and short- and long-term staff level effort to manage laboratory license changes (fiscal costs).

The Department also engaged in outreach to inform licensees about the proposed Laboratory regulatory changes. Outreach efforts provided interested parties the opportunity to provide feedback on draft regulations. Outreach included but was not limited to communication with potentially interested parties via email and phone, as well as organized events such as Cannabis Advisory Committee meetings and other DCC events.

1.4 Report Organization

The report is structured as follows. Section 2 describes the types of economic and fiscal effects attributable to the proposed regulations, and the analytic approach and data used to quantify (monetize) impacts. Section 3 provides an overview of the cannabis industry, establishing important baseline conditions used to evaluate fiscal and economic impacts of the proposed regulations. Section 4 summarizes the economic and fiscal impacts of the proposed regulations. Section 5 summarizes two alternatives that the Department considered, and the basis for selecting the proposed regulation over the two alternatives.

2. Analytic Approach and Data

The proposed regulations would result in direct costs to cannabis laboratories to adjust testing methods, modify procedures, potentially hire new staff, and potentially invest in new machinery and equipment. These direct costs will affect the entire licensed cannabis supply chain. Since the licensed market competes with the illicit market, this will also affect and be affected by the illicit market. Changes in direct costs and adjustments across the licensed cannabis supply chain will affect other businesses and individuals in ancillary industries. These economic impacts are measured following a standard process to quantify direct business costs, evaluate how those costs affect the licensed market cannabis, and the evaluate so-called multiplier effects in all related industries. The proposed regulations would result modest fiscal costs to the Department, which are quantified and disclosed. After accounting for how the market would adjust (i.e., economic effects) to the proposed regulations, it was determined that fiscal costs would be absorbed within the existing Department budget.

The analysis applies public industry data to the maximum extent possible. However, as noted earlier, the licensed cannabis industry is still relatively new, and industry data are limited in many cases. For example, there is no centralized data/information for the illicit market in California, so additional analysis is completed to address this data gap. Where data were unavailable, judgment and reasonable assumptions based on industry outreach were applied. All prices and costs are inflation-adjusted and reported in 2024 dollars.

The following subsections provide an overview of the direct costs, economic framework, baseline conditions, and models—including the Equilibrium Displacement Modeling (EDM) for market effects and IMPLAN model for regional economic impacts—used to measure the shifts in production costs, prices, job creation or loss, and regional economic outcomes resulting from the proposed regulation.

2.1 Overview of Economic and Fiscal Impacts

The proposed regulations would result in quantifiable and unquantifiable (i.e., non-monetized) costs and benefits (collectively, economic impacts) for licensed cannabis businesses. The economic impacts of the proposed regulations are from increased compliance costs for

laboratories, leading to higher testing costs, potentially increased testing failure rates, and a corresponding reduction in cannabis supply in the licensed market. That is, as testing standards become stricter under the proposed regulations, more products are expected to fail testing, initially reducing cannabis in the licensed market. However, this supply contraction puts upward pressure on wholesale and retail prices in the licensed market, which has implications for illicit market purchases.

Market adjustments were quantified using an Equilibrium Displacement Modeling (EDM) framework to estimate price and quantity changes, and licensed/illicit market effects. An IMPLAN analysis was applied to estimate the indirect and induced economic effects, such as job losses and changes in industry-wide economic output.

Economic and fiscal impacts were quantified using a standard sequential approach:

1. **Direct economic impacts.** These represent direct costs and benefits to businesses and individuals that are attributable to the regulation and can be quantified. For example, additional lab testing time and equipment costs.
2. **Market economic effects.** The direct economic costs or benefits represent changes in the cost to produce cannabis and/or the quantities of cannabis products being purchased. Industry supply changes in response to direct costs or benefits to producers, while industry demand changes with quantities of products sold. Both can affect the market price and quantity of cannabis produced. These market equilibrium changes affect the broader industry. For example, higher lab costs caused by the proposed regulations will be reflected in lab pricing, which will affect prices throughout the cannabis supply chain up to and including retail prices for consumers.
3. **Indirect and induced economic impacts.** Multiplier effects on other businesses and individuals result from the direct costs or benefits and associated changes in the equilibrium market conditions for the industry. For example, labs employ scientists and other staff that live in local communities and purchase other goods and services from non-cannabis related business. These measures of economic activity are assessed using a customized version of the multiplier model, IMPLAN®, adjusted to include cannabis business sectors.
4. **Fiscal impacts.** The fiscal impact analysis follows the economic impact analysis by quantifying the fiscal cost of the regulation to the Department and other state/local agencies after accounting for the industry adjustments that are reflected in the economic impact analysis.

The economic impacts of the proposed regulations are established relative to a baseline. The baseline condition, per the California Administrative Procedure Act guidelines, is the most cost-effective set of regulatory measures that ensure full compliance with the authorizing statute or

other law being implemented.³ This ensures that the economic impacts only measure the incremental changes attributable to the regulation. In this case, the baseline condition is the no action alternative (i.e., absence of the proposed regulatory change). All economic impacts are measured relative to this baseline (no action).

The economic effects/impacts of the proposed regulations are summarized in terms of direct (changes in lab practices), market effects (changes in price and quantity of licensed cannabis), indirect (changes in related businesses), and induced (changes in expenditures by employees), which are succinctly summarized in the following subsections.

2.2 Direct Effects

Direct effects are costs and benefits that directly affect the businesses and individuals in the industry. In the case of the proposed regulations, these businesses would be licensed cannabis laboratories.

The potential monetizable economic impacts of the regulatory changes in the laboratory package include:

- Benefits
 - Potentially significant but unquantified (non-monetized) benefits to human health and the environment.
- Costs
 - Increases in labor, materials, and equipment costs for laboratories from meeting new pesticide residue standards.
 - Decreased supply of cannabis from increased failure rate of pesticide residue testing.

2.3 Market Effects

The regulation would affect the marginal cost to produce cannabis. Producers need to receive a price at least equal to marginal cost to continue production. The industry supply is the relationship between price and quantity produced by the industry. As supply (cost) changes, market price and quantity produced are affected.

This analysis applies an economic Equilibrium Displacement Modeling (EDM) approach to estimate the potential market effects of the proposed regulations. The EDM is widely applied for evaluating the effects of changes in production costs, trade policies, advertising, taxes, and regulation of agricultural commodities. It has been extensively applied to crop and livestock

³ Government Code of California, Title 2, Division 3, Part 1, Chapter 3.5, Article 5, §11346.3 (e)

systems such as the dairy sector, beef production, sheep production, marketing, and research and development (Alston et al., 2006, Alston et al., 1995).

The basic EDM for the aggregate cannabis industry, which modeled both licensed and illicit markets, was developed for the 2017 SRIA following Muth (1964), Gardner (1988), and Wohlgenant (1993). The EDM used in this analysis updates the original version and considers licensed and illicit cannabis supply and demand.

The market effects in this analysis can be summarized as follows:

- Cost increases for licensed distributors from increased testing costs.
- Decreased supply of licensed cannabis from increased test failures resulting in destroyed product.
- Potential increase in consumer demand for licensed cannabis in response to the improved safety of cannabis products sold at a licensed retailer. However, there is no research to support the magnitude of this effect; therefore, health and environmental benefits and their market implications are unquantified.

These effects would result in a change in gross economic output.

2.4 Fiscal Impacts

Fiscal impacts are changes to public agency costs and revenues associated with the regulations.

The Department may see minor increased workload associated with updating internal laboratory test methods to align with the new action levels and additional pesticides, receiving updated ISO accreditation documents from licensees, and increased remediation requests resulting from any increases in testing failures. All costs for implementing the proposed regulations will be absorbed within the existing Department budget. Department fiscal costs are estimated and disclosed. Impacts to state revenue from losses in sales and excise tax revenue from up-front costs, recurring costs, and reduced retail revenue are also estimated and disclosed.

2.5 Indirect and Induced Impacts

The analysis of indirect and induced impacts (so-called multiplier effects) evaluates the overall effect of changes in prices and quantities from the market analysis on jobs, income, taxes, and value-added across the State.

The total economic impact is expressed as changes in costs, benefits, and direct, indirect, and induced impacts. The direct impacts in this analysis are 1) changes in spending by licensed cannabis laboratories, and 2) a change in primary production value (gross economic output) resulting from decreased supply. The indirect impacts capture changes in intermediate input purchases by the primary industry from other sectors of the economy. For example, retailers purchase technology such as POS systems and other supplies required to run a retail business.

Induced impacts capture the change in expenditures of income by proprietors and employees in the primary industry and all linked industries.

This analysis uses the Impacts for Planning and Analysis (IMPLAN[®]) v3.1 model (MIG, Inc, 2016) with a California county-level 2014 dataset as the baseline year for the analysis.⁴ The IMPLAN software is an input-output economic model that estimates the effects of exogenous changes in final demand within a specified geographic region (in this case, California). The model uses a comprehensive dataset of national and regional economic accounts that document purchasing relationships between industries through multiple rounds of spending. The software also incorporates institutional demand and inter-institutional transfers that reflect purchases made by households and government agencies.

A limitation of the IMPLAN model or any input-output model is that the default IMPLAN model data does not include any businesses in the cannabis industry. Three licensed cannabis cultivation sectors, which include Indoor, Outdoor, and Mixed-Light cultivation, were created for the 2017 SRIA using financial data from cultivator surveys and various secondary sources. These customized sectors were adjusted for inflation and indexed to current market conditions and applied to this analysis. For this analysis, customized laboratory testing and retail sectors were also developed (see section 4.4).

3. Cannabis Industry Baseline Overview

Current relevant baseline conditions for the cannabis industry were developed using cultivation license data, industry data developed for the 2017 SRIA, and previous EFIAs developed for the Department, California Cannabis Track and Trace (CCTT) data, a recent Market Report, and other updated data developed for this analysis. The proposed regulatory amendments would directly affect laboratories and indirectly affect other licensed cannabis businesses, including cultivators, manufacturers, retailers, and distributors. Therefore, this section focuses on this part of the licensed cannabis supply chain in California.

3.1 Cannabis Supply

This section describes estimated licensed production. Production is defined as the weight of cannabis (in terms of dry-flower equivalent⁵) harvested, packaged, and transferred for sale by cultivators. Total production in the licensed market was estimated by combining information

⁴ The IMPLAN 2014 data for California counties is used for consistency with the 2017 SRIA and other previous economic and fiscal analyses of the cannabis industry. That data also includes the custom Cannabis sectors created for the SRIA. All dollar values are indexed for inflation and reported in 2024 dollars. A review of IMPLAN data from 2015 to 2022 for the industries identified to be similar to cannabis shows little variation from this 2014 data. That is, the economic multipliers in the 2014 IMPLAN database, with custom cannabis sectors, are appropriate for this impact analysis.

⁵ “Dry-flower equivalent” is the normalization of raw cannabis products, such as trim, leaves, and fresh plants to flower based on approximate THC content., These are also used as inputs for cannabis products sold at retail.

from multiple data sources and applying statistical methods. Data include CCTT, production budgets, and cultivation tax receipts.

Cultivation (production) data, stratified by taxes on flower, leaves and other plant material, and fresh plant material, are available from CDTFA through July 1, 2022. Collection of the cultivation tax began in 2018 and was suspended on July 1, 2022. Prior to July 1, 2022, the cultivation tax rate was \$10.08 per ounce for dry-weight flowers (\$9.65 prior to January 2022 and \$9.25 prior to January 2020), \$2.87 per ounce for dry-weight leaves (\$2.75 prior to January 2020), and \$1.35 per ounce for fresh cannabis (\$1.29 prior to January 2020). The “dry-weight leaves” category includes leaves and all other dry non-flower plant material, such as trim.

Cannabis leaves and other plant material typically undergo further processing. THC is extracted from this plant material for products such as edibles and vape cartridges. Cannabis trim is also included in the “dry-weight leaves” category. Trim can include sugar leaves and bits of buds, which are highly variable in THC content, but considerably higher in THC content than fan leaves.

Cultivation tax data were used to estimate cannabis production through 2021. CCTT data were used to estimate the quantity of licensed cannabis production sold for adult-use and medicinal consumption in California for 2019–2024. CCTT data were adjusted to account for reporting errors⁶.

Table 1 shows estimated total licensed cannabis production distributed to the licensed adult-use and medicinal retail markets for 2020–2024. Production has been increasing since 2020 with 2024 production equal to 1.429 million pounds. Cannabis production distributed to the medicinal market has been decreasing since 2021 from 120.7 to about 92.7 thousand pounds, whereas cannabis distributed to the adult-use retail market has steadily increased year-over-year.

