New York State, Office of Cannabis Management

Cannabis Laboratory Quality System Standard

January 2024

Contents

I. Introduction and Scope 2
II. Acronyms and Definitions 2
III. General Quality System Standards 5
IV. Reagents, Reference Standards and Media 9
V. Calibration and Maintenance of Laboratory Equipment 10
VI. Testing Standards 13
A. Chemistry – Analytical, Organic and Inorganic (Metals) 14
B. Physical Chemistry 22
C. Microbiology 23
VII. Laboratory-Developed Method Validation Protocols 28
A. Chemistry 28
B. Microbiology 29
VIII. Reporting of Results 32
IX. Record Retention 33
X. Significant Figures 33
XI. Potency / Cannabinoid Standardization 33
XII. Contact Information 34
XIII. References 34
XIV. Change Record 36

I. Introduction and Scope

The Cannabis Laboratory Quality System Standard ("Standard") will provide a cannabis laboratory with:

- information that will help the cannabis laboratory operate consistently and uniformly, as well as conduct testing in an impartial manner
- a framework for the cannabis laboratory to have an effective quality system for planning and assessing work performed by the laboratory
- required quality assurance and quality control procedures to promote and maintain the accuracy and reliability of test results
- a list of proficiency tests that must be performed by a cannabis laboratory to obtain an initial permit and during annual renewal of a permit.
- standards for traceability of cannabis laboratory activities from sample receipt to sample disposal, and any or all intermediary steps such as sample accessioning, processing, testing, and reporting.

All items identified in this standard must be made available by the cannabis laboratory during a regulatory audit, inspection, or upon request by the Office of Cannabis Management ("Office").

II. Acronyms and Definitions

Acceptable limit – AL – These are the testing limits for contaminants as directed in the Office's regulation (see Part 130 of Title 9 of New York's Codes, Rules and Regulations (Part 130)) and in guidance.

Analyte is defined in Part 130.

Analytical batch consists of prepared samples which are analyzed together as a group. An analytical batch can include prepared samples originating from different matrices and can exceed twenty (20) samples.

Approved method is defined in Part 130.

Batch – Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents.

Blank – A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results.

Bracketing – A method using X-point (e.g. 5-point, 6-point) standard calibration in order to suppress the indeterminate error caused by instrumental drift thus increasing the result precision.

Cannabis reference laboratory – CRL – The Department of Health's Wadsworth Center serves as the state's reference laboratory.

Certificate of analysis – COA – is defined in Part 130.

Certified reference material – CRM – Reference material, accompanied by a certificate of conformance, having a value, measurement uncertainty, and stated metrological traceability chain to a national or international metrology institute.

Continuing calibration verification – CCV – One of the primary calibration standards, analyzed periodically to verify that the calibration is still valid.

Data integrity training – DI training – is defined in Part 130.

Demonstration of capability – DOC – A procedure to establish the ability of the analyst or technician or technician to generate acceptable accuracy and precision using the method.

Department of Agriculture and Markets – AGM

Department of Health – DOH

Electronic Laboratory Notebook – ELN

Laboratory control sample – LCS – A portion of appropriate clean matrix that is spiked with known quantities of target analytes and carried through the entire sample preparation process, and treated exactly as a sample, including exposure to all glassware, equipment, solvents, and reagents that are used with other samples. The LCS measures the accuracy of the methodology. The LCS may be prepared from the same source as the calibration standards, or from a second source.

Laboratory fortified blank – LFB – A reagent-water sample (with associated preservatives) to which a known concentration of the analyte(s) of interest has been added. The LFB may be used as the LCS if the method requires a preliminary sample extraction or digestion.

Laboratory fortified matrix - LFM – See definition for Matrix Spike (MS).

Laboratory fortified matrix duplicate – LFMD – See definition for Matrix Spike Duplicate (MSD).

Laboratory information management system – LIMS

Laboratory reagent blank – LRB – An aliquot of extraction and/or dilution solvent(s) that is treated exactly as if it were a sample including exposure to all glassware, equipment, solvents, internal standards, and reagents that are used with the samples. The LRB is used to determine whether method analytes or other interferences are present in the laboratory environment, reagents or apparatus.

Limit of detection – LOD – The statistically calculated minimum concentration of an analyte that can be measured with 99% confidence that the value is greater than zero. It is also referred to as method detection limit (MDL). Refer to the definition below.

Limit of quantification – LOQ – The concentration of an analyte that can be reported within the accuracy and precision limits defined by the method. The LOQ can be no lower than the lowest calibration standard used in the analysis. For reporting purposes, it is synonymous with the MRL.

Linear dynamic range – LDR – The concentration range over which the instrument response to an analyte has been demonstrated to be linear.

Low level continuing calibration verification – LLCCV – The calibration standard that reprsents the lowest level of the calibration curve.

Matrix includes cannabis, and it may come in different forms such as oil, hemp, edible, pre-roll, and flower.

Matrix-Assisted Laser Desorption/Ionization Time-of-Flight mass-spectrometer – MALDI-TOF MS

Marihuana Regulation and Taxation Act – MRTA

Marginal exceedance – ME – is based on the number of analytes in a LCS.

Matrix spike – MS – A portion of an actual sample that is first spiked with a known quantity of target analytes, and then carried through the entire sample preparation and analysis process. The sample from which the portion to be spiked was taken must be analyzed separately to determine endogenous background analyte concentrations. The MS is corrected for background concentrations and used to determine whether or not the sample matrix affects the sample results. It is also referred to as a laboratory fortified matrix (LFM).

Matrix spike duplicate – MSD – A second portion of actual sample used to prepare the MS that is spiked and processed in the same manner as the MS. The MS and MSD are used together to measure the precision of the methodology. It is also referred to as a laboratory fortified matrix duplicate (LFMD).

Method blank – MB – An aliquot of appropriate pure matrix that is carried through the entire sample preparation process, and that is treated exactly as a sample including exposure to all glassware, equipment, solvents, and reagents that are used with other samples. The MB is used to determine whether contamination with method analytes or other interferences are present in the laboratory environment, reagents or apparatus.

Method detection limit – MDL – The minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results. For the purposes of this procedure, "spiked samples" are prepared from a clean reference matrix, such as reagent water, spiked with a known and consistent quantity of the analyte. It is determined using the US EPA procedure federally codified under Title 40, Part 136, Appendix B. It is also referred to as the limit of detection (LOD).

Minimum Reporting Limit – MRL – See definition for LOQ.

New York State – NYS

Office of Cannabis Management – OCM or Office

Polymerase chain reaction – PCR

Preparation batch includes samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A preparation batch consists of one to twenty samples (not including method blanks, lab control samples, matrix spikes and matrix duplicates) of the same matrix with a maximum processing time of twenty-four (24) hours between the first and last sample.

Quality assurance – QA

Quality assurance officer – QAO – is defined in Part 130.

Quality control – QC

Quality system – QS – is defined in Part 130.

Relative error – RE – is the ratio of the absolute error of a measurement to the measurement being taken. It is expressed as percent (%RE).

Relative percent difference – RPD

Relative standard deviation – RSD

Relative standard error – %RSE – is calculated by dividing the standard error of the estimate by the estimate itself, then multiplying that result by 100. Relative standard error is expressed as a percent of the estimate.

Standard operating procedure – SOP

Technical director – TD – is defined in Part 130.

III. General Quality System Standards

A laboratory must establish a documented quality system that describes its policies and procedures related to the following five (5) components as listed in the latest version of ISO/IEC 17025.

1) General requirements
2) Structural requirements
3) Resource requirements
4) Process requirements
5) Management system requirements

These topics are to be incorporated into a quality manual, or similarly named document. The quality manual must include the following information, where applicable, and preferably in the order noted. If the information is contained in another controlled document, it must be cross-referenced in the manual.

1) Title;
2) Laboratory's name and contact information;
3) Document control number;
4) Revision number and date;
5) Approval signatory(ies), their titles/roles and approving date;
    a. At a minimum, the approval signatures are to include the lead technical director and quality assurance officer.
6) Page numbering (e.g., page 1 of 22);
7) Revision/change record section;
8) Table of contents;
9) Definitions;
10) Scope and application, including, but not limited to objectives of a laboratory quality system, quality policy statement and commitment to uphold ISO/IEC 17025, OCM's Laboratory Quality System Standard as set forth in this document, the MRTA, and NYS Cannabis Law and regulations.
11) Procedures related to the following:
    a. Organizational structure and ownership, including any organizational charts;
    b. Personnel, including, but not limited to job descriptions, competency, minimum qualifications, and trainings;
    c. Facilities and environmental conditions;
    d. Equipment;
    e. Metrological traceability;
    f. Externally provided products and services;
    g. Subcontracting analyses;

h. Review of requests, tenders and contracts;
i. Selection, verification and validation of methods;
j. Sampling;
    1. This is only applicable to laboratory sampling firms.
k. Transportation;
    1. This applies when the permitted cannabis laboratory subcontracts testing to another OCM permitted cannabis laboratory. Please refer to transportation requirements specified in Part 130.
l. Handling of test or calibration items;
m. Technical records and notebooks;
    1. The ELN is an initiative to allow scientists to replace paper notebooks with digital records, including audit trails, required quality controls and cross database interfaces. An ELN is a computer program which can be used to document research, experiments and procedures performed in a laboratory. ELNs also allow for direct incorporation of data from laboratory instruments to streamline processes. With this technology, scientists will be able to save, organize, compile, share and protect Intellectual Property.
n. Evaluation of measurement uncertainty;
o. Ensuring the validity of results;
p. Reporting of results;
    1. Please also refer to "certificate of analysis" as defined and described in Part 130.
q. Non-conforming work;
r. Control of data and information management (i.e., LIMS);
s. Management system of documents (or document control system);
t. Improvement (or preventive actions);
u. Corrective actions, including root-cause analysis;
v. Complaints;
w. Internal audits;
    1. Internal audits must include both the audit of administrative and technical procedures, and it must be performed on at least an annual basis.
x. Management reviews;
    1. Management reviews must be performed on at least an annuals basis, and they must be distributed to upper management and address the following criteria: the suitability of policies and procedures; reports from managerial and supervisorial personnel; the outcome of recent internal audits; corrective and preventive actions; audits by external bodies; the results of interlaboratory comparisons or proficiency tests; any changes in the volume and type of work undertaken; feedback from clients; complaints; and other relevant factors, such as quality control activities, resources and staff training.
y. Electronic signatures;
z. References; and
aa. Any master list of documents related to controlled documents, equipment inventory, vendors, and consumables, tables, figures, and appendices.