Table 1. Estimated Licensed Cannabis Production, by Year and Medicinal and Adult Use Markets

Year	Adult-use total, flower-equivalents	Medicinal, flower-equivalents	Total licensed, flower-equivalents	Year-over-year change
	<i>Pounds., thousands</i>			<i>%</i>
2020	734.1	104.7	838.9	N/A
2021	863.3	120.7	984.0	17.3
2022	1,014.5	99.8	1,114.3	13.2
2023	1,184.4	93.7	1,278.0	14.7
2024	1,336.7	92.7	1,429.4	11.8

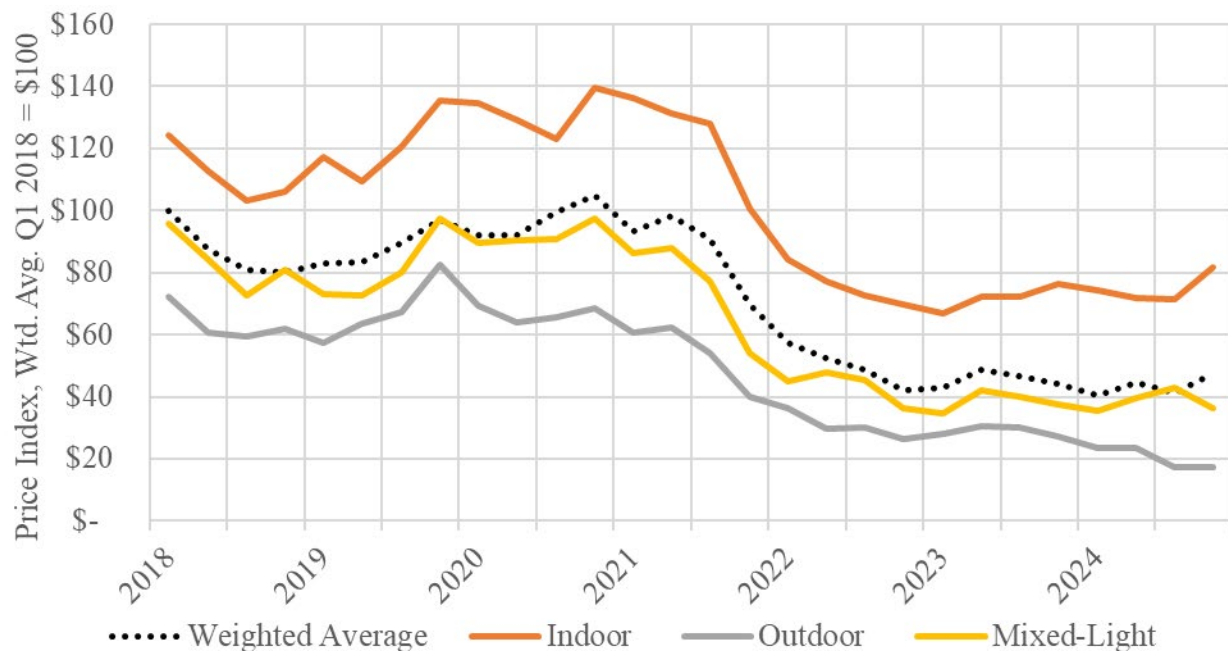
Notes: One pound of trim is equivalent to approximately 1/3 pound of flower.

⁶ Adjustment methods include a range of statistical analyses and labor-intensive review, cleaning, and flagging of errors. This process is informed by working with the CCTT data for several years and understanding the nuances of reporting and likely errors, which is done in coordination with Department staff.

3.2 Wholesale Prices

Wholesale flower prices have decreased since 2021. Weekly weighted average wholesale prices were between \$1,000 and \$1,500 per pound in 2018 and as high as \$1,600 per pound in 2020. As of Q4 2024, the weighted average of wholesale prices was \$769 per pound. This price is applied to the current analysis. Wholesale prices are from Cannabis Benchmarks (2024), CCTT data, and industry wholesale listings, and adjusted for general inflation. Figure 1 illustrates indexed and inflation-adjusted quarterly average wholesale prices in California by cultivation method from 2018 through 2024, with weighted average quarterly prices in Q1 2018 = \$100. Prices have been relatively stable in the past couple years after decreasing substantially in 2021.

Figure 1. Quarterly Wholesale Price Index (2018 = \$100) by Cultivation Method, 2015–2024



3.3 Cannabis Demand

Total cannabis consumption is the amount of cannabis consumed in California from both licensed and unlicensed (illicit) production. Since cannabis is consumed in different forms, consumption is normalized to a dry-flower equivalent basis.

Total cannabis consumption is estimated using statewide (and nationwide) survey data. The federal Substance Abuse and Mental Health Services Administration (SAMHSA) conducts the National Survey on Drug Use and Health (NSDUH) quarterly, with a total of 67,625 people surveyed annually (SAMHSA, 2024). Interviewees are sampled from all 50 states and the District of Columbia. Survey responses are weighted by SAMHSA based on census characteristics to be both representative of the nation as well as the 50 states and District of Colombia individually.

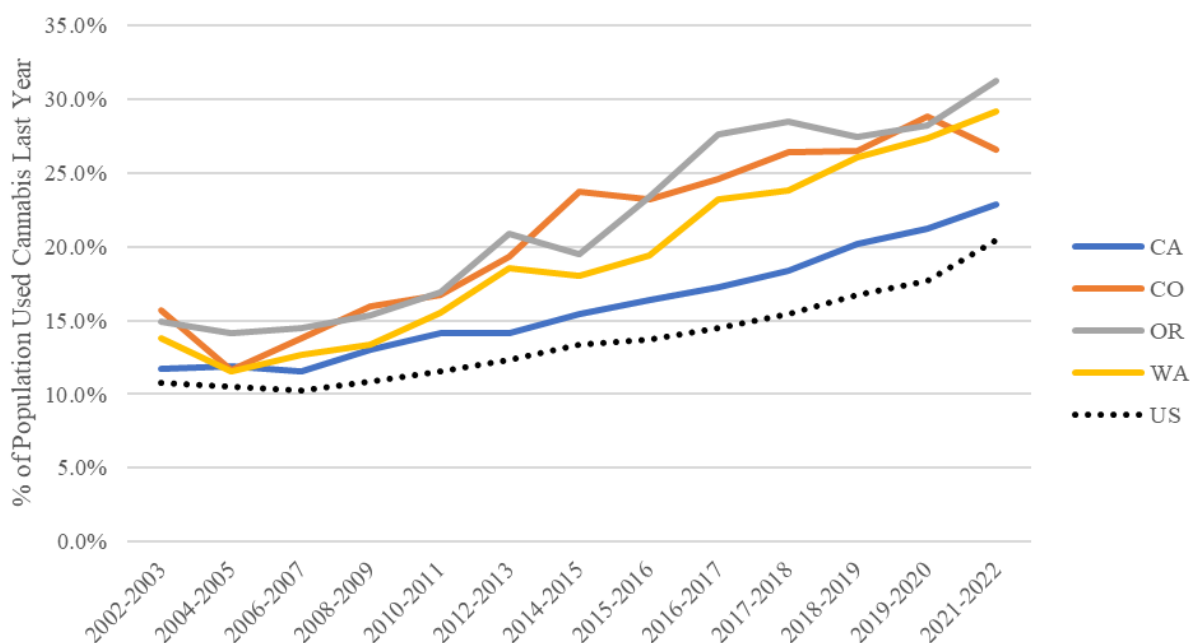
NSDUH survey data (as with all drug use surveys) may underreport cannabis consumption. Respondents may deny use or misreport frequency of use of cannabis products. This analysis applies an econometric model to identify the effects of legalization on underreporting cannabis use. In short, the method applied adjusts for both denial/misreporting issues (as identified by academic researchers cited⁷) and the effect of legalization/policy change over time, at both state and federal levels. This analysis is completed for all states (including California).

Frequency of use estimates were combined with estimates of cannabis consumption per use-day to calculate total state-level consumption. Grams per use-day values by Light et al. (2015) were applied. Total annual consumption estimates for each year were calculated. The dataset was then used in a reduced form econometric analysis to estimate the effects of underreporting and legalization on consumption. The econometric model estimates grams per capita as a function of factors that affect consumption including market data (e.g., sales), socioeconomic data, and indicators for legalization and other policy changes. Separate regressions are run for heavy users and light users to allow for heterogeneous effects by user type. The model outputs allow for adjustments for underreporting, and to project consumption for 2023–2024 (years for which NSDUH surveys are not yet available).

Figure 2 shows 2-year averages of cannabis consumption prevalence in California compared to the U.S. and other selected states. These are raw survey estimates from NSDUH, prior to adjustments for underreporting. Survey results from NSDUH represent average prevalence of consumption for the adult population, and for teen users who may be using cannabis illegally.

⁷ Kilmer et al. (2013), Kilmer et al. (2019), and Caulkins et al. (2019) use an adjustment factor of 1.22 to correct for this issue in Washington; Light et al. (2015) and Orens et al. (2018) use an adjustment factor of 1.11 for heavy users and 1.22 for light users in Colorado; and Canada’s Office of the Parliament Budget (OPBO, 2016) and MacDonald and Rotterman (2018) use an adjustment factor of 1.063 for heavy users and 1.125 for light users in Canada. However, none of these studies adjust for how underreporting may change over time.

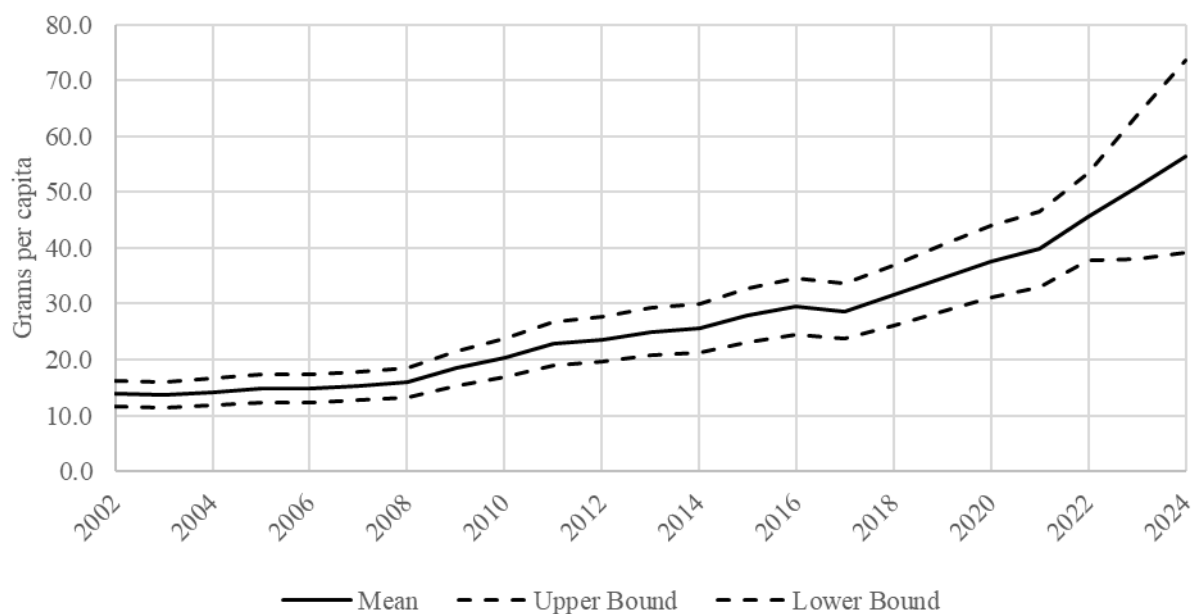
Figure 2. NSDUH Prevalence of Past-Year Cannabis Consumption, Unadjusted



Note: NSDUH data are only available through 2022.

Figure 3 illustrates estimated per capita consumption in California since 2002. The solid line represents mean estimated per capita consumption, and the dashed lines correspond to a 95 percent confidence interval.

Figure 3. California Per Capita Consumption Estimates, Adjusted for Underreporting



Note: Per capita consumption for 2023–2024 is estimated using an econometric model.

Table 2 summarizes estimated total cannabis consumption from 2019–2024 for the California population age 18 or older. Total state level cannabis consumption is estimated at 3.80 million pounds in 2024. This is the baseline applied to this SRIA.

Table 2. California Total Cannabis Consumption Estimates, 2019 – 2024

Year	Lower Bound Consumption	Mean Consumption	Upper Bound Consumption
<i>Pounds Dry-Flower Equivalent, Millions</i>			
2019	1.92	2.32	2.72
2020	2.08	2.51	2.94
2021	2.20	2.66	3.11
2022	2.52	3.04	3.57
2023	2.55	3.41	4.27
2024	2.64	3.80	4.96

Note: Per capita consumption for 2023–2024 is estimated using the econometric model/analysis described in this report.

Increasing per capita consumption reflects growing demand as well as the shift toward value-added retail products that require more cannabis (dry-flower equivalent) to produce. This is consistent with the trend prior to MAUCRSA in California, and consistent with trends in other states with licensed cannabis markets and the broader United States.

3.4 Licensed Market Share of Total Consumption

The licensed market share is the estimated share of California cannabis consumption that is met by licensed market production and purchased at licensed retail locations (i.e., excluding homegrown cannabis and diversions from licensed producers to the illicit market). The analysis of licensed market production and total consumption was combined to estimate licensed market share and trends over time.

Table 3 summarizes the estimated share of California cannabis consumption met by licensed market production for 2019–2024. The licensed market share is based on CDTFA and CCTT sales data through 2024 and NSDUH frequency of use survey data that extend only through 2022. The confidence interval (lower bound to upper bound) reflects uncertainty in underreporting consumption in the NSDUH survey, uncertainty in average consumption volumes per use-day, and additional statistical error from estimating consumption for 2023–2024 (missing NSDUH survey years).

Table 3. Licensed Cultivation Share of California Cannabis Demand, Adjusted for Underreporting

Year	Applying Lower Bound Per Capita Consumption	Applying Average Per Capita Consumption	Applying Upper Bound Per Capita Consumption
2019	30%	25%	21%
2020	40%	33%	29%
2021	45%	37%	32%
2022	44%	37%	31%
2023	50%	38%	30%
2024	54%	38%	29%

Notes: Licensed cultivation is a share of survey-based demand estimates, with *ex post* adjustments made for underreporting.

The average market share of licensed cannabis in 2024 is 38 percent, with a statistical confidence interval range of 29–54 percent. The licensed market share increased annually from 2018 through 2021. A share of 38 percent is applied as the baseline for this SRIA.

3.5 Description of Laboratory Testing

Testing laboratories ensure cannabis products are safe for consumption. To accomplish this, all batches of cannabis goods must be tested before they can be sold. This includes dried cannabis flower as well as manufactured cannabis products. As of January 1, 2024, licensed laboratories must use the Department’s standardized cannabinoids test method and standardized operating procedures for testing dried flower, including non-infused pre-rolls.

Laboratories are required to test cannabis goods for the following:

- Cannabinoids and terpenes,
- Residual solvents and processing chemicals,
- Residual pesticides,
- Heavy metals,
- Microbial impurities,
- Mycotoxins,
- Moisture content and water activity, and
- Foreign material.

Testing labs report results on a Certificate of Analysis (COA). The COA says whether the batch passes or fails testing for each substance. Labs can only issue COAs and results after they complete all tests. Labs cannot change a COA after it is issued without permission from the Department. Within one day of finishing testing of a batch, the testing lab must upload the COA to CCTT and send a copy of the COA to the Department.

Batches of cannabis that fail testing must be destroyed by the distributor or remediated by a manufacturer to remove contamination from a product. Remediation must be approved in advance by the Department. After remediation, cannabis goods must be retested to ensure the contaminant was removed.

Laboratory licensees are required to maintain ISO/IEC 17025 accreditation. This accreditation specifies general requirements for competence and consistent operation, sets out requirements for reference material, and enables laboratories to demonstrate they operate competently and generate valid results. Laboratories must also use standard operating procedures, develop a laboratory quality assurance program, and participate in a proficiency testing program.

Laboratories use advanced analytical instruments to detect cannabinoids and contaminants. Specific tools include:

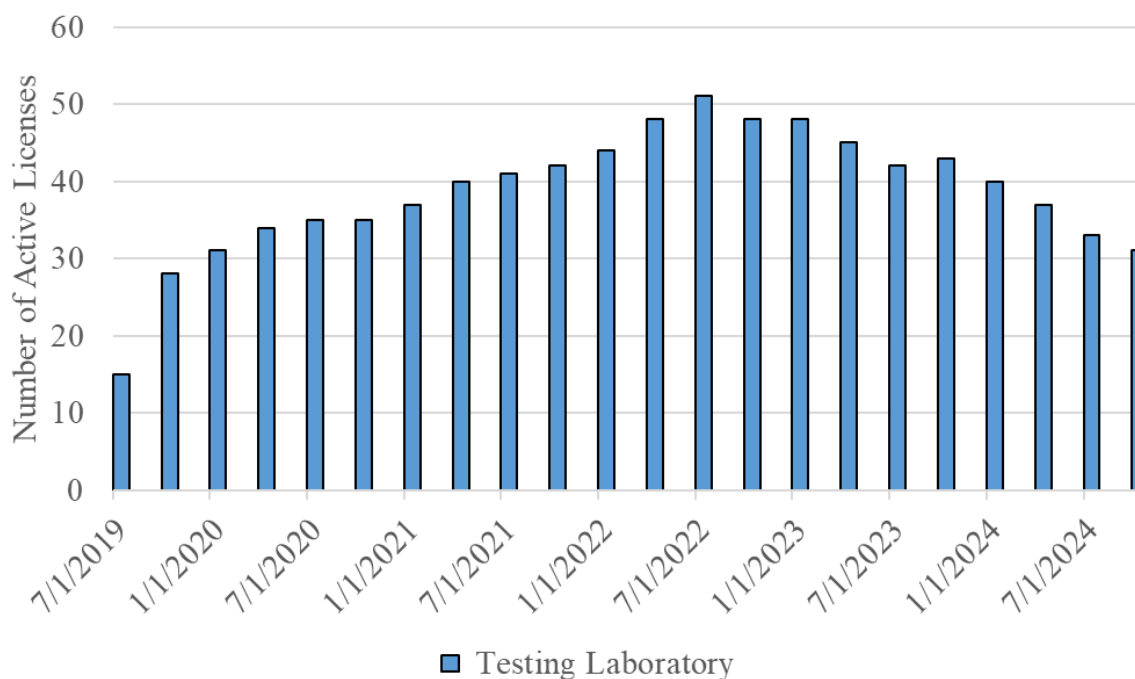
- High-performance liquid chromatography (HPLC) for cannabinoids.
- Gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS) for pesticide residues and solvents.
- Inductively coupled plasma mass spectrometry (ICP-MS) for heavy metals.
- Polymerase chain reaction (PCR) for microbial contaminants.

Mass spectrometry (MS), used for pesticide residue testing, operates by identifying and quantifying chemical compounds based on their mass-to-charge ratio. This is the industry standard for testing pesticide residue. Labs typically use both GC-MS and LC-MS instruments for pesticide residue testing.

3.6 Laboratory Licenses

Figure 4 shows license trends for testing labs. The number of testing lab licenses has decreased consistently, from a peak of 51 in July 2022 to 28 as of January 2025. Prior to enforcement of standardized potency procedures as of January 2024, labs that may have provided inflated potency were at a competitive advantage relative to other labs (this advantage still exists, but to a lesser extent). Additionally, labs that use less precise testing methods may be able to charge lower prices and fail fewer batches than competitors. These factors have contributed to a difficult environment for licensees that discourages proper compliance and potency testing. This may have contributed to some labs exiting the market.

Figure 4. Change in active testing laboratory licenses, 2019 to 2024



3.7 Laboratory Testing Failure Rates

As of the lab testing regulations developed in 2017 after MAUCRSA, there is a lack of specificity for laboratory testing methods (i.e., LOQs and action limits), resulting potentially in passed laboratory tests that would otherwise fail under the proposed regulatory changes.

Distributors often have product samples tested for certain pesticides prior to full batch compliance testing. This is called R&D testing and is considerably cheaper than compliance testing (R&D testing is also commonly conducted to determine potency). Most labs conduct both R&D testing and compliance testing, although a few labs exclusively conduct R&D testing. If pesticide residue is detected during R&D testing, the distributor can destroy the product and save on total testing costs. The distributor may also opt to seek testing at a second location, in hopes of a more favorable result. This is often referred to as “lab shopping.”

Distributors have an economic incentive—lowering total testing expenditures, inflating potency, and avoiding the destruction of contaminated products—to shop for laboratories with higher rates of passed testing for contaminants. To remain competitive, it could be advantageous for some laboratories to use lower precision methods to pass testing for pesticides and other contaminants. That is, there is potential for an adverse incentive for laboratories to manipulate testing, leading to unsafe products entering the market and putting consumers at risk.

Establishing new pesticide residue testing standards has mixed implications for active labs. The incentive for lab shopping would be diminished, resulting in fewer samples tested in total. This would result in lower average lab revenue, which may lead to some labs exiting the industry.

However, standardizing lab testing procedures makes it more difficult for labs to provide sub-standard test results. This would benefit some laboratories and discourage those that are not compliant, which is the intent of the proposed regulations.

There may be some current economic incentives for labs to maintain high passed test rates. For example, some distributors may be more likely to seek out labs with higher passed test rates. If products that would have otherwise failed testing reach the market, then businesses avoid lost revenue. This may lead to potentially harmful products at retail that should have failed testing. Lab shopping and testing practices cannot be directly identified in CCTT data, causing enforcement of these activities to be difficult. However, past DCC regulations have proven to be effective at countering bad lab testing practices. Regulations implemented in January 2024 to standardize procedures for testing and calculating total THC have greatly reduced incentives for inflating THC test results.

Table 4 summarizes the expected decrease in cannabis supply from implementing the proposed regulations. The average expected decrease in cannabis supply, as determined by the mean of the lower and upper bounds, is 1.61 percent. These changes are implemented as supply shifts in the Market Supply and Demand Effects section. The following subsections describe the derivations of these expected supply shifts.

Table 4. Expected Decrease in Cannabis Supply from Increased Failure Rate

	Lower Bound	Upper Bound	Mean
Supply Shift	0.56%	2.65%	1.61%

3.7.1 Lower Bound Supply Shift

The proposed regulations would initially increase testing failure rates as non-compliant product would fail testing. To examine the potential extent of falsely passed tests, test failure rates were compared across labs as well as with agricultural products. Table 5 summarizes test failure rates for flower and vape products for laboratories with below and above average fail rates, as well as the overall industry failure rate.

Table 5. Laboratory Failure Rates by Product Type, 2024

Product Type	Labs With Below Average Fail Rates	Labs With Above Average Fail Rates	Overall Fail Rate
	<i>Failure rate</i>		
Flower	0.43%	1.60%	1.02%
Vape	0.25%	1.75%	1.23%

Note: Failure rates are for January 2024 – September 2024.

Based on the failure rates in Table 5, if the failure rate for below average labs were to increase to the same rate as above average labs, there would be a 0.59 percent decrease in the supply of

flower products and a 0.53 percent decrease in the supply of vape products.⁸ The increase in failures across testing of all products would decrease supply of cannabis by 0.56 percent. This effect is considered the lower bound change in test failures and is treated as the lower bound decrease in licensed cannabis supply in the Market Supply and Demand Effects section. The higher the test failure rate, the greater the decrease in licensed cannabis supply.

3.7.2 Upper Bound Supply Shift

Other agricultural products were reviewed to assess standard failure rates for pesticide residue testing. The rate of failure in cannabis is currently considerably lower than what is observed across other agricultural products. According to DPR's 2022 Pesticide Use Annual Report data (DPR, 2022), 3.09 percent of agricultural products from California failed testing for pesticide residues. Note that this failure rate is just for pesticides—cannabis may also fail testing due to contaminants such as aspergillus, heavy metals, water activity, and salmonella. Furthermore, agricultural commodities have higher permissible pesticide residue levels than cannabis products. If the proposed action limits for non-inhalable cannabis products were applied to agricultural commodities, the failure rate for agricultural products would increase to 3.46 percent. The failure rate would be even higher if the proposed action limits for inhalable cannabis products, although this is not a direct comparison because of the considerable differences in chemicals used.

Part of the difference in failure rates for cannabis and agricultural products may be attributable to testing failures during R&D prior to compliance testing. However, it is likely that lab shopping and inaccurate lab testing methods also contribute to this difference. Representatives from currently active laboratories have suggested that it is common for some laboratories to use substandard testing methods. Laboratories testing agricultural products have generally been long established, and they have developed more consistent and reliable testing methods. The proposed changes to pesticide residue testing would limit the extent to which cannabis laboratories could employ substandard methods, bringing failure rates more in line with those observed for agricultural products.

Overall failure rates for laboratories in 2024 were approximately 1.10 percent (this includes flower and vape product failures as shown in Table 5, as well as all other cannabis products). Based on a lab testing data summary provided by the Department, and adjusting for discrepancies between the data used in this SRIA and data used by the Department, the failure rate specifically attributable to pesticides for flower is estimated to be 0.47 percent. If the pesticide failure rate for cannabis increased to the same failure rate observed in other agricultural products, the overall testing failure rate for cannabis would increase from 1.10 percent to 3.72

⁸ The decrease in supply of flower is equal to the new expected failure rate relative to the current failure rate, $1 - (1 - 0.0160) / (1 - 0.0102) = 0.0059$. Similarly for vape supply, the change is $1 - (1 - 0.0175) / (1 - 0.0123) = 0.0053$.

percent, all else equal. The corresponding decrease in cannabis supply would be 2.65 percent.⁹ This is treated as the upper bound of the expected decrease in the supply of cannabis.

3.8 Baseline Cost of Laboratory Testing

The proposed regulations would increase lab testing costs through practices, labor, maintenance, and potentially investment in new equipment. Current (baseline) lab costs were reviewed to establish a baseline to measure the additional costs of the proposed regulation.

Table 6 shows the average estimated annual costs for a medium-size laboratory (average of 5,895 samples analyzed per year). Cost information is from Valdes-Donoso, Sumner, & Goldstein (2020), adjusted for inflation to 2024 dollars, and updated based on recent CCTT data, license fees, and test pricing information. Lab costs are substantial, exceeding several million dollars per year. Amortized fixed costs (e.g., capital investment, equipment, and rent/utilities overhead) can account for around 40 percent of total annual costs.

Table 6. Average Annual Laboratory Costs (Example Average Medium-Sized Lab)

Item	Annual Cost
	<i>(\$1,000)</i>
Capital investment, interest plus depreciation	\$455
Equipment maintenance and acquisition and maintenance of ISO/IEC-17025	\$507
Rent and basic utilities	\$400
Sales, general and administrative costs	\$106
License fees	\$30
Labor	\$1,076
Consumable costs	\$1,042
Return to management (profit, ~7.5%)	\$279
Total Cost	\$3,895

Costs in Table 6 represent average estimated costs for a laboratory and are not necessarily representative of any individual laboratory. For example, some labs run multiple shifts and run tests up to 24 hours per day, considerably reducing their average fixed costs. Furthermore, these estimates reflect the costs of laboratories that are compliant with current standards¹⁰. Low failure rates, low testing prices, and rapid test turnaround times indicate that some laboratories are

⁹ The decrease in supply of cannabis is equal to the new expected failure rate relative to the current failure rate, $1 - (1 - 0.0372) / (1 - 0.0110) = 0.0265$.