Each administrative and technical SOP generated by the laboratory must include the following information, where applicable. Some laboratories may wish to establish an administrative manual, which incorporates all administrative procedures, and a technical methods manual, which incorporates all technical procedures. If the information is contained in another controlled document, it must be cross-referenced in the SOP.

1) Title or topic;
2) Document control number;
3) Revision number and date;
4) Approval signatory(ies) and date;
5) Page numbering;
6) Revision/change record section;
7) Table of contents;
8) Definitions;
9) Scope and application, including analytes to be analyzed and identification of the approved method;
10) Limits of detection and quantitation;
11) Summary of the method;
12) Interferences;
13) Safety;
14) Equipment and supplies;
15) Reagents and standards;
16) Sample collection, preservation, shipment and storage;
17) Quality control;
18) Calibration and standardization;
19) Procedure;
20) Data analysis and calculations;
21) Method performance;
22) Pollution prevention;
23) Data assessment and acceptance criteria for quality control measures;
24) Corrective actions for out-of-control data;
25) Contingencies for handling out-of-control or unacceptable data;
26) Waste management;
27) References; and
28) Any tables, bench or log sheets, diagrams, flowcharts and validation data or studies.

For each preparation (e.g., digestion, extraction) and analytical method, a cannabis laboratory must establish document-controlled analytical bench or log sheets, which produce unequivocal, accurate records documenting all laboratory activities and allows for historical reconstruction of all laboratory activities that produced the resultant sample analytical data. Such analytical bench or log sheets must capture the following, at a minimum:

1) Laboratory sample ID code,
2) Date of analysis and time of analysis if the hold time is 72 hours or less,
3) Instrumentation identification and instrument operating conditions/parameters (or reference to such data),
4) Analysis type (method or technique),
5) All calculations (e.g., automated and manual integrations),
6) Technician's initials or signature,
7) Sample preparation (including cleanup & separation protocols, incubation periods or subcultures, ID codes, volumes, weights, instrument printouts, meter readings, calculations, & reagents used),
8) Sample analysis (test results),
9) Standard and reagent origin, receipt, preparation, and expiration,
10) Calibration criteria, frequency, and acceptance criteria,

11) Data and statistical calculations, review, confirmation, interpretation, assessment, & reporting conventions,
12) Quality control protocols,
13) Electronic data security, software documentation, software & hardware audits, backups of automated data entries, records of any changes to automated data entries, and
14) Method performance criteria including expected quality control requirements.

Pursuant to Part 130, a laboratory must ensure each employee completes data integrity training pon hire and annually thereafter, and such training shall be documented for each employee. The data integrity (DI) training must address the following criteria: the laboratory's organizational mission and its relationship to the critical need for honesty and full disclosure in all analytical reporting, how and when to report data integrity issues, accurate record keeping, any infractions to laboratory data which will result in a detailed investigation that could lead to very serious consequences including immediate termination or civil or criminal prosecution, specific examples of breaches of ethical behavior, discussion regarding all DI procedures, DI training, in-depth data monitoring, and DI procedure documentation, and an emphasis on the importance of proper written narration on the technician's part with respect to those cases where analytical data may be useful, but are in some way partially deficient.

A laboratory must maintain a master of list of all controlled quality system documents and a signature log that includes the names, initials and signatures for all individuals who are responsible for signing or initialing any laboratory record.

Additionally, a laboratory must demonstrate a technician's ability to perform a preparation and/or analytical method through:

1) a documented training program,
2) a documented attestation that the technician read and understands the method SOP, and
3) a documented demonstration of capability (DOC).

An individual who performs any activity involved with preparation and/or analysis of samples must have constant, close supervision until a satisfactory initial DOC is completed. An initial DOC must also be performed any time there is a change in instrument type, method, or any time that a method has not been performed by the analyst or technician or technician in a twelve (12) month period. The initial DOC may be completed using a representative matrix (e.g., hemp oil).

An initial DOC process for a method includes:

1) Obtaining quality control samples from an outside source or preparing the samples using stock standards that are prepared independently from those used in instrument calibration.
2) Preparing four (4) aliquots at the concentration specified, or if unspecified, to a concentration of one (1) to four (4) times the LOQ for low concentration analytes either concurrently or over a period of days. For higher concentration analytes (such as potency), the concentration may be greater than four (4) times the LOQ.
3) Analyzing the aliquots either concurrently or over a period of days.
4) Using all results, assess the results against established and documented method acceptance criteria.

If all analytes meet the acceptance criteria and the analyst or technician has successfully completed the DOC, the analyst or technician can begin testing samples. If any of the analytes do not meet acceptance criteria, a supervisor or other qualified designee must locate the source of the problem, correct the problem, and have the analyst or technician repeat the test for all analytes that failed to meet method acceptance criteria.

When an analyte not currently found on the laboratory's list of approved analytes is added to an existing accredited method, an initial DOC must be performed for that analyte.

Annually thereafter, a continuing DOC is required. One of the following options must be performed and documented:

1) another initial DOC (as described above),
2) participation in a proficiency test study offered by an ISO/IEC 17043 proficiency test provider (if available), or
3) analysis of one (1) sample of clean matrix that is fortified with a known quantity of the target analyte, with the result compared to method acceptance criteria.

For any unacceptable result in the analyst or technician's continuing DOC, a supervisor or other qualified designee must identify the source of the problem, correct the problem, and have the analyst or technician repeat the test for all analytes that failed to meet method acceptance criteria.

The laboratory must have a documented procedure describing ongoing DOC that includes procedures for how the laboratory will identify data associated with ongoing DOCs. The analyst or technician must demonstrate on-going capability by routinely meeting the QC requirements of the method, laboratory SOP, client specifications, and/or this Standard. If the method has not been performed by the analyst or technician in a twelve (12) month period, a new initial DOC must be performed.

IV. Reagents, Reference Standards and Media

A laboratory must maintain a consumables log or inventory for all reagents, reference standards and media purchased and received. All reagents and reference standards, including any working standards, must be:

1. labeled to indicate identity, batch number, date received or prepared, expiration date, and where applicable, concentration or purity, and date opened;
2. stored under appropriate conditions to minimize degradation or deterioration of the material;
3. within their expiration or re-qualification dates at the time of use; and
4. documented on \records for each analysis.

Deteriorated or outdated reagents, reference standards and media must be properly discarded, complying with all federal, state and local regulations governing waste management.

All reference standards must be acquired from certified sources. A laboratory may elect to internally produce reference standards. When internally produced, a laboratory must utilize validated standard analytical techniques to document or verify, or both, the purity and concentration of the internally produced reference standards. Internally developed standards must be verified against externally validated standards from known sources meeting ISO/IEC 17034:2016 requirements.

A laboratory must obtain, or for internally produced standards, create a certificate of conformance for each lot of reference standard. Each certificate of conformance must be kept on file and the lot number of the reference standard used must be recorded in the documentation for each analysis requiring the use of the standard.

For a chemistry laboratory, the following criteria must be met for reagent water quality:

1) In methods where the purity of reagents is not specified, analytical reagent grade must be used. Reagents of lesser purity than those specified by the method must not be used. Documentation of purity must be available.
2) The quality of water sources must be monitored and documented and must meet method specified requirements.

For a microbiological laboratory, the reagent water quality and media checks that must be done are listed below.

1) Monitor quality as per Standard Method Table 9020:II.
2) Keep certificate of analysis from laboratory testing the water quality.

Additional quality controls for a microbiology laboratory are listed in Table 1 below.

Table 1

Microbiology QC	**Action Item**	**Frequency**
Certified Reference Materials	Cell/CFU concentration	Each new lot
Dilution buffers	Sterility	Each new lot
	pH	Each new lot
	Volume accuracy	Each new lot
Stock Culture Maintenance	Prepare new working stock	Each new lot
	Monthly transfers	Monthly
Media Performance (lab and commercially made)	Sterility	Each new lot
	Growth promotion	Each new lot
	Growth inhibition	Each new lot
	pH	Each new lot or per manufacturer's instructions*
	Appearance	Each new lot
	Count comparisons of old and new lots	Upon arrival of new lot
Automated MPN Instrumentation	Measurement Performance or equivalent	Monthly or per manufacturer's instructions**

* For manufacturers such as 3M™, pH of the Petrifilm is done post hydration with the dilution buffer.
** Automated MPN instrumentation will require QC specific to the instrument and methodology.