¹⁰ The SRIA differentiates between “compliant” labs that already follow standard best methods and “non-compliant” labs that do not, currently, follow all of these methods. This is a way to segment the labs into different direct costs of the proposed regulations. In practice, each lab is not simply compliant or non-compliant, and there are variations in practices across labs, which is one of the reasons for the proposed regulations to standardize methods.

possibly not fully compliant with California’s current testing regulations (or operate in legally grey areas to circumvent testing regulations).

Testing costs vary by lab size, efficiency, and type of cannabis good. Cannabis harvest batches are capped at 50 pounds, and there is a minimum sample size of 0.35 percent of the batch weight. Cannabis product batches are capped at 150,000 units. The number of required sample units increases with batch size, ranging from 2 samples for a batch of 50 or less units, to 50 samples for a batch size of 35,001 – 150,000 units.

Large labs, benefiting from economies of scale, generally offer lower per-sample costs than smaller labs. The average testing cost for distributors in 2019 was \$136 per pound of dried cannabis flower (\$163 in inflation-adjusted 2024 dollars). Batch size and failure rates significantly impact costs (Valdes-Donoso, Sumner, and Goldstein, 2020); the cost of destroyed product from failed testing is incorporated in their estimate of average testing costs per pound of flower. Failed testing increases overall testing costs due to inventory losses and re-testing expenses. Their estimate of average testing cost per pound of flower was based on an average batch size of 8 pounds and testing failure rate of 4 percent.

The average testing cost per pound of flower decreases as less cannabis fails testing and is destroyed. Failure rates in 2024 have dropped to approximately 1 percent. The inflation-adjusted cost of testing to distributors with a failure rate of 1 percent would be approximately \$121 per pound based on the Valdes-Donoso, Sumner, and Goldstein estimates.

Table 7 summarizes laboratory testing totals and estimated revenue per lab by type of test in 2024. There were 28 active labs, 26 of which conducted an estimated total of 114,315 compliance tests (2 active labs conducted 0 compliance tests). 22 of these labs accounted for 99.9 percent of compliance tests, averaging 5,193 tests per lab and a test failure rate of 1.10 percent; the other 6 active labs presumably focused mostly or entirely on R&D testing.

Table 7. Estimated Annual Laboratory Totals, 2024

Item	Value
Total number of compliance tests	114,315
Active labs conducting compliance testing	22
Compliance tests per lab	5,193
Average revenue per lab	\$3,895,000
Compliance testing, \$450/test	\$2,337,000
R&D testing, pesticide residue, \$150/test	\$779,000
R&D testing, potency and other, variable pricing	\$779,000
Failed tests (share)	1.10%

Note: Excluding R&D-focused and small laboratories with less than 100 compliance tests per year.

Labs are highly variable in terms of how many R&D tests they conduct for potency and contaminants relative to compliance testing. Only compliance testing data are recorded in CCTT. Based on industry feedback, for each compliance test conducted, there are, on average, one R&D

test conducted for pesticide residue and several other R&D tests conducted for potency and other contaminants. Compliance testing accounts for close to 60% of lab revenue and R&D testing 40% of lab revenue (half of which is for pesticide residue testing), industry wide.

Applying approximate rates of \$450 per compliance test across flower and manufactured products (e.g., vapes and edibles), \$150 per R&D test for pesticide residue, and \$150 total revenue from other R&D testing, the implied average annual revenue per lab, as shown in Table 7, is \$3.895 million (excluding labs with less than 100 tests per year).¹¹ The implied average testing batch size is 12.5 pounds of dry-flower equivalents (1.429 million pounds of dry-flower equivalents divided by 114,315 compliance tests).

For a typical lab with a 60/40 revenue split from compliance and R&D testing, average revenue per sample batch (inclusive of compliance and R&D testing) is \$749 per batch, or \$60 per pound of dry-flower equivalents. After accounting for test failures, the average cost to distributors is \$67 per pound of dry-flower equivalent.

Based on an approximation of 260 business days per year, the average laboratory conducts compliance testing for 20 samples per day (and R&D testing for pesticide residue on an additional 20 samples). This could reasonably be achieved with one LC-MS and one GC-MS, considering that residual pesticide testing has an estimated runtime of 30 minutes per sample. To achieve this level of efficiency, labs would need to be consecutively running pesticide residue analysis 10 hours per day as well as concurrently preparing other samples, conducting analysis for other contaminants on other samples, and analyzing and reviewing test results.

4. Economic and Fiscal Impacts: Proposed Regulations

This section summarizes the direct costs and benefits of the Department's proposed laboratory regulations. The benefits and costs from regulations accrue to different businesses and different sectors of the economy. The total impact of regulations to cannabis businesses and the corresponding total impact to each related sector of the economy are also estimated.

The cost of regulations summarized in this section represents the additional incremental costs of the regulations. For example, if a proposed regulatory requirement is already part of standard industry production practices, then there is no incremental cost attributable to that proposed requirement. The economic impact analysis considers a point-in-time (annual, 12 month) comparison of the SRIA baseline (defined in Section 3) to conditions with the proposed regulation.

¹¹ The average rate of \$450 per test is for medium sized labs compliant with current regulatory standards. It has been reported that there are bad actor labs not following current testing requirements and therefore offering considerably lower compliance testing prices. Many labs lower compliance testing costs and prices by conducting more R&D tests which typically have higher margins than compliance testing. Data are unavailable for R&D testing for pesticides and potency.

4.1 Direct Economic Benefits

The proposed regulations require validating test methods (via ISO 17025 certification) and establishing new standards for pesticide residue testing. These changes benefit laboratories by ensuring that all licensees are using the same testing standards. This would reduce distributors' incentives to shop for labs that produce more favorable test results. This provides a direct, but unquantifiable, economic benefit to good-actor laboratories.

Establishing new standards for pesticide residue testing would reduce the amount of products with harmful levels of chemicals that reach consumers. The human and environmental health benefits are direct, but unquantifiable, economic benefits.

4.2 Direct Industry Costs

Direct industry cost are the incremental costs of the proposed regulation to affected businesses, namely laboratories. This includes operating, overhead, and any capital costs (e.g., investments in new machinery).

Table 8 summarizes the total expected regulatory compliance costs for laboratories, separated by one-time and recurring annual costs. The economic analysis then considers the market implications of these costs for producers and consumers in both the licensed and illicit markets. In the Market Supply and Demand Effect section, one-time costs are annualized based on an interest rate of 7.5 percent over a 10-year period and combined with annual variable costs to determine the overall cost shift, relative to the wholesale value of cannabis. All costs are interpreted as the incremental cost relative to current practices.

Table 8. Total Direct Costs per Laboratory and Total Industry Costs

Item	Cost per Laboratory	Total Industry Cost
<i>Thousands</i>		
New instruments	\$900.00	\$19,800.00
One-time labor	\$19.20	\$422.40
One-time consumables	\$16.22	\$356.84
Total One-Time Costs	\$935.42	\$20,579.24
Equipment maintenance	\$146.10	\$3,214.18
Variable labor	\$187.35	\$4,121.81
Variable consumables	\$94.14	\$2,071.15
Total Variable Costs	\$427.59	\$9,407.14
Total Costs	\$1,363.02	\$29,986.37

Note: Total industry costs calculated under the basis of 22 labs conducting compliance testing.

The costs to laboratories to implement the new standards would be substantial. However, currently there appear to be unrealistically low rates of pesticide testing failure rates based on reports of pesticide residue found on products at retail and testing failure rates for other agricultural commodities (DPR, 2025). The proposed regulatory changes will enable the

Department to ensure laboratories are compliant and would significantly reduce the quantity of unsafe products that reach consumers, leading to unquantified human and environmental health benefits.

The following subsections describe the regulatory compliance costs in detail, how they are calculated, and any regulatory costs that were still uncertain at the time this analysis was finalized.

4.2.1 §15719. Residual Pesticides Testing

Laboratories are expected to incur one-time and variable cost increases from expanding the list of pesticides required for residual testing and from revising LOQs for pesticides. Many, if not all, laboratories would need to upgrade their instruments to MS capable of testing at lower LOQs. Recalibrating their methods for lower LOQs also necessitates revalidating tests, which requires the work of highly educated analytical chemists. Achieving lower LOQs would also require additional time spent preparing samples and calibrating instruments, longer chromatographic total runtime, additional quality control checks, more frequent equipment downtime for maintenance, and more detailed data analysis.

Revised action levels and LOQs would likely cause a large increase in failed testing, resulting in a reduction in the supply of cannabis. This is evaluated in the Market Supply and Demand Effects section.

The specific regulatory changes expected to increase costs include:

- Increasing the list of residual pesticides from 66 to 80 pesticides.
- Revising action levels for many pesticides and establishing action levels for newly added pesticides.
- Revising the LOQ for Category I pesticides from a constant of 0.10 µg/g for all pesticides to an LOQ that is variable by pesticide, set to 50 percent of the proposed action limit.
- Revising the action limits for Category II pesticides and establishing an LOQ set to 50 percent of the proposed action limit.

The median action limit established by the proposed regulations is 0.10 µg/g and the minimum is 0.005 µg/g. High-end MS instruments are hypothetically capable of quantifying residue at an LOQ of 0.0025 µg/g—the lowest LOQ proposed in the regulatory package. Of the 28 active laboratories in California as of January 2025, 21 disclose their instruments online for detecting pesticide residue, and all 21 use LC-MS and/or GC-MS. However, depending on the specific MS instrument and technique used, upgraded instruments may be necessary to achieve an LOQ as low as 0.0025 µg/g. Laboratories with capable instruments would still need to modify and revalidate their methods. Additionally, there have been no proven methods to demonstrate that even high-end MS are capable of detecting pesticide residues at the proposed LOQs. As such,

there is considerable uncertainty regarding the validation time, methods, and instruments needed to comply with the proposed limits.

Lowering the LOQ for some pesticide residues would increase the likelihood that a cannabis good fails testing due to contamination. Higher LOQs reduce the likelihood of detecting low concentrations of pesticide residues, thereby preventing the detection of trace levels of pesticides that are harmful and exceed regulatory limits. This can compromise consumer safety by allowing small amounts of harmful pesticides to go undetected. Balancing LOQ with regulatory standards and safety needs is critical for effective pesticide residue management.

There are several recalibration and optimization steps a laboratory would need to take to lower LOQs. Many of these are likely to be implemented by laboratories already but would require expanded effort or investment. Achieving lower LOQs would necessitate some combination of investment in new capital, one-time adjustments, revalidation of methods, additional high-skilled labor, and different materials or methods.

- **Enhanced Instrument Sensitivity:**
 - Upgrade detectors to those with higher sensitivity (e.g., triple quadrupole (TQ-MS), time-of-flight systems (QTOF-MS) to improve signal detection at lower analyte concentrations.
 - Use advanced ionization techniques, such as electrospray ionization (ESI) or atmospheric pressure chemical ionization (APCI), to increase the ionization efficiency of pesticides.
- **Optimization of Analytical Conditions:**
 - Fine-tune chromatographic separation (e.g., using ultra-high-performance liquid chromatography) to enhance signal resolution and reduce interference.
 - Adjust mobile phase composition and flow rates to optimize the ionization of specific pesticide molecules.
- **Reduction of Noise and Interference:**
 - Implement cleaner sample preparation methods, such as QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe), to reduce matrix effects that interfere with detection.
 - Employ spectral deconvolution software to distinguish analyte signals from background noise.
 - Prepare additional samples and additional injections with multiple preparations (e.g., filtered and unfiltered).
- **Calibration with Standards:**

- Use highly purified analytical standards to recalibrate the instrument for lower detection thresholds.
- Create calibration curves with concentrations below current LOQ to establish accurate quantification at these levels.
- **Frequent Recalibration and Maintenance:**
 - Regularly recalibrate the MS using isotopically labeled internal standards to ensure the instrument's accuracy at lower LOQs.
 - Maintain the cleanliness and functionality of the ion source and detector to prevent signal degradation.
 - Additional cleaning of instruments between samples, and more frequent instrument downtime for maintenance.
- **Expand Capacity:**
 - Hire additional staff for sample preparation and cleaning, analysts for testing and data analysis, analytic chemists for method validation, and engineers for equipment maintenance.
 - Invest in additional instruments to account for lost capacity from extended runtimes, repeat testing, and more frequent instrument downtime.

Of the 80 pesticides included in the DPR memorandum, 52 require an LOQ lower than current standard practices (0.1 µg/g). Of these 52, 48 of the pesticides have a moderate decrease in LOQ that would require some combination of the changes described above, but there is uncertainty whether investment in new instruments would be necessary. The action limits and LOQ decreases of the other 4 pesticides would almost certainly require investment in new instruments for most labs. However, there has been no research to date demonstrating the methods and instruments needed to achieve the decreased LOQs. Therefore, a conservative approach is taken in cost estimation, and it is assumed that labs must invest in new instruments.

4.2.2 Costs of Compliance

This section provides a detailed description of the compliance costs provided in Table 8. Compliance costs are based on outreach with PhD chemists unaffiliated with the California cannabis industry, experts within the Department, and owners/employees of currently active testing labs in California. The anticipated one-time direct costs are labor costs for revalidation of tests from changing action limits and LOQs and adding new pesticides, materials costs from purchasing pesticide mixes and other consumables for revalidation, and capital costs from investment in new testing instruments. As of January 2025, there are 28 active laboratories, 22 of which conduct a significant number of compliance tests. Labs that only engage in R&D testing are not expected to make changes to adhere to new pesticide requirements.