V. Calibration and Maintenance of Laboratory Equipment

A laboratory must calibrate and maintain its equipment as specified below, and the calibration, verification and/or check and maintenance must be documented.

1) Air in a microbiological lab
   a) Monitor bacterial density monthly
2) Autoclaves
   a) Check temperature with max-registering device weekly

   b) Check performance with bioindicator monthly
   c) Check timing quarterly
   d) Use heat-indicating tape with each cycle
3) Automatic Pipettes or Micropipettors and Pipette Tips
   a) Check dispensing accuracy and precision quarterly
   b) Calibrate annually
   c) Keep certificate of conformance for each lot of pipette tips
   d) Discard pipette tips after each use
4) Balances
   a) Check zero daily before use
   b) Check accuracy with at least 2 weights over the range of use daily before use
   c) Service and recalibrate annually
   d) Keep service record
5) Biosafety cabinet – Class 1 or 2
   a) Inspect for airflow with each use
   b) Have certified annually
6) Blenders (Autoclavable)
   a) Clean and autoclave after each homogenization of submitted cannabis or cannabis products to be composited per lot
7) Cell spreaders and loops
   a) Check sterility with each lot, or alternatively, keep certificate of conformance with each lot
8) Centrifuges
   a) Follow manufacturer's instructions
9) Conductivity meter
   a) Calibrate monthly
10) Dilution water bottles
   a) Check sterility, pH, and volume with each batch or lot
11) Freezers
   a) Check temperature daily
   b) Defrost annually
   c) Use temperature devices with temperature increments of 1 or 0.5°C
12) Glassware for chemistry laboratory
   a) Inspect for cleanliness, chips, and etching with each use
   b) Use class A when specified by the approved method, and keep certificate of conformance per each piece of class A glassware
   c) If class B or class A without a certificate of conformance, perform verification check upon purchase or prior to first use
13) Glassware for microbiological laboratory
   a) Inspect for cleanliness, chips, and etching with each use
   b) See 12 b) and c) above.
   c) Check pH with bromothymol blue with each wash batch
   d) Conduct inhibitory residue test with initial use and new washing procedure (also may be annual)
   e) Check for autofluorescence if used for testing with each batch or lot
14) Hot-block digestors
   a) Perform temperature distribution and stability study initially upon purchase and after any major maintenance / repairs

15) Hot-air sterilizing oven for microbiological lab
    a) Check temperature with each use
    b) Check performance with bioindicator monthly
16) Incubators
    a) Perform temperature distribution and stability study initially upon purchase and after any major maintenance / repairs
    b) Check temperature daily if using continuous temperature monitoring device with data logger and capability to notify analyst or technician of any deviations, or twice daily for other temperature monitoring devices
    c) Use temperature monitoring devices with temperature increments of 0.5°C or less, as appropriate (e.g., for a 44.5 +/- 0.2°C water bath used for incubation of thermotolerant bacteria, use a thermometer with 0.1°C increments
17) Laminar Flow Hoods
    a) Check and service annually
    b) Keep service record
18) Media-dispensing apparatus
    a) Check volume dispense accuracy with each volume change
19) Microbiological membrane filters and filter apparatus
    a) Check sterility and properties with each new lot
    b) Check sterility pre and post filtration series
20) Microscope
    a) Clean optics and stage
    b) Check alignment with each use
    c) Keep any service records
21) Microwave digestors
    a) Follow manufacturer's instructions
    b) Keep any service records
22) Muffle furnaces
    a) Check accuracy annually using one of the following: 1) high-temperature thermometer with range to at least 500 C and with readable subdivisions of 5 C or less; 2) melting-point solids with capability of differentiating 5 C differences between 400 C and 500 C; or 3) independent potentiometer capable of differentiating 5 C differences between 400 C and 500 C
    b) Keep any service records
23) pH meters
    a) Standardize with at least 2 buffer solutions daily before use
    b) Determine slope daily before use
24) Plastic or other non-glass volumetrics
    a) Prior to use, keep certification of conformance per lot
25) Refrigerators
    a) Check temperature daily
    b) Use temperature devices with temperature increments of 1 or 0.5°C
26) Spectrophotometers
    a) Check wavelength annually
    b) Keep any service records
27) Syringes
    a) Keep certificate of conformance per syringe

b) Clean after use

28) Temperature devices

a) Working units: For most types, check accuracy annually and establish a correction factor

Table 2

Temperature Device	Frequency
Liquid spirit in glass	Annually
Hg in glass	Annually
Digital, thermocouple or similar device	Annually
Dial	Quarterly
IR gun*	Quarterly

* In addition, check at single point daily on day of use

b) Reference units: Recertify every 5 years

29) Timers

a) Autoclave: Check timing with stopwatch quarterly

b) Stopwatch: Check against National Time Signal (i.e., cell phone) annually

30) UV-lamps and short-wave disinfection

a) Monitor bulb use with each use

b) Test with UV meter or perform plate count check quarterly

31) Water baths for microbiological labs

a) Check temperature daily if using continuous temperature monitoring device with data logger and capability to notify analyst or technician of any deviations, or twice daily for other temperature monitoring devices

b) Use temperature monitoring devices with temperature increments of 0.5°C or less, as appropriate (e.g., for a 44.5 +/- 0.2°C water bath used for incubation of thermotolerant bacteria, use a thermometer with 0.1°C increments)

c) Fill unit only with reagent-quality water. Maintain water level so it is above the upper level of the medium in either tubes or flasks

d) Equip water bath with a gable cover to prevent evaporation and with a circulating pump to maintain even temperature distribution. Use only stainless steel, plastic-coated, or other corrosion-proof racks. Use screens or weights to keep materials from floating

e) Empty and clean bath as needed to prevent buildup of salts and microbial growth, and disinfect before refilling

32) Weights

a) Working: Check with reference weights annually

b) Reference: Recertify every 5 years or more often (annually) if heavily used

c) Keep recertification record

33) Analytical Instrumentation (e.g., pH meters, GCMS, ICP, HPLC, MALD-TOF)

a) Follow manufacturer's instructions for cleaning and maintenance

b) Document all cleaning, calibrations, maintenance, and repairs

c) Keep any service records

VI. Testing Standards

These standards establish the minimum QA/QC procedures for chemistry and microbiological analysis. A laboratory must establish written procedures related to the following, where applicable:

- Method selection

- Method validation, including accuracy, precision, bias, and selectivity (sensitivity)
- Initial demonstration of capability
- Continuing demonstration of capability
- Calibration
- Continuing calibration
- Quality control
- Data acceptance and rejection criteria
- Handling sample results

A. Chemistry – Analytical, Organic and Inorganic (Metals)

These Standards must be performed for each analytical, organic and metal chemistry method. Each laboratory must maintain sufficient raw data records to ensure the QC was performed at the frequency specified.

'Bracketing' of QC samples, rotating from across the calibration curve range, is required. QC samples must follow the first twenty (20) samples after an initial calibration, every 20 samples thereafter, and at the end of testing samples. This would also apply to a continuing calibration.

1) LOD determination
    a. An initial LOD determination is required if a laboratory reports results below its limit of quantitation (LOQ).
        i. Please follow the US EPA Method Detection Limit (MDL) procedure included in Title 40 of the Code of Federal Regulations Part 136 (40 CFR 136), Appendix B to 40 CFR 136. eCFR :: Home
    b. The laboratory must record the analytical and preparation methods used, dates of preparation and testing, the batch identifiers, the testing instrument, quality system matrix, technology, analyte, concentration in the spiked sample with units, and the test result (if any) for each LOD verification test.
    c. A laboratory that does not report results below its LOQ must still complete an initial LOD determination.
2) LOQ or MRL determination
    a. Selection of a LOQ
        i. Please select an appropriate LOQ based on technology/methodology, reference standards, and regulatory limits.
        ii. An initial verification sample must consist of a spiked matrix blank at or below the selected LOQ.
        iii. The LOQ must be at or above the lowest corresponding calibration standard concentration with the exception of methods using a single point calibration.
        iv. The laboratory must establish accuracy acceptance criteria for the LOQ verification spikes. It must be at least as stringent as the lowest corresponding calibration standard.
    b. Initial verification of LOQ

i. If low level spikes were analyzed to generate a LOD, the results may be used to perform the initial verification of the LOQ.
ii. Initial verification of accuracy and precision must include ≥7 low level spikes at or below the LOQ over at least three (3) batches on three (3) separate days, for a representative matrix of cannabis.
iii. Samples must be processed through all steps of the method, including any preparations or extractions and analysis.
iv. If there are multiple instruments that will be assigned the same LOQ, the low-level spikes must be distributed across all of the instruments.
v. A minimum of two (2) low-level spikes prepared and analyzed on different days shall be tested on each instrument. Alternatively, perform a comparison study to show each instrument is responding similarly.
vi. All results are quantitative, and if the results do not meet the qualitative identification criteria in the method, the laboratory must perform a corrective action and the verification repeated.

c. Ongoing LOQ verification
i. Ongoing LOQ verification must be done quarterly.
ii. The laboratory must prepare and analyze a minimum of one (1) LOQ verification sample spiked at the same concentration as the initial LOQ verification on each instrument during each quarter in which samples are being analyzed for a representative matrix, method, and analyte.
iii. If an ongoing LOQ verification test fails, the laboratory must take corrective action and document a technically valid reason for the corrective action. A corrective action may include, but not be limited to, the following:
1. correcting method or instrument performance and repeating the verification test;
2. evaluating the laboratory established control limits to ensure they reflect current performance; or
3. raising the spiking level (and the quantitation limit if the spiking level is above it) and repeating the initial verification study.
iv. Any samples analyzed in a batch associated with a failing LOQ verification must be re-analyzed or reported with qualifiers.
v. The laboratory must stop any further testing of samples until the LOQ failure is corrected. To continue to qualify results is not an appropriate corrective action.
vi. Using the previous five (5) quarters, the laboratory must tabulate all results of the ongoing verification sample testing. All data representative of the current operations must be used. A minimum of seven (7) samples is required.
vii. The laboratory must record the analytical and preparation methods used, dates of preparation and testing, the batch identifiers, the testing instrument, quality system matrix, technology, analyte, concentration in the spiked sample with units, and the test result (if any) for each LOQ verification test.
viii. For each analyte, the laboratory must record the percent recovery, the number of results (n), the mean and standard deviation of the percent recovery, and the spiking concentration of the spiked samples with units.

3) Initial calibration

a. Samples results must be associated with an acceptable initial calibration. If the initial calibration is not acceptable, corrective actions must be performed and all associated samples re-analyzed.
    i. No sample results are to be reported nor data qualified for a failed initial calibration.
b. Samples must be analyzed under an initial calibration that was performed no more than one month prior.
c. The following items are required elements of an initial calibration:
    i. the details of the initial calibration procedures including calculations, integrations, acceptance criteria, and associated statistics must be included or referenced in the method SOP. When initial calibration procedures are referenced in the method SOP, then the referenced material must be retained by the laboratory and be available for review;
    ii. sufficient raw data records must be retained to permit reconstruction of the initial calibration (e.g., calibration date, method, instrument, analysis date, each analyte name, and analyst or technician's initials or signature; concentration and response, calibration curve or response factor; or unique equation or coefficient used to reduce instrument responses to concentration);
    iii. the laboratory must use the most recent initial calibration analyzed prior to the analytical batch;
    iv. standards used for calibration must be traceable to an international or national standard, when commercially available; and
    v. the laboratory must have a written procedure addressing removal and replacement of calibration standards.
d. The laboratory may remove individual analyte calibration levels from the lowest and/or highest levels of the curve. Multiple levels may be removed. Removal of one (1) interior level is permitted provided that enough valid points remain.
e. The laboratory may remove an entire single standard calibration level from the interior of the calibration curve when the instrument response demonstrates that the prepared standard was not properly introduced to the instrument, an incorrect prepared standard was analyzed, or the laboratory demonstrates that enough valid points remain.
    i. Removal of calibration points from the interior of the curve is not to be used to compensate for lack of maintenance or repair to the instrument.
f. The laboratory must adjust the LOQ/reporting limit and quantitation range of the calibration based on the concentration of the remaining high and low calibration standards.
g. For a single point, the laboratory may replace a calibration standard provided that: the laboratory analyzes the replacement standard within twenty-four (24) hours of the original calibration standard analysis for that particular calibration level.
h. The laboratory limits the replacement of calibration standards to one calibration standard concentration.
i. Based on the calibration type, the laboratory must use the minimum number of calibration standards specified below:
    1. Threshold Testing 1
    2. Average Response 4
        a. Fewer calibration standards may be used only if equipment firmware or software cannot accommodate the specified number of standards. Documentation detailing that limitation shall be maintained by the laboratory.
    3. Linear Fit 5

4. Quadratic Fit 6

ii. For metals testing, a single point calibration may be used for mercury (Hg), and a standard run at the LOQ for verification.

j. For regression or average response/calibration factor calibrations, the minimum number of non-zero calibration standards must be as specified in the section above.

k. The lowest calibration standard must be at or below the lowest concentration for which quantitative data are to be reported without qualification.

l. The highest calibration standard shall be at or above the highest concentration for quantitative data are to be reported without qualification.

m. Sample results must be quantitated from the initial calibration and may not be quantitated from any continuing calibration verification.

n. Criteria for the acceptance of an initial calibration must be established including any calculations (e.g., relative error, relative standard deviation).

i. $R^2 \geq 0.990$ and curve recovery of ±20% (and ±30% for the lowest point) for all points must be maintained.

o. The laboratory must use and document a measure of relative error in the calibration.

i. For calibrations evaluated using an average response factor, the determination of the relative standard deviation (RSD) is the measure of the relative error.

ii. For calibrations evaluated using correlation coefficient or coefficient of determination, the laboratory must evaluate relative error using either equation 1. <u>or</u> 2. below. The former is less complex than the latter. Laboratory must use one of them.

1. Relative Error (RE) is calculated using the following equation: %RE = ((X`i – Xi)/Xi)*100, where Xi = True value for the calibration standard and X`i = Measured concentration of the calibration standard.

a. This calculation must be performed for all calibration levels in use.

b. The RE at all initial calibration levels must meet the criteria specified in the method. If no criterion for the lowest calibration level is specified in the method, the criterion and the procedure for deriving the criterion must be specified in the laboratory SOP.

2. Percent Relative Standard Error (%RSE) is calculated using the following equation:

$$\% RSE = 100 \times \sqrt{\sum_{i=1}^{n} \left[\frac{x_i' - x_i}{x_i}\right]^2 / (n-p)}$$

where xi = True value of the calibration level I; x'i = Measured concentration of calibration level I; p = Number of terms in the fitting equation (average = 1, linear = 2, quadratic = 3); and n = Number of calibration points

a. The RSE must meet the criterion specified in the method. If no criterion is specified in the method, the maximum allowable RSE must be numerically identical to the requirement for RSD in the method. If there is no specification for RSE or RSD in the method, then the RSE must be specified in the laboratory SOP.

4) Initial Calibration Verification

a. All initial calibrations must be verified with a calibration standard obtained from a second manufacturer or a separate lot prepared independently by the same manufacturer.
b. Initial calibration verification is performed by analyzing a test solution of known analyte concentration(s) after initial calibration and prior to sample analysis.
c. In general, the check must be ± 20% (± 30% for the lowest point) of the known value. Some individual methods may require tighter tolerances (± 10% of the known value).
d. Some methods such as metals and water activity allow data within the linear range of the instrument, but above the daily calibration, to be reported without qualification. Please refer to section 14 – linear dynamic range – below.
    i. For these methods, the laboratory must establish the upper reporting limit through analysis of a series of standards. The upper reporting limit is equal to the concentration of the highest standard meeting the method limits for accuracy.
    ii. The laboratory must establish linearity annually and check it at least quarterly with a standard at the top of the linear working range, or at the frequency defined by the method.
    iii. The laboratory must dilute samples with results above the linear calibration range or qualify the over-range results as estimated values.

5) Continuing Calibration Verification
a. The validity of the initial calibration must be verified prior to sample analyses by a continuing calibration verification with each analytical batch.
b. A CCV is performed by analyzing a test solution of known analyte concentration(s) prior to sample testing on each testing day and continued periodically during the analytical batch run, no less frequently than once after each set of 20 samples, and at the end of each run.
c. The CCV must be a standard that is from the same vendor/lot that is used for the calibration curve.
d. In general, the check must be ± 20% (and ± 30% for the lowest point) of the known value.
e. Calibration must be verified for each compound, element, or other discrete chemical analyte, except for multi-component analytes where a representative chemical, related substance or mixture can be used.
f. Instrument continuing calibration verification must be performed at the beginning and end of each analytical batch, and at the frequency defined in the method except:
    i. If an internal standard is used, calibration verification must be performed at the beginning and end of each analytical batch;
    ii. A second source initial calibration verification that passes the continuing calibration verification criteria may be used in place of a continuing calibration verification standard;
    iii. A LCS may be used in place of a CCV (but not as a replacement for a failing CCV) for methods where the calibration goes through the same process as the LCS (using the continuing calibration verification acceptance criteria).
g. Sufficient raw data records must be retained to permit reconstruction of the CCV (e.g., method, instrument, analysis date, each analyte name, concentration and response, calibration curve or response factor, or unique equations or coefficients used to convert instrument responses into concentrations).
h. CCV records must explicitly connect the CCV data to the initial calibration.
i. If the CCV results obtained are outside the established acceptance criteria, the following steps must be taken:

i. If the cause for the CCV failure is identified that impacts only the calibration verification sample (e.g. a missed autosampler injection), then analysis may proceed if a second CCV sample is analyzed immediately and the result is within acceptance criteria. Samples analyzed previously must be considered valid if bracketed by a passing CCV sample. The cause for the failure of the first CCV result must be documented; and
ii. If the cause for the CCV failure is not identifiable or has impacted other samples, then a corrective action must be performed and documented. Prior to analyzing samples, the laboratory must demonstrate acceptable performance after corrective action with an acceptable CCV] or a new initial calibration must be performed. Samples analyzed prior to the CCV failure must be reanalyzed.

j. Data associated with an unacceptable calibration verification may be reported with a qualifier if certain conditions are met. When the acceptance criteria for the CCV are exceeded high (I.e., high bias) and there are associated samples that are non-detects, then those non-detects may be reported. Otherwise, the samples affected by the unacceptable calibration verification shall be re-analyzed after a new calibration curve has been established, evaluated and accepted. Alternatively, when the acceptance criteria for the CCV are exceeded low (I.e., low bias), those samples may be reported if they exceed the regulatory limit. Otherwise, the samples affected by the unacceptable CCV shall be re-analyzed after a new calibration curve has been established, evaluated and accepted.