The testing validation process likely requires a minimum of two weeks of labor per validation from a high-skilled (PhD) analytic chemist. This is the best-case scenario—validation may take several months to complete. The validation process would need to be conducted for flower and repeated for an additional non-flower cannabis good. The validation process would also need to be repeated by a second chemist on different days. A pesticide mix kit would need to be purchased to revalidate the 66 current pesticides, and another pesticide mix kit would need to be purchased to validate the 14 new pesticides. Method validation may fail during initial attempts and require repetition (i.e., additional labor time and consumables).

One-time labor costs. The average wage rate in California for high-skilled (PhD) analytical chemists is approximately \$60/hour (\$124,800 per year). Validation of residual pesticide testing would therefore incur an average labor cost of \$19,200 per laboratory in the first 12-months of enacting the policy (2 validations per chemist*80 hours per validation*2 chemists*\$60/hour). One-time labor costs would be \$19,200 per laboratory and total industry labor costs for validation would be \$422,400 in the first year of implementation.

One-time materials costs. Pesticide mix kits for LC-MS for all 66 pesticides currently required for testing are approximately \$620 per kit (Emerald Scientific, 2025), and industry sources have suggested a kit for the additional 14 chemicals is likely to cost upwards of \$200. However, it would take time for these individual kits to be developed by manufacturers and likely would not be available in the first year of implementation. Currently available pesticide mix kits that are more exhaustive than the list provided by the DPR memorandum (200 plus pesticides) are \$1,620 per kit for LC-MS and \$2,434 per kit for GC-MS (Restek, 2025). The expected one-time cost of consumables per laboratory is approximately \$16,220 (8 mix kits per laboratory, 4 of each type), and the total cost to the industry is \$356,840.

Capital costs. The standard instruments used by labs for residual pesticide testing are LC-MS and GC-MS. However, the capabilities of MS instruments are variable. Achieving the proposed LOQs may require laboratories to use a TQ-MS or QTOF-MS. Without these or similarly capable instruments, the runtime of pesticide residue testing would be impractically long and financially infeasible. The cost of these instruments is highly variable, ranging from \$100,000–\$500,000 with a median price of \$300,000. Prices vary depending on whether the instrument is new or refurbished, and the warranties, accessories, and software included. Top of the line MS instruments can exceed \$1,000,000 including software and maintenance agreements.

Laboratories currently perform 20 compliance tests per business day on average. This equates to roughly 30 minutes per test for residual pesticides and 10 hours of testing per day. However, decreasing LOQs from 0.10 µg/g to as low as 0.005 µg/g would increase testing time as well as require more frequent instrument cleaning and equipment maintenance. MS runtime for testing is expected to increase by 15 minutes, cleaning time between each sample is expected to increase by 15 minutes, and downtime for maintenance is expected to double.

In addition to upgrading their MS to a TQ-MS or QTOF-MS, laboratories also must invest in additional instruments to maintain the same number of tests per day. The expected revenue loss

from reducing capacity is considerably greater than the costs of additional labor and instruments. Therefore, investment in better and additional instruments is expected to be the most cost-effective means of compliance. The median price per instrument is \$300,000, and 3 MS instruments would be needed to maintain the testing rate of 20 tests per day, accounting for increased testing, cleaning, and maintenance downtime. The expected capital investment necessary for compliance, therefore, is \$900,000 per lab, and \$19.8 million total for the industry. Annual maintenance costs for equipment are expected to increase proportionally, resulting in \$146,100 per laboratory and \$3.21 million total for the industry.

Due to higher perceived risk and federal laws against cannabis, it is often difficult for cannabis businesses to secure funds. Many laboratories, especially smaller labs, may be unable to secure financing needed to invest in new instruments and cover other up-front costs. This is expected to lead to laboratories exiting the market.

Variable labor costs. In addition to investment in more capable instruments, laboratories are expected to hire additional analysts, technicians, samplers, and engineers. The following components contribute to increased staffing needs:

- **Quality Control.** Laboratories would be subject to more rigorous quality control that requires a broader range of calibration standards to verify instrument accuracy and preparation and running additional standards. More frequent instrument calibration is necessary owing to increased drift at low LOQs. More spike samples are required to ensure accuracy and precision at lower concentrations.
- **Sample Preparation.** At lower LOQs, sample matrices are more sensitive to interference that impacts detection of pesticides. More thorough cleanup is needed, adding to processing time. There is also an increased risk of cross-contamination, requiring stricter handling protocols and cleaning between samples. Some analytes may require labs to split pesticide panels into multiple runs for use on multiple instruments of varying sensitivity.
- **Repeat Testing.** The probability of ambiguous test results is higher at low LOQs. Labs may need to repeat testing more often to confirm and validate findings. They may also need to run more blank samples or spiked samples to verify the system is detecting low levels of pesticides.
- **Maintenance.** In addition to requiring more cleaning to ensure instruments are detecting pesticides at low LOQs, more frequent maintenance is expected as well.
- **Data Processing.** Detecting and quantifying a greater number of pesticides at lower LOQs generates more data that require more careful analysis. Particularly, the signal-to-noise ratio decreases at low LOQs, making it more difficult to distinguish between true signals and background noise, therefore requiring more meticulous review.

Based on industry outreach, labor requirements associated with pesticide residue compliance testing are expected to increase by about 30 minutes per test on average (and turnaround time of testing is expected to double). Additional labor costs from increased average testing time are roughly 67 percent for sample preparation (average wage of \$25 per hour) and 33 percent for analysis (average wage of \$35 per hour). Cost increases apply to pesticide residue R&D testing as well, although the R&D cost increases are estimated to be just one-third of the increases for compliance testing. Additionally, laboratories are expected to hire an additional engineer to assist with instrument maintenance (average salary of \$90,000) or realize similar cost increases in instrument service agreements. Overall, the expected increase in annual variable labor costs is \$187,350 per lab and \$4.12 million total for the industry.

Variable materials costs. As mentioned, labs are expected to repeat testing more often, as well as run more blank samples and spiked samples. The need for more frequent retesting may double the cost of consumables per compliance test from an average cost of \$13.63 to \$27.26. Consumable costs for R&D pesticide residue testing are expected to increase by \$4.54 per test. This results in increased annual variable costs for consumables of \$94,140 per lab and \$2.07 million for the industry.

4.3 Market Supply and Demand Effects

The purpose of the market analysis is to estimate the effects of proposed laboratory regulations on producers and consumers, and the resulting market equilibrium. The driving force of these regulations on the cannabis sector can be characterized as an aggregate shift in supply of licensed cannabis (increased rate of failure for laboratory testing), as well as cost shifts in supply (increased testing costs).

The market effects of the proposed regulation were evaluated using an equilibrium displacement model (EDM) of the California cannabis market. EDM has a well-documented history in analyzing the effects of changes in trade policies, advertising, taxes, and regulation of primary production systems. It has been extensively applied to agricultural systems such as dairy, beef, and lettuce. An EDM is a mathematical representation of the supply and demand for an aggregate market and underlying market segments that is used to assess how the market would respond to a change in market conditions (in this case, changes to marginal production costs and shifts in production).

The EDM model is a set of logarithmic differential equations that characterize the comparative economic statics of the system and is used to measure shifts from one equilibrium to another caused by exogenous effects on supply and demand, such as would result from new regulations. Since it uses elasticities to measure the change in comparative static equilibria, it can be readily applied to new empirical situations since all the essential relationships are expressed in percentage terms and are not changed by different empirical scales that are required by a more structural modeling approach.

The cannabis market EDM was developed by ERA Economics and initially applied for the 2016/2017 Standardized Regulatory Impact Assessment of the CalCannabis Cultivation Licensing Program (and Medical Cannabis Cultivation Program). The cannabis market structure has changed since the initial assessment in response to new laws, regulations, better industry data, industry interviews, and various economic studies. ERA has developed a series of EDM frameworks to incorporate these changes and evaluate market effects for different segments of the California cannabis market.

The proposed regulations are not expected to have differing effects by cultivation method (outdoor, indoor, and mixed-light) or product segment (flower and manufactured products). Therefore, the EDM used in this report includes the following market segments:

- Licensed production,
- Illicit production,
- Licensed market consumer demand,
- Illicit market within-state demand, and
- Illicit market export demand.

Inputs to the EDM model are the changes to industry supply (horizontal shifts in supply proportional to quantity, and vertical shifts in supply proportional to marginal costs) caused by the proposed regulation. To implement these changes in the EDM, the net cost increase of laboratory testing and the expected increase in the laboratory failure rate were calculated. The change in production cost was calculated on a per-pound basis relative to average wholesale cannabis flower prices, and the horizontal shift in supply was calculated as a proportion of the initial equilibrium quantity.

The cannabis market equilibrium is specified as follows.

$$D_{LC} = D_{LC}(P_{LC}^r, P_{IC}^r) \quad [\text{Legal cannabis demand}] \quad (1)$$

$$D_{IC} = D_{IC}(P_{LC}^r, P_{IC}^r) \quad [\text{Illicit cannabis within-state demand}] \quad (2)$$

$$D_{XC} = D_{XC}(P_{IC}^f) \quad [\text{Illicit cannabis export demand}] \quad (3)$$

$$S_{LC} = S_{LC}(P_{LC}^w) \quad [\text{Supply of legal cannabis}] \quad (4)$$

$$S_{IC} = S_{IC}(P_{IC}^w) \quad [\text{Supply of Illicit cannabis}] \quad (5)$$

$$P_{LC}^r = P_{LC}^r(P_{LC}^w) \quad [\text{Market-clearing licensed cannabis price}] \quad (6)$$

$$P_{IC}^r = P_{IC}^r(P_{IC}^w) \quad [\text{Market-clearing illicit cannabis price}] \quad (7)$$

$$D_{LC} = S_{LC} \quad [\text{Market-clearing legal cannabis}] \quad (8)$$

$$D_{IC} = S_{IC} \quad [\text{Market-clearing illicit cannabis}] \quad (9)$$

Equations (1), (2), and (3) define consumer demand for licensed cannabis, within state demand for illicit cannabis, and export demand for illicit cannabis, respectively. Equations (4) and (5) are licensed and illicit supply of cannabis.

The market clearing conditions are represented by equations (6)–(9) and define the relationship between wholesale and retail prices, and they equate market segment supply to market segment demand.

Endogenous variables in the model are cultivator output of licensed and illicit cannabis (S_{LC} and S_{IC}), quantity demanded (D_{LC} , D_{IC} , and D_{XC}) for licensed, illicit, and exported illicit cannabis, and the prices of licensed and illicit cannabis at wholesale and retail (P_{LC}^w , P_{IC}^w , P_{LC}^r , and P_{IC}^r).

The equilibrium solutions are derived by taking the total derivatives of the structural model, expressing them in log-differential form, to obtain a solvable system of equations:

$$d\ln D_{LC} = \eta_{LC} d\ln P_{LC}^r + \eta_{LC,IC} d\ln P_{IC}^r \quad (10)$$

$$d\ln D_{IC} = \eta_{IC,LC} d\ln P_{LC}^r + \eta_{IC} d\ln P_{IC}^r \quad (11)$$

$$d\ln D_{XC} = \eta_{XC} d\ln P_{IC}^w \quad (12)$$

$$d\ln S_{LC} = \epsilon_{LC} (d\ln P_{LC}^w - \theta_L) + \beta_L \quad (13)$$

$$d\ln S_{IC} = \epsilon_{IC} d\ln P_{IC}^w \quad (14)$$

$$d\ln P_{LC}^r = \tau_{LC} d\ln P_{LC}^w \quad (15)$$

$$d\ln P_{IC}^r = \tau_{IC} d\ln P_{IC}^w \quad (16)$$

$$d\ln S_{LC} = d\ln D_{LC} \quad (17)$$

$$d\ln S_{IC} = \alpha_X d\ln D_{XC} + (1 - \alpha_X) d\ln D_{IC} \quad (18)$$

Here, θ_L is the increase in marginal production cost for licensed cannabis, and β_L is the decrease in licensed cannabis supply proportional to quantity supplied. Own-price and cross-price elasticities of demand are represented by η , and elasticities of supply are represented by ϵ . The share of export cannabis demand in total illicit cannabis demand is α_X .

This analysis assumes that the cannabis group is weakly separable from other (non-cannabis) consumption, and therefore the cross-price demand elasticities in (1) and (2) can be decomposed into functions of the overall cannabis group demand elasticity, η , the licensed market share in California cannabis demand, ω_{LC} , and the elasticity of substitution between licensed and illicit cannabis, σ (Edgerton, 1997):

$$\eta_{LC} = \omega_{LC}\eta - (1 - \omega_{LC})\sigma \quad (19)$$

$$\eta_{IC} = (1 - \omega_{LC})\eta - \omega_{LC}\sigma \quad (20)$$

$$\eta_{LC,IC} = (1 - \omega_{LC})(\eta + \sigma) \quad (21)$$

$$\eta_{IC,LC} = \omega_{LC}(\eta + \sigma) \quad (22)$$

Changes in consumer (CS), producer (PS), and total (TS) surplus for the licensed market can be measured as:

$$\Delta CS = -D_{LC}P_{LC}^r d\ln P_{LC}^r (1 + 0.5d\ln D_{LC}) \quad (23)$$

$$\Delta PS = S_{LC}P_{LC}^w (d\ln P_{LC}^w - \theta_L + \beta_L/\epsilon_{LC})(1 + 0.5d\ln S_{LC}) \quad (24)$$

$$\Delta TS = \Delta CS + \Delta PS \quad (25)$$

Producer surplus (PS) is a measure of the benefits producers receive from participating in the market and is measured as the difference between the market price and the minimum amount a producer would accept for a given quantity of a good, as defined by the supply curve. Similarly, consumer surplus (CS) is the benefit consumers receive from participating in the market and is measured as the difference between what consumers are willing to pay (as defined by the demand curve) for a given quantity of a good and the price of the good. Total surplus is simply the sum of PS and CS, or the total surplus for agents participating in the market.