6) Low level continuing calibration verification
   a. A LLCCV will be run at the end of each analytical batch.
   b. The measured value must be within ± 30 % of the prepared value.
7) Precision and Bias
   a. For reference methods with a spiking procedure, the laboratory must evaluate the precision and bias of a reference method for each analyte of concern for each quality system matrix.
   b. For lab-developed methods with a spiking procedure, the laboratory must have a documented procedure to evaluate precision and bias. The laboratory must also compare results of the precision and bias measurements with criteria established by the Office. Please refer to section IX, Chemistry.
   c. Precision and bias measurements must evaluate the method across the analytical calibration range of the method. The laboratory must also evaluate precision and bias in the relevant quality system matrices and must process the samples through the entire measurement system for each analyte of interest.
8) Negative control – Method blank (MB) or Laboratory Reagent Blank (LRB)
   a. The method blank or LRB must be analyzed at a minimum of one (1) per preparation batch.
      i. When possible, the lab must alternate between the use of a MB and LRB.
   b. The MB or LRB must be processed along with and under the same conditions as the associated samples to include all steps of the preparation and analytical procedure.
   c. The MB or LRB is used to assess the samples in the preparation batch for possible contamination during the preparation and processing steps.
   d. The measured concentration of each analyte in the MB or LRB must be < LOQ or MRL.
   e. Procedures must be in place to determine if a MB or LRB is contaminated.

        i. While the goal is to have no detectable contaminants, each method blank must be critically evaluated as to the nature of the interference and the effect on the analysis of each sample within the batch.

f. The source of contamination must be investigated and measures taken to minimize or eliminate the problem and affected samples reprocessed if:
    i. the concentration of a targeted analyte in the blank is at or above the LOQ or MRL.
    ii. the blank contamination otherwise affects the sample results as per the method requirements or the individual project data quality objectives; and
    iii. a blank is determined to be contaminated. The cause must be investigated and measures taken to minimize or eliminate the problem. Samples associated with a contaminated blank must be evaluated as to the best corrective action for the samples (e.g., reprocessing or data qualifying codes). In all cases, the corrective action must be documented.
g. Any affected samples associated with a contaminated MB or LRB must be reprocessed for analysis.
h. If used instead of a LRB, a MB must consist of a quality system matrix that is similar to the associated samples and is known to be free of the analytes of interest.

9) Positive control – Laboratory control sample (LCS)
   a. The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps.
   b. Results of the LCS are compared to established criteria and, if found to be outside of these criteria, indicates that the analytical system is "out-of-control."
   c. Any affected samples associated with an out-of-control LCS must be reprocessed for re-analysis or the results reported with appropriate data qualifying codes.
   d. The LCS must be carried through the entire sample preparation process and analyzed.
   e. The LCS must be analyzed at a minimum of one (1) per preparation batch.
   f. The LCS is a quality system matrix, known to be free of analytes of interest, spiked with known concentrations of analytes that are within the calibration range.
      i. The matrix spike may be used in place of this control if the acceptance criteria are as stringent as for the LCS.
      ii. The lab may use commercially available or pre-prepared standards (separate from calibrators) for QC.
   g. Alternatively, the LCS may consist of a media containing known and verified concentrations of analytes or as certified reference material (CRM). All analyte concentrations must be within the calibration range of the methods.
      i. The lab may use commercially available or pre-prepared standards (separate from calibrators) for QC.
   h. The individual LCS is compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory must determine internal criteria and document the method used to establish the limits. A common acceptance criteria for a LCS is ± 20% of the known value.
   i. The results of the individual batch LCS are calculated in percent recovery or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory must document the calculation.

j. When the acceptance criteria for the positive control are exceeded low (i.e., low bias) or high (i.e., high bias; e.g., potency), those sample results must be investigated, and a corrective action implemented.
k. Allowable marginal exceedances (ME) are listed in Table 3. If a large number of analytes are in the LCS, it becomes statistically likely that a few will be outside control limits. This may not indicate that the system is out of control, therefore corrective action may not be necessary. Upper and lower marginal exceedance limits can be established to determine when corrective action is necessary. A ME is defined as being beyond the LCS control limit (three standard deviations), but within the ME limits. ME limits are between three (3) and four (4) standard deviations around the mean. The number of allowable marginal exceedances is based on the number of analytes in the LCS. If more analytes exceed the LCS control limits than is allowed, or if any one analyte exceeds the ME limits, the LCS fails, and corrective action is necessary. This marginal exceedance approach is relevant for methods with long lists of analytes. It will not apply to target analyte lists with fewer than eleven analytes.

Table 3

Number of Analytes	Number of Allowed ME
>90	5
71-89	4
51-70	3
31-50	2
11-30	1
<11	0

l. If the same analyte exceeds the LCS control limit consecutively, it is an indication of a systemic problem. The source of the error must be located, and corrective action taken. A laboratory must have a written procedure to monitor the application of marginal exceedance allowance to the LCS.

10) Matrix spikes and Matrix spike duplicates
a. Analyze an actual sample with a known amount of standard added; this is the MS. A second portion of the actual sample used to prepare the MS that is spiked and processed in the same manner as the MS; this is the MSD.
b. Calculate the RPD between first sample and replicate. The calculations must be documented, and the target value must be close to the first value and have a RPD of less than 20%.
c. Routine MS and MSD samples are not required if an isotope dilution standard is being used to monitor matrix suppression/enhancement in every sample.
d. Matrix-specific QC samples indicate the effect of the sample matrix on the precision and accuracy of the results generated using the selected method. The information from these controls is sample/matrix specific and would not normally be used to determine the validity of the entire batch.
e. The frequency of the analysis of matrix spikes and matrix duplicates are as specified by the method or may be determined as part of the contract review process.
f. For methods that include one (1) to ten (10) targets, spike all components.
g. For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.

h. For methods with more than twenty (20) targets, randomly spike at least sixteen (16) components.
i. Matrix duplicates are performed on replicate aliquots of actual samples. The composition is usually not known.

11) Sample duplicates
   a. Analyze the same sample twice, this must be two separate preparations. The sample should be chosen at random and run together on the same analytical run.
   b. Calculate the RPD between first sample and replicate. Calculations must be documented, and the target value must be close to the first value and have a RPD of less than 20%.
   c. Variability may be introduced during sample preparation. To account for this, if more than one staff member is prepping samples, each staff must also prepare and analyze a sample matrix duplicate for each set of prepared samples.
12) Surrogate spikes (organic methods only and if required by the method)
   a. Surrogates, when required, are chosen to reflect the chemistries of the targeted components of the method and are added prior to sample preparation/extraction.
   b. Except where the matrix precludes its use or when not commercially available, surrogate compounds must be added to all samples, standards, and blanks for all appropriate methods.
   c. The results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory must determine internal criteria and document the method used to establish the limits.
   d. Surrogates outside the acceptance criteria must be evaluated for the effect indicated for the individual sample results. An appropriate corrective action must be implemented.
   e. Results reported from analyses with surrogate recoveries outside the acceptance criteria must include appropriate data qualifiers.
13) Linear dynamic range (metals methods only)
   a. Establish an LDR for each analyte annually by analyzing a standard prepared at a suitable concentration. The measured concentration must be within ±10 % of the prepared value.
14) Internal standards are required if the method was validated using them.
15) Isotope dilution is required if the method was validated using them.
16) Data reduction
   a. The procedures for data reduction, such as use of linear regression, must be documented.

B. Physical Chemistry

1) Water Activity
   a. Sample duplicates
      i. See Section 11 above under A. Chemistry – Analytical, Organic and Inorganic (Metals).
   b. Calibration
      i. If the a_w instrument is being used in a single location at the same temperature (+/-1°C) and humidity (+/-5% relative humidity), calibrate if it has been more than seven consecutive days since the last calibration.
      ii. If the a_w instrument is physically moved from one location to another, calibrate immediately following the move and prior to analyzing samples.

iii. If the a_w instrument has been cleaned, then calibrate immediately following the cleaning.
iv. Follow any other calibration procedures listed in a consensus method and manufacturer's instructional manual.

c. Monitor temperature and humidity daily or on day of use, and keep a record of the check.

2) Filth and Foreign Materials

The laboratory must perform foreign material testing on not less than 30% of the total representative sample of intact buds and flower material prior to sample homogenization (using grinding or milling). In addition to establishing a sample homogenization SOP, the laboratory must establish a SOP that addresses the following:

a. Separation of material into no less than 10 increments
b. Calculation for foreign material used to determine 30% of the total representative sample
    i. If a sample fails for foreign material, the sample result must be qualified.
c. Quantification of filth based on total surface area
d. Use of a microscope with both low- and high-power magnification and photographic capabilities to assess foreign matter, including mildew, pests, and molds.
    i. Indicate when photographs are taken.
e. Compare the results to the limits established by the Office.

3) Moisture Content

Moisture content must be determined on dried, flower products such as pre-rolls and whole flower and ground flower products. The laboratory must use 1.00 ± 0.10 gram of cannabis flower product for testing that is not manipulated, homogenized, or otherwise altered from how it was received.

Moisture content must be determined by either using a moisture analyzer or a drying oven in conjunction with an analytical balance and desiccator. The temperature must be set within this range: 90 to 105 ºC. The loss on drying time will vary depending on whether a moisture analyzer or drying oven is used. The end goal is to reach a constant weight.