Model parameters are provided in Table 9. The elasticity of supply of licensed cannabis represents an approximate weighted average of outdoor, indoor, and mixed-light elasticities of supply. Outdoor cultivators are assumed to have a relatively inelastic supply—elasticity of supply equals 0.75—as a result of infrequent harvest (usually only once per year). Mixed light production is estimated to have a unit elasticity (1.0) that reflects more frequent harvests. Indoor production is modeled as being slightly elastic with a supply elasticity of 1.25 because of the greater frequency of production (up to four harvests per year based on cultivator surveys). The average of these, weighted by their share in total cultivation, is approximately 1.0.

Table 9. Equilibrium Displacement Model Parameters

Symbol	Description	Value
D_{LC}, S_{LC}	Quantity supplied of demand for licensed cannabis, millions of pounds	1.43
P_{LC}^w	Wholesale price of licensed cannabis, dollars per pound	769
P_{LC}^r	Retail price of licensed cannabis, dollars per pound	3,361
η	Own-price elasticity of demand for cannabis	-0.2
η_{LC}	Own-price elasticity of demand for licensed cannabis	-1.32
η_{IC}	Own-price elasticity of demand for illicit cannabis	-0.88
$\eta_{LC,IC}$	Cross-price elasticity of demand for licensed cannabis with respect to the price of illicit cannabis	1.12
$\eta_{IC,LC}$	Cross-price elasticity of demand for illicit cannabis with respect to the price of licensed cannabis	0.68
η_{XC}	Own-price elasticity of export demand for illicit cannabis	-0.4
ϵ_{LC}	Elasticity of supply of licensed cannabis	1.0
ϵ_{IC}	Elasticity of supply of illicit cannabis	1.5
σ	Elasticity of substitution between licensed and illicit cannabis	2.0
τ_{LC}	Elasticity of price transmission for licensed cannabis wholesale-to-retail	0.5
τ_{IC}	Elasticity of price transmission for illicit cannabis wholesale-to-retail	0.5
ω_{LC}	Share of licensed cannabis in cannabis demand	0.38
α_X	Share of export cannabis in illicit cannabis supply	0.83
θ_L	Cost shift for licensed cannabis	1.27%
β_L	Supply shift for licensed cannabis (range)	-0.56%, -2.65%

Other parameters that are fixed in the EDM are established from published studies where available, summarized here, and discussed in previous sections. The weighted average of price per pound of cannabis dry-flower equivalents at retail (\$3,361) is estimated based on total expected sales (\$4.80 billion) and total expected cultivation (1.43 million pounds) in 2024. Manufacturing of value-added cannabis products is a major factor contributing the high wholesale-to-retail markup.

The own-price elasticity of demand represents the change in quantity demanded of a good due to a change in price of that good. The cross-price elasticity of demand represents the change in quantity demanded of a good due to a change in price of another good. The elasticity of substitution measures the degree of substitutability between two goods. The elasticity of price transmission represents the percent change in the price of a good downstream the supply chain in response to a price change of the good upstream the supply chain. There is little recent economic literature examining demand elasticities for cannabis. The demand elasticities used in this analysis are drawn from the 2017 SRIA prepared by ERA Economics (CalCannabis, 2017), and they have been updated based on more recent data and internal econometric analysis.

The cost shift parameter, θ_L , reflects both the variable cost increases as well as the one-time costs from revalidation and investment in new instruments. The one-time costs are annualized over a 10-year period with an interest rate of 7.5 percent. One-time and annual variable costs are based on the direct cost estimates described in section 4.2 and Table 8. Table 10 summarizes the first-year costs per laboratory. These represent the most cost-effective means of industry compliance.

Table 10. First-Year Annualized Costs Per Laboratory

Item	Cost per Laboratory
	<i>Thousands</i>
New instruments	\$131.12
Equipment maintenance	\$146.10
Variable labor	\$187.35
One-time labor	\$2.80
Variable consumables	\$94.14
One-time consumables	\$2.36
Total Cost	\$563.87

The increase in costs of \$563,870 per laboratory is equal to an increase of \$81.43 per compliance test and \$27.14 per pesticide residue R&D test for a laboratory that conducts 5,193 compliance tests and 51,193 pesticide residue R&D tests per year on average. Based on an average batch size of 12.5 pounds of dry-flower equivalents, and accounting for the current test failure rate of roughly 1 percent, the cost increase is \$6.30 per pound of cannabis. Based on recent average wholesale prices in Q4 2024 of \$769 per pound, this represents a 1.27 percent increase in the wholesale price of flower.

The supply shift for licensed cannabis, β_L , represents the decrease in cannabis supply owing to the increased compliance testing failure rate. The derivation of the lower and upper bounds of this estimate is described in section 3.7. The expected supply change varies from -0.56 percent to -2.65 percent.

Table 11 summarizes the results of the EDM analysis. The proposed regulations affect the price and quantity of licensed and illicit cannabis. This affects the returns for cannabis businesses throughout the supply chain.

Table 11. EDM Analysis Market Effects Selected Results

Description	Lower Bound	Upper Bound	Mean
	<i>(% Change)</i>		
Quantity demanded of licensed cannabis	-0.71	-1.53	-1.12
Quantity supplied of licensed cannabis	-0.71	-1.53	-1.12
Price of licensed cannabis, retail	0.56	1.19	0.88
Price of illicit cannabis, retail	0.02	0.04	0.03
Price of licensed cannabis, wholesale	1.12	2.39	1.76
Price of illicit cannabis, wholesale	0.03	0.07	0.05

Cost increases and supply decreases result in substantial losses to producers and consumers, higher cannabis prices, and increased demand for licensed cannabis. Table 12 summarizes the changes in consumer surplus, producer surplus, and retailer revenue for the licensed market segment. Lower bound, upper bound, and mean changes are provided. On average, consumer surplus decreases by \$41.8 million, producer surplus decreases by \$12.3 million, and licensed retail revenue decreases by \$12.4 million.

Table 12. Changes in Surplus and Retailer Revenue for Licensed Market

Description	Lower Bound	Upper Bound	Mean
	<i>(Thousands)</i>		
Consumer Surplus	-\$26,693	-\$56,931	-\$41,812
Producer Surplus	-\$7,829	-\$16,699	-\$12,264
Retailer Revenue	-\$7,745	-\$17,055	-\$12,400

4.4 Indirect and Induced Effects

The total economic impact includes costs, benefits, and direct, indirect, and induced impacts. Indirect and induced (secondary) economic impacts result from other changes in spending caused by the direct impacts of the proposed regulations. Indirect impacts result from changes in business-to-business spending, and induced impacts result from changes in spending by employees and owners because their income has changed. Indirect and induced impacts are estimated using multipliers from regional economic impact models, also called multiplier models.

Multiplier models are calibrated using national tax data. Since there is no federal licensed cannabis market, these models do not have defined cannabis businesses sectors. To capture the impacts to the California cannabis market, the model approximates the market through emulating the relationships of existing similar sectors:

- A custom retail cannabis sector was developed using the “Retail - Health and personal care stores” sector in IMPLAN as a base. ERA reviewed IMPLAN sectors and identified this sector as best approximating the spending and employment of a licensed cannabis dispensary. Spending patterns were modified to reflect wholesale purchases of cannabis from custom cannabis cultivation sectors, and from a custom cannabis labs sector.
- Cannabis labs are adapted from the “Diagnostic labs” sector in IMPLAN. This sector best reflects the market relationships, spending, and employment of cannabis labs testing retail products for safety. In addition, the impacts upstream on wholesale cannabis from outdoor, indoor, and mixed light producers are captured using a custom agricultural production sector.
- The IMPLAN sector “Tobacco farming” is repurposed (customized) for a cannabis production sector.

The IMPLAN model geographic scope is all California counties (collectively) because the economic impacts of the proposed regulations would apply to all of California. Economic impacts are summarized in terms of jobs, economic output value (business activity), value added (gross domestic product), and labor income (proprietor income and employee wages).

There are two components of the IMPLAN analysis:

- The decrease in retail sales resulting from additional failed tests
- The change in costs for the cannabis lab sector.

The decrease in retail sales is modeled in IMPLAN as a decline in direct economic output in the retail cannabis sector. In this manner, impacts to other, upstream parts of the cannabis supply chain (e.g., licensed cannabis cultivators) are captured in the indirect impacts. Indirect impacts are net of impacts to cannabis laboratories because these are captured in the second part of the IMPLAN analysis. The decrease in direct economic output is calculated as the change in retail quantity sold (resulting from the EDM analysis) multiplied by the original market price (i.e., the price of cannabis at retail before the EDM shifts). The original market price is used because the structure of the cannabis sector in IMPLAN (e.g., the jobs per million dollars of sales and the set of input-output coefficients linking the cannabis sector to other economic sectors) is based on the original price.

The change in costs for the cannabis lab sector is modeled in IMPLAN using the industry cost shift parameters summarized in Table 9. To account for changes in the lab industry’s production function, a two-stage modeling process is employed. In the first stage, the industry’s current total output is modeled with its current production function. In the second stage, the industry’s modified total output is modeled with a new production function accounting for its new cost structure. In stage one, the total lab industry contribution is estimated using its baseline output of

\$85.5 million. In stage two, the lab industry production function is modified to reflect the changes in Table 9, increasing the industry total output by \$29.99 million. The difference between the indirect and induced effects in each model stage gives us the secondary effects of the industry change.

Table 13 summarizes the results of the IMPLAN analysis for retail and laboratory sectors. The market effects are evaluated at the retail sector to capture all upstream indirect and induced effects throughout the supply chain. The retail sector result is based on the mean shift in quantity supplied from the previous section at current retail prices. This results in a decrease in gross economic output of \$53.81 million. The cannabis laboratory sector results are based on the \$30 million increase in lab spending to comply with regulatory changes.

Table 13. IMPLAN Results

Sector	Impact Type	Employment	Labor Income	Value Added	Output
		<i>Count</i>		<i>Millions</i>	
Retail	Direct Effect	(869)	(\$21.03)	(\$30.02)	(\$53.81)
	Indirect Effect	(137)	(\$8.67)	(\$11.47)	(\$16.02)
	Induced Effect	(139)	(\$8.91)	(\$15.78)	(\$26.42)
	Total Effect	(1,144)	(\$38.61)	(\$57.27)	(\$96.24)
Laboratories	Direct Effect	100	\$11.83	\$12.97	\$29.99
	Indirect Effect	108	\$8.78	\$13.96	\$23.06
	Induced Effect	95	\$6.12	\$10.85	\$18.16
	Total Effect	304	\$26.74	\$37.78	\$71.21
Net Impact	Net Effect	(841)	(\$11.87)	(\$19.49)	(\$25.03)

As a result of decreased cannabis production, industries supporting cannabis retailers experience decreases in gross economic output of \$16.0 million and \$26.4 million in indirect and induced effects, respectively. Support industries' labor income sees net indirect and induced decreases of \$17.6 million, while indirect and induced total value added decreases by \$27.3 million. Including direct effects, the net impact to gross economic output would be a decrease of \$96.2 million to the California economy.

As a result of increased lab spending, industries supporting cannabis laboratories experience increases in gross economic output of \$23.1 million and \$18.2 million in indirect and induced effects, respectively. Support industries' labor income sees net indirect and induced increases of \$14.9 million, while indirect and induced total value added increases by \$24.8 million. Including direct effects, the net impact to gross economic output would be an increase of \$71.2 million to the California economy.

The gross impact to laboratories equals an additional \$71.21 million in gross output value, including all indirect and induced effects. The gross impact to the retail sector equals a loss of \$96.24 million in gross output value, including all indirect and induced effects. The net impact to the California economy from impacts to both sectors is a decrease in employment of 841 jobs, a

decrease in labor income of \$11.9 million, a decrease in value added of \$19.5 million, and a decrease in output value of \$25.03 million.

The net direct, indirect, and induced impacts are:

- **Direct Effects.** 969 jobs, \$32.86 million in labor income, \$42.99 million in value added, and \$83.80 million in output.
- **Indirect Effects.** 245 jobs, \$17.45 million in labor income, \$25.43 million in value added, and \$39.08 million in output.
- **Induced Effects.** 234 jobs, \$15.03 million in labor income, \$26.63 million in value added, and \$44.58 million in output.

4.5 Economic Impacts Summary

This section summarizes the key economic impacts of the proposed regulations.

4.5.1 Employment (Job) and Income Estimated Effects

As displayed in Table 13, the direct impact due to increased spending by cannabis laboratories is an increase in employment of 100 full-time equivalent jobs, and the direct impact due to decreased licensed cannabis supply is a decrease of 869 jobs. The total employment impact from laboratory spending, including indirect and induced impacts, is an increase of 304 jobs. The total employment impact from decreased licensed cannabis supply, including indirect and induced impacts, is a decrease of 1,144 jobs.

The total labor income impact is an increase of \$26.74 million from increased laboratory spending and a decrease of \$38.61 million from decreased licensed cannabis supply.

4.5.2 Gross State Product

The investment in California's gross state product is the value added. The net impact on statewide value-added is a decrease of \$19.49 million (as shown in Table 13), which is significant but is still a small share of the total economy. Net changes in valued added are attributed to increased lab spending and decreased licensed cannabis supply as a result of the proposed regulations.

4.5.3 Creation or Elimination of Businesses

Based on discussions with the Department, economic analysis summarized in this SRIA, and the number of active laboratories, the regulations are estimated to result in the elimination of up to 50 percent of the 22 active laboratories that conduct compliance testing. Given the difficulty some labs have had in meeting current regulatory standards, it is likely that some labs would not be able to comply with the more stringent pesticide residue detection requirements and would exit the market. In addition, smaller laboratories that are compliant may not have access to financing necessary for capital investment and other one-time costs, leading to additional exits.

However, new businesses (particularly those with experience testing agricultural commodities for pesticide residue) are likely to enter the market, or expand existing operations, to offset losses as labs exit the market.

The economic analysis of the proposed regulations includes the direct costs to labs (e.g., one-time and ongoing investments to meet the new standards) and the consolidation of labs in the industry (e.g., about half of the 22 labs would exit the industry). That is, the economic analysis shows the impact of the proposed regulations on the total amount of licensed cannabis that would be tested by labs that stay in the industry (about ½ of the current labs) and these businesses would incur the costs estimated and disclosed in this SRIA (one-time and ongoing investments).

Some cannabis cultivators would exit the market. The combined effect of increased failed pesticide residue testing and increased cost of testing has an expected market effect of a 1.12 percent reduction in the supply of licensed cannabis. This is likely to result in an exit of licensed cultivation businesses of a similar magnitude. As of January 2025, there are 2,809 businesses holding cultivation licenses, implying an exit of 31 businesses.

Average retailer revenue is expected to decrease, but retailers' inventories are typically supplied from many sources; therefore, interrupted supply from increased failures is not expected to have disproportionate effects across retail locations that would lead to additional retailer exits. Therefore, exits are expected to be limited to cultivators and labs, and the total number of businesses potentially eliminated is 42.

All 5,463 businesses throughout the cannabis supply chain are expected to be affected by the regulatory changes. Of these 5,463 businesses, an estimated 97.1 percent (5,303 businesses) are estimated to qualify as small businesses.

4.5.4 Expansion of Businesses

Labs that can comply with the regulations and securing financing are likely to expand substantially to meet the demand for laboratory testing.

4.5.5 Competitive Advantages or Disadvantages

Labs that are currently compliant are expected to be at a competitive advantage relative to bad actor labs. Bad actor labs, which prioritize expedient test results over accurate testing methods, are unlikely to be able to comply with the proposed regulatory changes. Furthermore, these labs are less likely to utilize high-end MS instruments capable of achieving lower action limits and LOQs.

Large compliant labs are expected to be at a competitive advantage relative to small compliant labs. Although they are both expected to be capable of complying with the proposed regulations, smaller labs have relatively worse access to financing. Smaller labs are more likely to struggle to

secure financing needed for capital investment and expansion. Larger labs are, therefore, better positioned to expand in response to the anticipated contraction in active laboratories.

4.5.6 Investment in the State and Taxes

There would be an increase in investment in the state through laboratories' investment in new instruments. This would also result in an increase in taxes collected. The increase in investment in new instruments would equal \$19.8 million. Considering the state sales tax of 7.25 percent, the up-front equipment, material, and labor investments would increase state tax revenues between \$1.5 and \$2 million with an additional \$0.75 to \$1 million in annual on-going purchases.¹²

As shown in Table 12, there would be a loss in cannabis retail revenue of approximately \$12.4 million. Applying the cultivation excise tax equal to 15 to 19 percent (as of 7/1/25) of gross retail sales, this implies an additional decrease in tax revenue of \$1 to \$3 million.

There would be additional state tax revenues from wages in directly and indirectly affected industries that are not included in these estimates. In addition, the proposed regulations create other, non-monetized benefits including but not limited to increased product safety, trust, and transparency through more effective lab testing, as well as broader benefits for human health and the environment. These are expected to support growth in the licensed cannabis market, providing future, unquantified state tax revenues. In summary, the net effect on state tax revenues is uncertain with increased lab and related industry investments partially or fully offsetting a decrease in cannabis excise tax revenues. There is no expected change in tax revenues from Department fiscal costs (staff costs) because these are existing positions.

4.5.7 Incentives for Innovation

The proposed LOQs and action limits require the development of more precise testing methods to remain compliant. The exit of non-compliant labs and entrance of new laboratories incentivize innovation in testing methods to remain competitive.

4.5.8 Estimated Effects on a Typical Business and Small Business

The total direct cost to laboratories, shown in Table 8, is \$30.0 million. The total increase in output value equals \$71.21 million, including all multiplier effects.

All but a few of the 28 active laboratories are estimated to have fewer than 100 employees or annual gross receipts of \$15 million or less and therefore qualify as small businesses. Hence, small businesses are also considered to be typical businesses, and the expected one-time and recurring annual costs are the same for each type.

¹² Sciex, a lead manufacturer of MS instruments, has its sales and service headquarters in Redwood City, CA.

One-time up-front expenses, shown in Table 7, for a representative typical and small business equal \$935,420. This includes purchases of new instruments and additional labor and consumables for revalidation of testing methods. Expected recurring annual costs are \$427,590 per year. This includes additional labor costs as well as the additional consumables needed for testing.

4.5.9 Other Economic Impacts to Businesses, Individuals, Worker Safety, and the State's Environment

Currently, licensed cannabis cannot be exported to other states or imported from other states. Therefore, the proposed regulations would not affect the ability of businesses in the state to compete with those in other states.

The proposed regulations would not require additional business reports. They would require ISO 17025 reaccreditation for changed methods, but these requirements are already standard practice for compliant laboratories. Only laboratories that are non-compliant with existing regulations are expected to change reporting. Compliance with the proposed regulations would require the use of specific technologies or equipment. Laboratories would likely need a TQ-MS, QTOF-MS, or similarly capable MS instrument. The use of lower-end MS instruments could theoretically be used, but the expected runtime of achieving the target LOQs would cause pesticide testing to be prohibitively expensive. The proposed LOQs and associated ISO 17025 reaccreditation for testing methods are necessary to ensure laboratories are compliant and to safeguard consumers by limiting exposure to harmful levels of pesticides in cannabis goods.

Quantified benefits, in terms of change in related industry purchases, are summarized in Table 13. These benefits result from direct regulatory costs to laboratories, which in turn increase purchases and generate economic activity in other industries. The total increase in labor income is \$26.74 million, the increase in value-added is \$37.78 million, and the increase in terms of output value is \$71.21 million. The sum of total benefits is \$135.73 million.

The regulations would have a positive, unquantifiable impact on California residents. Regulations would improve cannabis product safety by increasing the likelihood that unsafe cannabis goods fail testing for pesticide residue, which has positive implications for consumer health outcomes and the environment. Public safety may improve through reduced access to products containing harmful levels of pesticides, enforcement of pesticide testing requirements, and compliance with these requirements, but there are insufficient data to analyze this effect. Worker safety may improve from reduced use of harmful pesticides.

The proposed regulations are expected to provide benefits to the environment that are not quantified. Reducing LOQs and action limits for pesticide residue is expected to result in reduced applications of harmful pesticides, thereby reducing contamination of water, soil, and air.

4.6 Department Fiscal Costs

The Department may see minor increased costs for workload associated with updating internal laboratory test methods to align with the new action levels and additional pesticides, and for purchasing additional consumable laboratory supplies and updating training materials. The costs are expected to be no more than \$50,000 and are absorbable within existing resources.

4.6.1 Other State and Local Public Agencies Fiscal Costs

There would not be changes to other state and local public agency costs under the proposed regulations. See section 4.5.6 for a description of changes to state sales and excise taxes.

4.7 Impact Summary

Table 14 summarizes the key economic outcomes of the proposed regulations. The economic impacts reported in Table 14 are used to determine whether the proposed regulations reach the threshold of a major regulation. The total economic impact is expected to exceed \$50 million in the first 12 months of implementation. All values reported in Table 14 were derived in previous sections of this SRIA and are reported in the accompanying STD 399 Economic Impact Statement and DF-131 Major Regulations Standardized Regulatory Impact Assessment Summary.

Table 14. Total Economic Impact Summary

Description	Unit	Value
Total statewide benefits for businesses and individuals	\$, millions	\$135.73
Total statewide costs for businesses and individuals	\$, millions	\$222.11
Businesses impacted	Count	5,463
Share of businesses that are small	Percent	97.1%
Businesses eliminated	Count	42
Jobs created	Count	304
Jobs eliminated	Count	1,144
Initial costs per laboratory	\$, millions	\$0.94
Annual ongoing costs per laboratory	\$, millions	\$0.43

Note: Total statewide costs for businesses and individuals are calculated as the sum of laboratory costs and total direct, indirect, and induced effects at retail.

5. Economic and Fiscal Impacts: Proposed Alternatives

The Department considered alternatives to the proposed regulations. Alternatives include the no action alternative (which in this SRIA is also the baseline against which regulatory impacts of the proposed regulation are measured), and one additional alternative that would not require ISO 17025 reaccreditation for the initial list of pesticides (66 in total) developed by DPR.

This section presents the results of the economic and fiscal impact analysis of two alternatives to the proposed regulations that was considered by the Department. The alternatives are summarized as follows:

- Alternative 1 would require ISO 17025 reaccreditation for the 14 new pesticides and only for the original 66 pesticides only if their action limit is lower than the previous action limit of 0.1 µg/g.
- Alternative 2 is the no action alternative.

5.1 Economic and Fiscal Impacts of Regulation Alternative 1

Under this alternative, laboratories would only need to revalidate their testing methodologies for chemicals already on the current residual pesticide list if the proposed action limit is lower than 0.1 µg/g. ISO 17025 reaccreditation would be required for 1 of 66 chemicals on the current residual pesticide list, as well as the 14 new chemicals. However, there is not expected to be an increase in the failure rate attributed to chemicals that forego ISO 17025 reaccreditation. Comparing failure rates to agricultural commodities as in section 3.6 implies an upper bound failure rate of 1.60 percent (compared to 3.09 percent under the proposed regulations) for failures attributable to pesticides. The pesticide failure rate for cannabis would increase from 0.47 percent to 1.60 percent, for an overall upper bound failure rate of 2.23 percent. Because revalidation is only required for 15 of 80 pesticides, testing would likely continue to pass at the same rate for the other 65 chemicals. The lower bound increase in failure rate would decrease from 0.56 percent to 0.11 percent.

The one-time costs of validation would decrease proportionally to the decrease in revalidation efforts. There would also be no increase in variable costs for detecting pesticide residue for pesticides that do not require revalidation. Therefore, both the one-time and recurring costs are estimated to be 18.75 percent of the costs under the proposed regulations.

5.1.1 Alternative 1 Direct Economic Benefits

As is the case for the proposed regulations, there are no direct economic benefits under this alternative. However, unquantified human health benefits would be lower due to an increase in the amount of products with harmful levels of chemicals that reach consumers.

5.1.2 Alternative 1 Direct Economic Costs

Table 15 summarizes the expected regulatory compliance costs for laboratories.

Table 15. Total Direct Costs per Laboratory and Total Industry Costs

Item	Cost per Laboratory	Total Industry Cost
<i>Thousands</i>		
New instruments	\$168.75	\$3,712.50
One-time labor	\$3.60	\$79.20

One-time consumables	\$3.04	\$66.91
Total One-Time Costs	\$175.39	\$3,858.61
Equipment maintenance	\$27.39	\$602.66
Variable labor	\$35.13	\$772.84
Variable consumables	\$17.65	\$388.34
Total Variable Costs	\$80.17	\$1,763.84
Total	\$255.57	\$5,622.44

5.1.3 Alternative 1 Market Effects

The one-time costs are annualized over a 10-year period with an interest rate of 7.5 percent. The cost shift for licensed cannabis, θ_L , decreases from 1.47 percent to 0.24 percent. The upper bound of the supply shift for licensed cannabis, β_L , decreases from 2.65 percent to 1.16 percent. Table 16 summarizes the first-year costs per laboratory.

Table 16. First-Year Annualized Costs Per Laboratory

Item	Cost per Laboratory
	<i>Thousands</i>
New instruments	\$24.58
Equipment maintenance	\$27.39
Variable labor	\$35.13
One-time labor	\$0.52
Variable consumables	\$17.65
One-time consumables	\$0.44
Total Cost	\$105.73

Table 17 summarizes the results of the EDM analysis. The proposed regulations affect the price and quantity of licensed and illicit cannabis. This affects the returns for cannabis businesses throughout the supply chain.

Table 17. EDM Analysis Market Effects Selected Results

Description	Lower Bound	Upper Bound	Mean
	<i>(% Change)</i>		
Quantity demanded of licensed cannabis	-0.13	-0.55	-0.34
Quantity supplied of licensed cannabis	-0.13	-0.55	-0.34
Price of licensed cannabis, retail	0.11	0.43	0.27
Price of illicit cannabis, retail	0.00	0.01	0.01
Price of licensed cannabis, wholesale	0.21	0.85	0.53
Price of illicit cannabis, wholesale	0.01	0.03	0.02

Cost increases and supply decreases result in substantial losses to producers and consumers, higher cannabis prices, and increased demand for licensed cannabis. Table 18 summarizes the changes in consumer surplus, producer surplus, and retailer revenue for the licensed market segment. Lower bound, upper bound, and mean changes are provided.