Sample duplicates must be performed with each batch of samples. See Section 11 above under A. Chemistry – Analytical, Organic and Inorganic (Metals).

C. Microbiology

1) Culture Methods and Most Probable Number Instrumentation – Qualitative and Quantitative

The quality control (QC) samples that are required for culturing of cannabis and cannabis products using qualitative and quantitative methods are included in Table 4.

Table 4

Quality Control	Specific Control	Frequency
Positive Control	Analyze a Matrix Spike/CRM for TAMC and TYAM	Per batch

Method Blank/Negative Control [A]	Incubate and analyze a dilution buffer for TAMC and TYAM	Per batch
Analyst or technician Quantitative Performance	Plate count comparisons • 2 or more analyst or technicians within 10% • 1 analyst or technician within 5%	Monthly

A – For automated MPN methods only

Positive Control: A CRM, or spiked matrix form may be used as a positive control. Either form must meet the acceptance criteria of either the CRM growth in CFU/g or growth of the target organism in the matrix spike to be considered passing. If the CRM is outside of the determined limits, or there is no growth on the matrix spike, the results are considered unacceptable. QC will need to be repeated and results are not to be reported or accepted until the QC failure is investigated and the root cause determined. The cause of the QC failure will determine if sample results require retesting.

Negative Control/Method Blank: The negative control must be negative for all organisms and growth. Any growth on the method blank or negative control is considered failing, and the results are considered unacceptable. QC will need to be repeated and results are not to be reported or accepted until the QC failure is investigated and the root cause determined. The cause of the QC failure will determine if sample results require retesting.

Analyst or Technician Quantitative Performance: For manual plate counting methods, the analyst(s) must be within a 5% difference in plate counts of a sample duplicate or duplicate QC if the only one performing manual plate counts, or within 10% of a sample duplicate or duplicate QC if 2 or more analysts are performing manual plate counts. If there is >5% for a single analyst or >10% for two or more analysts, the cause of the QC failure must be investigated and root cause determined. Analyst(s) must be retrained until <5% or <10% can be achieved.

2) Molecular Assays/Methods

The QC samples that are required for molecular (i.e., polymerase chain reaction (PCR) and probe-based qPCR with or without melting curve analyses) analysis of cannabis and cannabis products are listed in Table 5. However, because PCR analysis includes a broad range of nucleic acid targets and procedures, all QA/QC procedures necessary for a particular protocol may not be addressed. If this is the case, the Office of Cannabis Management in conjunction with colleagues from other state agencies (i.e., DOH, AGM) will put together another guidance addressing the specific protocol.

Table 5

Quality Control	**Specific Control**	**Frequency**
Positive Controls	1) PCR Positive Control 2) PCR Inhibition Positive Controls (Internal Sample Control)	Per each PCR assay run In every extracted sample

	3) Matrix Spike	On every sample form and every target with each batch.
Negative Controls	1) PCR Negative Control 2) No Template Control 3) Method Blank	With each PCR assay run With each PCR assay run Once per extraction batch
QC for Confirmation Procedures	1) Probe-based Quantitative PCR and Melting Curve Analysis	See section below.

PCR positive DNA controls are used to verify that the PCR master mix and reagents were prepared correctly to produce amplification of the specific assay target nucleic acid. This type of positive control is analyzed *with each PCR assay run*. A PCR assay run is defined as a group of samples that are analyzed at the same time under the same amplification conditions, using the same PCR master mix, for the same target analyte, and in the same thermocycler. A PCR run may contain more than one extracted sample batches. A PCR run with multiple assays must have a DNA positive control for each assay run.

Inhibition positive controls (also called internal sample controls) are used to verify that interfering constituents from a cannabis form, which may be carried over during isolation of nucleic acids or organisms during sample processing, do not inhibit the PCR. Because cannabis forms are constantly changing, inhibition positive controls must be performed *in every extracted sample.*

As described above for inhibition position controls, cannabis forms are constantly changing. As a result, *matrix spikes (MS)* must be performed regularly on a particular form to assess if any potential changes in the form have affected method performance, or until it can be documented that the variability of the recoveries within a given cannabis form is acceptable. Additionally, the MS is used to determine the effect of the matrix on the overall method recovery. This control can be performed by the analysis of a duplicate sample collected at the same time and location as the cannabis sample and seeded with known amounts of the target organism prior to sample processing. The seeded sample must be processed at the same time and in the same manner as the unseeded cannabis sample and the method positive control, if feasible.

PCR DNA negative controls are used to verify that the PCR master mix and reagents were prepared correctly to not produce incorrect amplification of the target nucleic acid. This type of negative control consists of non-target organism DNA that is not the same as the target of interest. This type of negative control is analyzed *with each PCR assay run*. A PCR run with multiple assays must have a DNA negative control for each assay type to verify that the amplification conditions are working properly.

No template controls are used to verify no contaminating nucleic acid has been introduced into the master mix. These controls are prepared once template has been added to the master mix. They are prepared as separate PCR reactions to which aliquots of molecular-grade water or buffer are added to the master mix in place of target nucleic acid or sample. A negative result with this control indicates that the master mix and final processing reagents are not contaminated. This type of negative control is analyzed *with each PCR run*. A PCR run with multiple assays must have a no template controls for each assay to verify the sterility of the assays.

The *method blank* is designed to check for contamination throughout sample processing and PCR analysis. This control is performed on a sterile reagent water or dilution buffer sample that is processed along with the test samples using the same preparation, extraction, sample transfer, and PCR procedures as the test samples. At a minimum, method blank samples must be performed *once per batch*. A sample batch is defined as a set of test samples processed together through all steps of the method leading to PCR.

Probe-based quantitative PCR and melting curve analysis are both part of real-time PCR, and the same positive and negative controls must be used for these confirmation techniques as are used for any type of PCR. In the event of unacceptable results from sequence analyses (e.g., the fluorescent signal is weak throughout the sequencing ladders of all samples), a sequencing reaction control using a template and primer provided by the manufacturer must be run according to the manufacturers' instruction. The source of the problem (e.g., poor PCR amplification, expired fluorescent dyes) must be determined and corrected, and any affected samples reanalyzed.

3) MALDI-TOF MS Assays/Methods

Matrix-assisted laser desorption/ionization time-of-flight mass spectrometry can be used to identify a wide range of microorganisms.

Internal Controls

Laboratories must perform internal QC before using MALDI-TOF MS to identify microorganisms. Internal QC consists of an automatic instrument calibration using a manufacturer-specified calibration standard. Depending on the system, calibrators include a manufactured extract of Escherichia coli (E. coli) or a specific E. coli calibration strain. Laboratories must follow manufacturers' specifications for preparing, using, and storing calibrators.

During calibration, the calibrator generates and automatically analyzes a mass spectrum to check the spectrum baseline and ensure the expected calibration peaks are present. Laboratories use these parameters to confirm their instrument settings are appropriate and their instruments will automatically adjust if necessary. The calibrator spectrum is also run against the reference database to ensure the correct identification is given with a level of confidence that meets the manufacturer's specifications. Laboratories must perform calibration *before every run.*

In addition, a laboratory must run a calibrator *control each day of testing, when a new target is used, or more often if the manufacturer recommends it.*

Laboratories must not only document calibration results but also promptly investigate calibration failures. Spectral acquisition cannot occur until calibration is successful. Calibration failures often result from user error, typically due to improper application of the calibrator. Laboratories can assess potential user error by reapplying and reanalyzing their calibrator. Calibration failure also occurs when the calibrator has been prepared improperly or when problems crop up with the matrix, reagents, target, or instrument.

External Controls

For positive controls (either an appropriate control micro-organism or calibrator), labs must test well-characterized strains using the same methodology they use for isolates. For example, yeast typically require extraction prior to analysis, so labs should process yeast QC organisms using the same extraction methodology. Laboratories must, at a minimum, test a bacterial QC organism *with each extraction technique*. Also, if laboratories are using MALDI-TOF MS to identify yeast, molds, etc. appropriate QC organisms for each organism type must be run each day they test for these microorganisms. Laboratories must obtain correct, high-confidence identifications for all QC organisms. If a laboratory fails to identify a QC organism, it must investigate and suspend testing until the problem is resolved.

Laboratories must also include a negative control (method blank) *with each extraction technique* consisting of water without cells. Typically, the negative control consists of reagents spotted directly on the target plate or slide. Matrix should be applied to a random blank spot on each target plate or slide to ensure there is no reagent contamination and, for systems that use a reusable target plate, to ensure that the target plate has been adequately cleaned between runs.

Laboratories must operate platforms with disposable or reusable targets, and test a blank or negative control to ensure adequate cleaning of the target and before sample analyses. If an extraction is performed, the reagents used for the extraction can be spotted and overlaid with matrix to ensure no false-positive results are produced due to reagent contamination. To clarify, a method blank consisting of only water and no organisms is performed in tandem with each sample preparation type being used. Because of the implications of reporting organism identifications directly from cultures, laboratories must test lysis buffers and other reagents used for sample preparation to ensure they are free of contamination. This must be done *per each lot* of buffer and other reagents used.

To ensure high-quality spectra are produced, laboratories must follow manufacturer's recommendations for optimal culture conditions, sample preparation and media types. Laboratories must also use isolates that are grown and maintained according to the

manufacturer's instructions. Spectral quality depends on placing an optimal quantity of microorganism on the target plate, and special spotting techniques and extractions might be necessary to identify certain microorganisms. Laboratories must analyze all isolates in duplicate and have procedures in place to help resolve discordant results between spots. In addition, since MALDI-TOF MS cannot identify all organisms in polymicrobial cultures, labs must ensure cultures are pure. Laboratories should report results as preliminary until purity can be confirmed.

Another important QC consideration involves interpreting and reporting of MALDI-TOF MS identifications. Spectral databases differ in composition depending on the manufacturer. Users also can develop custom databases. Unless the laboratory has extensively validated lower confidence thresholds, a laboratory must adhere to the manufacturer-recommended thresholds for genus and species-level identifications.

VII. Laboratory-Developed Method Validation Protocols

A completeness checklist established by the Office must be submitted with a laboratory-developed method validation package. A laboratory must submit, at a minimum, preferably through email:

- Cover letter
- Summary of study design
- Summary of results from extraction and/or preparation (prep) method, if applicable, and determinative method and comparison of the results to the approved extraction and/or preparation method, if applicable, and determinative method
- Laboratory-developed standard operating procedure or method, including any extraction and/or prep methods utilized
- Initial demonstration of capability (DOC), including summary data and bench sheets
- Limit of detection (LOD) study, including summary data and bench sheets. Alternatively, if the laboratory will not report below its validated LOQ, a limit of quantitation (LOQ) study, including summary data and bench sheets
- Proficiency test (PT) scores if offered from an ISO/IEC 17043 approved PT provider. These scores are sent directly from the provider to OCM.
- Certificate of analysis template

A. Chemistry

For organic and metals chemistry related lab-developed methods, the validation study must include samples run by the approved prep and determinative method (if applicable and available) and samples run by the lab-developed prep and determinative method.

A systematic approach to evaluate precision and bias of a lab-developed method is as follows:

- Analyze QC samples at least seven (7) containing the analytes of concern at or near the limit of quantitation, at the upper-range of the calibration (upper 20%) and at a mid-range concentration.
    - At least 7 samples at low-level
    - At least 7 at mid-level and
    - At least 7 at upper-level
- Process these samples on three (3) different days as three (3) sets of samples through the entire measurement system for each analyte of interest. A separate method blank must be subjected to the analytical method along with the QC samples on each of the three (3) days. (Note that the samples at the LOQ concentration can demonstrate sensitivity as well.)
- For each analyte, calculate the mean recovery for each day, for each level over each day, and for a minimum of twenty-one (21) samples per day.
    - At least 7 low-, 7 mid- and 7 high-level samples on day 1
    - At least 7 low-, 7 mid- and 7 high-level samples on day 2
    - At least 7 low-, 7 mid- and 7 high-level samples on day 3
- Calculate the relative standard deviation for each of the separate means obtained.
- Compare the standard deviations for the different days and the standard deviations for the different concentrations. If the different standard deviations are all statistically insignificant (e.g., F-test), then compare the overall mean and standard deviation with the established criteria from above.

The laboratory must evaluate selectivity by following the checks established within the lab-developed method, which *may* include mass spectral tuning, second column confirmation, mass fragment confirmation, fragment to parent ion ratio, ICP inter-element interference checks, chromatography retention time windows, sample blanks, spectrochemical absorption or fluorescence profiles, co-precipitation evaluations, and electrode response factors.

The laboratory will also complete an initial DOC, as well as a LOD or LOQ study for the lab-developed prep and determinative method. LOD study is required if the laboratory will report below its LOQ. The initial DOC and LOD or LOQ study are matrix specific. The initial DOC and LOD study criteria can be found in section III and V, respectively.

To perform a LOQ verification study, please refer to section V above. In addition to at least seven (7) matrix spikes being analyzed as part of the LOQ study, the laboratory must analyze a minimum of seven (7) blanks.

B. Microbiology

For microbiological related culture, molecular and MALDI lab-developed methods, the laboratory will submit a lab-develop method SOP, including any extraction and/or prep methods utilized. The SOP must include appropriate controls including a negative and positive control, a testing algorithm, and all expected reporting and reflex testing scenarios. Specimen reports for each scenario must be included. If any alterations from the manufacturer’s instructions or

reporting guidelines (including acceptable score) are instituted, submission of additional validation data supporting this change would be required.

Culture Methods

For the original NYS DOH MM culture methods, the validation tests used hemp oil as a proxy for medical marijuana products, which were unavailable. Recoveries of contaminants inoculated into a hemp oil: isopropyl myristate: PBST matrix and a hemp oil:ethanol: PBST matrix were evaluated. A laboratory can choose to use another a matrix/form more suitable to cannabis products.

If the culture method is being used for enumeration, the laboratory must establish reasonable percent recoveries and compare the results to previously approved, enumerated methods.

Listed below is the QC to be performed on the reference media used for the lab-developed, culture-based method.

1) Method blanks
    a. Per each lot of pre-prepared, ready-to-use media and for each batch of medium prepared in the laboratory
    b. Per each filtration series, one at beginning and one at the end
2) Duplicate counts when method specifies plate counts
    a. Monthly on one positive samples
    b. Two or more technicians – within 10%
    c. One technician – within 5%
3) Matrix spikes
    a. Per batch for plated media only to evaluate inhibition
4) Matrix spike duplicates
    a. Per batch for plated media only to evaluate inhibition
5) Negative controls
    a. Per each pre-prepared, ready-to-use lot of selective medium and each batch of selective medium prepared in the laboratory
6) Positive controls
    a. Per each pre-prepared, ready-to-use lot of selective medium and each batch of selective medium prepared in the laboratory

Molecular Assays/Methods

Molecular methods must include DNA extraction, inhibition, and reagent contamination controls and a validation report showing specificity, sensitivity, inter-assay reproducibility, intra-assay reproducibility, and accuracy verification for each PCR assay. If a laboratory uses a commercial test kit, the vendor must provide the information in lieu of the laboratory performing the validation. Specimen reports for each scenario must be included. If any alterations from the manufacturer's instructions or reporting guidelines (including acceptable score) are instituted, submission of additional validation data supporting this change would be required. All extraction methods that will be used in the laboratory must be included in the validation.

The validation study must include the analysis of the following quality control samples: positive extraction control, negative extraction control, reagent contamination control, and inhibition control. For the latter control, alternatively, data must be provided that demonstrate the absence (or only rare occurrence) of inhibition, in each specimen type. If the extraction method is well established, with supportive evidence in the peer-reviewed literature, these references can be submitted together with the laboratory's own validation data.

For specificity, a laboratory must:

- Provide a list of all organisms tested in the specificity study and verification run, including the source and concentration of each organism or nucleic acid target if whole organism is not available
- Provide the results of the specificity study. If there is any cross-reactivity, provide additional information on how the results will be resolved or interpreted

For sensitivity, a laboratory must:

- Provide a brief description of methods used to demonstrate the LOD of the assay
- Provide the results of the LOD study for each matrix

For inter-assay reproducibility, a laboratory must provide a brief experimental description and results demonstrating inter-assay reproducibility.

For intra-assay reproducibility, a laboratory must provide a brief experimental description and data demonstrating intra-assay reproducibility.

For accuracy verification, a laboratory must:

- Provide data from at least 30 positive samples and 10 negative samples for each type together with controls used in the assay.
- For each assay, provide the number and type of samples tested, including information on the subtypes, genotypes, etc. tested in the assay
- Provide a brief summary of the results, including an explanation of any discrepant results and how the discrepancy was resolved
- Submit one representative example of test results, a condensed summary of the raw data, and a complete description of how all results were interpreted

For molecular amplification assays for microbial detection that are not probe-based, data must be submitted from a secondary confirmatory method. The assays can be used as screening assay but must be confirmed with an alternative method (i.e., a probe-based, hybridization-based or sequence-based method. IN the absence of such confirmation, positive results are considered presumptive, and this should be clearly indicated thereof.

<u>MALDI-TOF MS Assays/Methods</u>

A table of these results must include comparison identification information, identification score from MALDI-TOF MS, and final reporting information.

All extraction methods that will be used in the laboratory must be included in the validation. At least 30 isolates for each extraction method must be included as part of the total number of representative isolates required in the validation.

Validation must include data from at least 100 representative bacterial isolates, 50 mold isolates or 50 yeast isolates including the most common species isolated from different sources in the laboratory. At least 30 isolates for each extraction method must be included as part of the total number of representative isolates. No negatives organisms are required. A table of these results must include comparison identification information, identification score from MALDI-TOF MS, and final reporting information.

Reproducibility studies must be performed. For inter-assay reproducibility, at least 3 clinical or certified reference isolates should be run on three different days. For intra-assay reproducibility at least 3 clinical or certified reference isolates should be run in triplicate.

If lab-developed or acquired databases will be used in addition to the library databases provided by the manufacturer, submit the criteria for isolate selection (how isolates will be selected for library addition), confirmation method (how the organism was identified), spectral quality and number of spectra required for library creation.

VIII. Reporting of Results

Prior to reporting the results, all results must be reviewed. The review of the results must be documented.

Pursuant to Part 130 of Title 9, a cannabis laboratory must issue a certificate of analysis (COA). A COA shall include, where applicable, those criteria specified in Part 130 of Title 9.