Table 18. Changes in Surplus and Retailer Revenue for Licensed Market

Description	Lower Bound	Upper Bound	Mean
	<i>(Thousands)</i>		
Consumer Surplus	-\$5,047	-\$20,438	-\$12,742
Producer Surplus	-\$1,480	-\$5,995	-\$3,738
Retailer Revenue	-\$1,431	-\$5,891	-\$3,661

5.1.4 Alternative 1 Indirect and Induced Effects

Table 19 summarizes the results of the IMPLAN analysis based on the \$5.6 million increase in cannabis laboratory spending and \$16.3 million decrease¹³ in gross economic output for cannabis retailers as a result of the alternative regulatory changes. The market effects are evaluated at the retail sector to capture all upstream indirect and induced effects throughout the supply chain.

Table 19. IMPLAN Results

Sector	Impact Type	Employment	Labor Income	Value Added	Output
		<i>Count</i>		<i>Millions</i>	
Retail	Direct Effect	(264)	(\$6.38)	(\$9.11)	(\$16.33)
	Indirect Effect	(42)	(\$2.63)	(\$3.48)	(\$4.86)
	Induced Effect	(42)	(\$2.70)	(\$4.79)	(\$8.02)
	Total Effect	(348)	(\$11.72)	(\$17.39)	(\$29.22)
Laboratories	Direct Effect	19	\$2.22	\$2.43	\$5.62
	Indirect Effect	20	\$1.65	\$2.62	\$4.32
	Induced Effect	18	\$1.15	\$2.03	\$3.41
	Total Effect	57	\$5.01	\$7.08	\$13.35
Net Impact	Net Effect	(291)	(\$6.71)	(\$10.30)	(\$15.86)

As a result of decreased licensed cannabis supply, industries supporting cannabis retailers (e.g., cultivators) experience decreases in gross economic output of \$4.9 million and \$8.0 million in indirect and induced effects, respectively. Support industries' labor income sees net indirect and induced decreases of \$5.3 million, while indirect and induced total value added decreases by \$8.3 million. Including direct effects, the net impact to gross economic output would be a decrease of \$29.2 million to the California economy.

As a result of increased laboratory spending, industries supporting cannabis laboratories experience increases in gross economic output of \$4.3 million and \$3.4 million in indirect and induced effects, respectively. Support industries' labor income sees net indirect and induced increases of \$2.8 million, while indirect and induced total value added increases by \$4.6 million. Including direct effects, the net impact to gross economic output would be an increase of \$13.4 million to the California economy.

The net impact to the California economy from impacts to both retail and laboratories is a decrease in employment of 291 jobs, a decrease in labor income of \$6.7 million, a decrease in value added of \$10.3 million, and a decrease in output value of \$15.9 million.

¹³ Based on change in supply quantity at current prices

5.2 Alternative 1 Economic Impacts Summary

This section summarizes the key economic impacts of Alternative 1.

5.2.1 Employment (Job) Estimated Effects

As displayed in Table 19, the direct impact due to increased spending by cannabis laboratories is an increase in employment of 19 jobs, and the direct impact due to decreased licensed cannabis supply is a decrease of 264 jobs. The total employment impact from laboratory spending, including indirect and induced impacts, is an increase of 57 jobs. The total employment impact from decreased licensed cannabis supply, including indirect and induced impacts, is a decrease of 348 jobs.

The total labor income impact is an increase of \$5.01 million from increased laboratory spending and a decrease of \$11.7 million from decreased licensed cannabis supply.

5.2.2 Gross State Product

The investment in California's gross state product is the value added. The net impact on statewide value-added is a decrease of \$10.30 million (as shown in Table 19), which is significant but is still a small share of the total economy. Increases in valued added are attributed to increased lab spending as a result of the regulatory changes, and decreases to value added are attributed decreased supply of licensed cannabis.

5.2.3 Creation or Elimination of Businesses

The expected change in laboratory exits is the same as under the proposed regulations, 50 percent of the 22 active laboratories that conduct compliance testing. The combined effect of increased failed pesticide residue testing and increased cost of testing has an expected market effect of a 0.34 percent reduction in the supply of licensed cannabis. This is likely to result in an exit of licensed cultivation businesses of a similar magnitude, 10 of the 2,809 active cultivation businesses.

5.2.4 Expansion of Businesses

Labs that are capable of complying with the regulations and securing financing are likely to expand substantially to meet the demand for laboratory testing.

5.2.5 Competitive Advantages or Disadvantages

Competitive advantages and disadvantages are the same as described in section 4.5.5.

5.2.6 Investment in the State and Taxes

There would be an increase in investment in the state through laboratories' investment in new instruments. The increase in investment in new instruments would equal \$3.7 million on average.

Considering the state sales tax of 7.25 percent, the total taxes paid through these purchases would equal about \$0.27 million on average.

However, as shown in Table 18, there would be a loss in cannabis retail revenue of approximately \$3.7 million on average. Applying the cultivation excise tax equal to 15 percent (19 percent as of 7/1/25) of gross retail sales, this implies a decrease in tax revenue of \$0.56 million. The lower and upper bound estimates of the market effects lead to a wider range of potential outcomes for tax revenue changes.

The net effect on state tax revenues is uncertain with increased lab and related industry investments partially or fully offsetting a decrease in cannabis excise tax revenues. There is no expected change in tax revenues from Department fiscal (staff) costs because these are all existing positions.

5.2.7 Incentives for Innovation

Incentives for innovation are the same as described in section 4.5.7.

5.2.8 Estimated Effects on a Typical Business and Small Business

The total direct cost to laboratories, shown in Table 19, is \$5.62 million. The total increase in output value equals \$13.35 million, including all multiplier effects.

As described in section 4.5.8, small businesses are also considered to be typical businesses, and the expected one-time and recurring annual costs are the same for each type.

One-time up-front expenses, shown in Table 15, for a representative typical and small business equal \$175,390. Expected recurring annual costs are \$80,170 per year.

5.2.9 Other Economic Impacts to Businesses, Individuals, Worker Safety, and the State's Environment

Quantified benefits result from direct regulatory costs to laboratories, and are in terms of changes in related industry purchases. As shown in Table 19, the total increase in labor income is \$5.01 million, the increase in value-added is \$7.08 million, and the increase in terms of output value is \$13.35 million. The sum of total benefits is \$25.44 million.

The regulations would have a positive, unquantifiable impact on California residents. Regulations would improve cannabis product safety by increasing the likelihood that cannabis goods fail testing for pesticide residue, which has positive implications for consumer health outcomes. Reducing LOQs and action limits for pesticide residue is expected to result in reduced applications of harmful pesticides, thereby reducing contamination of water, soil, and air. Under this alternative, both of these benefits would be lower compared to the proposed regulations owing the lower increase in the pesticide testing failure rate. There is no expected change to worker safety.

5.2.10 Department Fiscal Costs

The Department may see minor increased costs for workload associated with updating internal laboratory test methods to align with the new action levels and additional pesticides, and for purchasing additional consumable laboratory supplies and updating training materials. The costs are expected to be no more than \$50,000 and are absorbable within existing resources.

5.2.11 Other State and Local Public Agencies Fiscal Costs

There would not be changes to other state and local public agency costs under this alternative.

5.2.12 Impact Summary for Alternative 1

Table 20 summarizes the key economic outcomes of Alternative 1.

Table 20. Total Economic Impact Summary

Description	Unit	Value
Total statewide benefits for businesses and individuals	\$, millions	\$25.44
Total statewide costs for businesses and individuals	\$, millions	\$63.95
Businesses impacted	Count	5,463
Share of businesses that are small	Percent	97.1%
Businesses eliminated	Count	21
Jobs created	Count	57
Jobs eliminated	Count	348
Initial costs per laboratory	\$, millions	\$0.18
Annual ongoing costs per laboratory	\$, millions	\$0.08

Note: Total statewide costs for businesses and individuals are calculated as the sum of laboratory costs and total direct, indirect, and induced effects at retail.

5.2.13 Basis for Rejecting Alternative 1

The primary objectives of the proposed regulations are to prevent laboratories from falsely passing pesticide residue testing, and to ensure that products that reach consumers are safe for consumption. By not requiring revalidation and ISO 17025 reaccreditation of testing methods for all pesticides, laboratories will be able to continue to avoid properly testing for residue of these pesticides. As a result, there will continue to be products containing unsafe levels of pesticide residue which reach consumers.

5.3 Economic and Fiscal Impacts: Proposed Alternative 2

The second alternative is the no action alternative (which in this SRIA is also the baseline against which regulatory impacts of the proposed regulation are measured). The Department can meet its statutory requirements without modifying the existing regulations. Under this alternative, no changes would be made to laboratory testing requirements in response to DPR's recommendations. Direct benefits, costs, market effects, indirect and induced effects, and all

economic impacts would be 0. This is because there would be no change relative to the baseline of current regulations. This alternative is rejected as there would be no changes implemented to prevent products with unsafe levels of pesticide residue from reaching consumers. Ensuring that products that reach consumers are safe for consumption is the primary objective of the proposed regulations.

6. References

- Alston, J. M., Balagtas, J. V., Brunke, H., and Sumner, D. A. 2006. Supply and Demand for Commodity Components: Implications of Free Trade Versus the AUSFTA for the US Dairy Industry. *Australian Journal of Agricultural and Resource Economics*, 50(2), 131-152.
- Alston, J. M., Norton, G. W., and Pardey, P. G. 1995. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. London UK and Ithaca, NY: Cornell University Press for the International Service for National Agricultural Research.
- Atwood, J.A., and Brester, G.W., 2019. “The Mathematical Derivation of Internally Consistent Equilibrium Displacement Models.” Department of Agricultural Economics and Economics Staff Paper 2019-1. Montana State University. doi: 10.22004/ag.econ.296627.
- CalCannabis, 2017. Standardized Regulatory Impact Analysis (SRIA) of the CalCannabis Cultivation Licensing Program. Prepared by ERA Economics for the California Department of Food and Agriculture. CalCannabis Licensing Program.
- California Department of Pesticide Regulation (DPR). 2025. Pesticide Use Reporting – 2022 Summary Data. Available at: https://www.cdpr.ca.gov/docs/pur/pur22rep/22_pur.htm [Accessed 7 Jan 2025].
- Cannabis Benchmarks, 2024. Premium Weekly Reports. New Leaf Data Services, LLC.
- Caulkins, J.P., Davenport, S., Doanvo, A., Furlong, K., Siddique, A., Turner, M. and Kilmer, B., 2019. Triangulating Web & General Population Surveys: Do Results Match Legal Cannabis Market Sales? *International Journal of Drug Policy*, 73, pp.293-300.
- Edgerton, D.L., 1997. Weak Separability and the Estimation of Elasticities in Multistage Demand Systems. *American Journal of Agricultural Economics*, 79(1), pp.62-79.
- Emerald Scientific, 2025. State-Specific Cannabis Pesticide Mixes / California. Available at: <https://emeraldscientific.com/reference-standards/pesticides/state-specific-pesticides-standards/california/1/?page=1> [Accessed 23 January 2025].
- Gardner, B.L., 1987. *The Economics of Agricultural Policies*. New York: McGraw-Hill.
- Kilmer, B., Caulkins, J.P., Midgett, G., Dahlkemper, L., MacCoun, R.J. and Liccardo, P.R., 2013. Before The Grand Opening: Measuring Washington State’s Marijuana Market in the Last Year Before Legalized Commercial Sales. Santa Monica, CA: RAND Corporation.

- Kilmer, B., Davenport, S., Smart, R., Caulkins, J. P., and Midgette, G., 2019. After the Grand Opening: Assessing Cannabis Supply and Demand in Washington State. Santa Monica, CA: RAND Corporation.
- Light, M. K., Orens, A., Lewandowski, B., & Pickton, T., 2015. Market Size and Demand for Marijuana in Colorado. *Marijuana Policy Group*.
- MacDonald, R., and Rotermann, M., 2018. Constructing Historical Cannabis Consumption Volume Estimates for Canada, 1960 to 2015. *Statistics Canada*.
- MIG Inc., 2016. IMPLAN Economic Impact Modeling Software. Available at: <http://implan.com/>.
- Muth, R. F., 1964. The Derived Demand Curve for a Productive Factor and The Industry Supply Curve. *Oxford Economic Papers*, 16(2), 221-234.
- Office of the Parliamentary Budget Officer (OPBO), 2016. Legalized Cannabis: Fiscal Considerations.
- Orens, A., Light, M., Lewandowski, B., Rowberry, J. and Saloga, C., 2018. Market Size and Demand for Marijuana in Colorado: 2017 Market Update Prepared for the Colorado Department of Revenue. *Marijuana Policy Group*.
- Restek, 2025. Home / Reference Standards / Liquid Reference Standards / Multi-Component. Available at: https://www.restek.com/c/1128?Ns=restekProduct.x_productBadge%7C0 [Accessed 6 February 2025].
- Substance Abuse and Mental Health Services Administration (SAMHSA), 2021. NSDUH Data Files. Available at: <https://www.samhsa.gov/data/data-we-collect/nsduh/datafiles> [Accessed 20 November 2024].
- Valdes-Donoso, P., Sumner, D.A. and Goldstein, R., 2020. Costs of Cannabis Testing Compliance: Assessing Mandatory Testing in the California Cannabis Market. *PloS one*, 15(4), p.e0232041.
- Wohlgenant, M.K. 2011. “Consumer Demand and Welfare in Equilibrium Displacement Models.” In *The Oxford Handbook of the Economics of Food Consumption and Policy*, ed. Jayson L. Lusk, Jutta Roosen, and Jason F. Shogren. Oxford University Press.