For chemistry, results are *typically* reported as follows:

- Potency – in milligram (mg) per dose or serving and as a percentage (% weight)
- Moisture Content – as a percentage
- Metals – in micrograms of contaminant per gram (µg/g) or milliliter (mL)
- Mycotoxins – in micrograms of contaminant per gram (µg/g) or milliliter (mL)
- Pesticides – in micrograms of contaminant per gram (µg/g) or milliliter (mL)
- Residual Solvents – in micrograms of contaminant per gram (µg/g) or milliliter (mL)
- Terpenes – as a percentage (%)
- Water Activity – in a_w

Reporting of results in parts per million (ppm) and parts per billion (ppb) is also a common practice.

For microbiological results, a laboratory will report the results in colony forming units (CFU) per gram or milliliter.

- Total yeasts and molds – in cfu/g or cfu/mL

- Total viable aerobic bacteria count – in cfu/g or cfu/mL

For Filth & Foreign Material, refer to OCM's Required Testing of Each Lot of Adult Use Cannabis and Medical Cannabis Product.

When required by the Office, a laboratory must normalize results to estimate actual human exposure levels based on the manufacturer's recommended daily dosage. Therefore, the result will be expressed as the relevant units of mass per dose.

If a laboratory's calculated cannabinoid (THC or CBD) result exceeds 100 percent and the difference between the result and 100 percent is within the laboratory's calculated analytical uncertainty, the laboratory may report the result as 100 percent with a qualifying statement on the certificate of analysis or the laboratory may report the calculated result with or without a qualifying statement. If the difference between the result and 100 percent is outside the calculated analytical uncertainty, the calculated result shall be reported without correction. The qualifying statement on the certificate of analysis shall clearly state the calculated value and the laboratory's analytical uncertainty. For the purposes of calculating RPD or RSD, a laboratory shall use the calculated result and not the adjusted result described.

IX. Record Retention

Pursuant to Part 130 of Title 9, all records must be kept for a minimum of five (5) years.

X. Significant Figures

A laboratory must follow the rounding procedures specified in latest edition of Standard Method 1050B.

For water activity and moisture content, results are to be reported to two significant figures and to the nearest tenth, respectively, and as specified in the document issued by the Office that lists the analytes and sets testing limits for contaminants as directed in Part 130 of Title 9.

XI. Potency / Cannabinoid Standardization

Unless otherwise approved by the Office in writing, a laboratory's procedure for the preparation and analysis of cannabis flower products must meet the criteria in Table 6. For each lot of cannabis flower product received for compliance testing, three (3) separate sample preparations (replicates) must be made and documented. Each of the 3 samples is injected onto a high performance-liquid chromatography (HP-LC) once, and the average of the 3 results shall be reported.

Since 3 replicates must be prepared and analyzed, the requirement to be perform sample duplicates on cannabis flower products will not be required.

Table 6

Homogenized, composite sample (particle size)	Single Sample Mass (mg)	Number of Prepared Samples or Replicates	Solvent Volume / Sample (ml)	Extraction Time / Sample (minutes)	Extraction Solvent	HPLC Calibration Range (ppm)
3-5 mm	200 - 400	3	20-40	30	Methanol	0.500 – 50.0

If a laboratory seeks to receive Office approval to deviate from the criteria noted above, the laboratory must show its procedure produces equivalent or better results. Refer to Section VII as it relates to validating a lab-developed method.

XII. Contact Information

New York State, Office of Cannabis Management

1220 Washington Ave.

Harriman Campus, Building 9

Albany, NY 12226

https://cannabis.ny.gov

labs@ocm.ny.gov

1-888-OCM-5151 (1-888-626-5151)

XIII. References

AOAC Official Methods of Analysis, 20th Edition (2016)

AOAC Official Methods of Analysis, Microbiological Methods, Chapter 17 (2019)

AOAC/FDA Bacteriological Analytical Manual (BAM), 8th Edition (1998)

ASTM International Cannabis Standards and Publications (2020-2022)

Bourassa, L. MALDI TOF MS Quality Control in Clinical Microbiology, Clinical Laboratory News (January 1, 2018)

CA Department of Cannabis Control. Testing laboratories - Department of Cannabis Control

CA Department of Cannabis Control. Approved Text of Regulations – Standard Cannabinoids Test Method and Standardized Operating Procedures

CA Department of Cannabis Control. Final Statement of Reasons - Standard Cannabinoids Test Method and Standardized Operating Procedures for All Licensed Commercial Cannabis Testing Laboratories

Code of Federal Regulations, Title 21, Chapter I, Part 211 – Current GMP for Finished Pharmaceuticals

FDA CFSAN Laboratory Quality Assurance Manual (LQM). 4th Edition (2019)

FDA Guidelines for the Validation of Analytical Methods for the Detection of Microbial Pathogens in Foods and Feeds. Edition 3.0 (2019)

FDA Guidelines for the Validation of Chemical Methods for the FDA FVM Program. 3rd edition (2019)

ISO/IEC 11333:2014. Microbiology of food, animal feed and water — Preparation, production, storage and performance testing of culture media.

ISO/IEC 17025:2017(E). General requirements for the competence of testing and calibration laboratories. Third Edition.

Li L, Duffy BC, Durocher LA, Dittmar MA, Acosta RA, Delaney ER, Li L, Aldous KM, Spink DC (2019) Potency analysis of medical marijuana products from New York state, Cannabis and Cannabinoid Research 4:3, 195–203 https://www.liebertpub.com/doi/10.1089/can.2018.0037

MI Marijuana Regulatory Agency. Sampling and testing technical guidance for marijuana products. Version 5. (March 8, 2022)

National Institute of Health (NIH). Uncomfortably high: Testing reveals inflated THC potency on retail Cannabis labels - PMC (nih.gov) - 2023; 18(4): e0282396. Published online 2023 Apr 12.

NSF International Standard/American National Standard (NSF/ANSI) 173-2020 Dietary Supplements (2020)

NYS Department of Health, Cannabis Reference Lab Program (formerly, Medical Marijuana Program). Measurement of Phytocannabinoids in Medical Marijuana using HPLC-PDA (NYS DOH MML-300)

NYS Department of Health, Cannabis Reference Lab Program (formerly, Medical Marijuana Program). Medical Marijuana Sample Preparation Protocols for Potency Analysis (NYS DOH MML-301)

NYS Department of Health, Clinical Laboratory Evaluation Program Clinical Laboratory Evaluation Program | New York State Department of Health, Wadsworth Center

NYS Department of Health, Environmental Laboratory Approval Program Environmental Laboratory Approval Program | New York State Department of Health, Wadsworth Center

OR Health Authority, Public Health. Oregon Health Authority : Cannabis Testing Laboratories : Medical Marijuana : State of Oregon

PA Department of Health, Office of Medical Marijuana. 28 Pa. Code Chapter 1171. Laboratories—Temporary Regulations (pacodeandbulletin.gov)

Standard Methods for the Examination of Water and Wastewater, 23rd Edition

The NELAC Institute (TNI) 2003 Standards Standards - The NELAC Institute (TNI) (nelac-institute.org)

The NELAC Institute (TNI) 2016 Standards Standards - The NELAC Institute (TNI) (nelac-institute.org)

US Environmental Protection Agency. Method Detection Limit - Frequent Questions | US EPA

US Environmental Protection Agency. Quality Assurance/Quality Control Guidance for Laboratories Performing PCR Analyses on Environmental Samples (EPA 815-B-04-001) Quality Assurance/Quality Control Guidance for Laboratories Performing PCR Analyses on Environmental Samples (epa.gov)

US Pharmocopeia (USP). <61> Microbiological Examination of Nonsterile Products: Microbial Enumeration Tests.

US Pharmocopeia (USP). <62> Microbiological Examination of Nonsterile Products: Tests for Specified Organisms.

US Pharmocopeia (USP). <233> Elemental Impurities – Procedures. (2018)

US Pharmocopeia (USP). <1129> Nucleic Acid-Based Techniques – Genotyping. (2013)

US Pharmocopeia (USP). <1113> Microbial Characterization, Identification and Strain Typing (2013)

US Pharmocopeia (USP). <1736> Applications of Mass Spectrometry. (2014)

WA Department of Agriculture. 977-CLASPMethod-CannabinoidConcSamplePrep.pdf (wa.gov)

WA Department of Agriculture. 976-CLASPMethod-CannabinoidConcAnalysis.pdf (wa.gov)

WA Department of Agriculture. https://agr.wa.gov/departments/cannabis/cannabis-lab-analysis-program

XIV. Change Record

February 2023 – Section VIII. Reporting of Results, paragraph 3, was amended to include additional examples of how results may be reported (i.e., in ppm or ppt).

March 2023 – Updated CCV criteria in Section VI. A. Chemistry – Analytical, Organic and Inorganic Metals Section 5) c to be consistent with CCV definition in Section II.

May 2023 – Clarified the validation process for precision and bias. Removed the use of single point calibration for contaminant testing.

October 2023 – Standardized the analysis of cannabis flower products for moisture content.

December and January 2024 – For cell spreaders and loops, added "a. or alternatively, keep certificate of conformance with each lot." Amended Tables 1, 4 and 5 related to microbiology QC as well as clarified language within the microbiology section. Allowed for reporting results with a qualifier if a CCV fails. Clarified moisture content analysis is applicable to dried, flower products such as pre-rolls and whole and ground flower products. For the initial verification of the LOQ, added phrase: "or below" (page 15). Added phrase "or certified reference isolates" to "at least 3 clinical" in section VII. isolates. Updated section VIII to provide typical or common ways to report results and how to report total THC results >100%. Included a new section on potency or cannabinoid standardization for flower products, and sample duplicates are not required to be tested with potency testing of cannabis flower products. Additional references were included under section XIII.