Environmental Monitoring & Investigations

Definition: Basic knowledge of chemical testing in support of food safety related to environmental contamination.

Level 2 Competency: Discuss how the testing of environmental materials supports human and animal food safety.

Level 3 Competencies:

- Describe scenarios that would lead to environmental testing. - Communication
- Describe the limitations of environmental testing data in making decisions. - Leadership
- Explain the application of test results. - Programmatic
- Perform environmental testing. - Technical

Planning and Regulatory Response

BRAINSTORM

- Interpret results
- Data analysis
- Fit-for-purpose testing
- Precision
- Record keeping
- Many samples
- Experienced analyst
- Planning
- Communication plan
- Economic factors
- Regulatory ambiguity
- Regulatory decision-making
- Statistical error!
- Onsite investigations
- Test method unavailability
- FIFRA
- FERN
- Specification limit
- Regulatory agencies
- Impact
- Food tolerances
- Perishability
- Normal ranges
- ICS
- SQC
- Decision unit
- Time is of the essence
- Reporting channels
- Law enforcement response
- Training
- Role of laboratory
- Regulatory and laboratory interactions
- Internal laboratory planning

Definition: Planning of environmental testing for regulatory response.

Level 4 Competency: Discuss the planning of environmental testing related to regulatory response.

1. Level 5 Competency: Discuss the planning process for environmental testing**.**	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can recognize the importance of establishing the question to be answered. 2. The laboratory analyst can recognize that planning establishes objectives: a. data quality b. communication c. timing of reporting d. coordinate activities among all players 3. The laboratory analyst can recognize the challenge of receiving large quantities of samples with urgent TATs. 4. The laboratory analyst is aware that the laboratory is one of many players in environmental testing: a. Inspectors b. Laboratorians c. Regulators d. Other agencies e. Industry 5. The laboratory analyst has an awareness of several key elements in planning process: a. Analyte b. Specification limit c. Decision unit d. Statistical confidence requirements e. TAT f. Fit for purpose test method g. Fit for purpose laboratory sampling protocol h. Fit for decision primary sample i. Quality control events	1. The laboratory analyst can recognize that effective outcomes are the result of cooperative laboratory and regulatory planning. 2. The laboratory analyst can identify necessary methodology for testing. 3. The laboratory analyst can recognize when testing will require a modification to a method. 4. The laboratory analyst can suggest modifications to the method. 5. The laboratory analyst can describe how several key elements fit into the planning process: a. Analyte b. Specification limit c. Decision unit d. Statistical confidence requirements e. TAT f. Fit for purpose test method g. Fit for purpose laboratory sampling protocol h. Fit for decision primary sample i. Quality control events j. Maintaining analyte integrity k. Shipping requirements l. Record keeping requirements (chain of custody) m. How inference will be made n. Lab capacity and capability o. Reporting needs p. Coordination between agencies

j. Maintaining analyte integrity (preservation, holding times) k. Shipping requirements l. Record keeping requirements (chain of custody) m. How inference will be made n. Lab capacity and capability o. Reporting needs p. Coordination between agencies	
2. Level 5 Competency: Recognize the importance of identifying objectives for environmental testing.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst is aware of the importance of identifying objectives for data quality prior to testing. 2. The laboratory analyst can recognize the importance for analyte and analyte specification limits to be defined. 3. The laboratory analyst can recognize the importance for decision unit to be defined. 4. The laboratory analyst can recognize the importance for required statistical confidence to be defined. 5. The laboratory analyst can recognize the importance of defining protocols to protect sample integrity. 6. The laboratory analyst can recognize the difference in objectives for regulatory and program-specific testing.	1. The laboratory analyst can determine required testing (analyte, method) based on client request and environmental material. 2. The laboratory analyst can recognize that developing objectives pre-testing is imperative for adequate regulatory decisions. 3. The laboratory analyst can discuss factors impacting the choice of testing. 4. The laboratory analyst has an awareness of the emerging environmental analytes and methods.

3. Level 5 Competency: Recognize the impact of test results on regulatory decisions.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can recognize that test results may have an economic impact. 2. The laboratory analyst can recognize that test results may have an impact on regulatory intervention: a. Environmental cleanup b. Recall c. Product quarantine d. Stop sale e. Cleanup public water supply f. Abandon private well 3. The laboratory analyst can recognize the role of the laboratory in contributing to regulatory decisions (consulting on data interpretation). 4. The laboratory analyst can recognize the impact of analytical uncertainty the on ability to make a decision. 5. The laboratory analyst can recognize the impact of sampling error on the ability to make a decision. 6. The laboratory analyst can recognize the impact of test method choice on test results. 7. The laboratory analyst can recognize the importance of record-keeping/administrative record. 8. The laboratory analyst can recognize the importance of the timeliness of test result reporting. 9. The laboratory analyst can recognize the impact results have on human and animal food safety. 10. The laboratory analyst can recognize the importance of chain of command when reporting test results (ICS).	1. The laboratory analyst can discuss the role of the laboratory in making regulatory decisions. 2. The laboratory analyst can discuss the relationship between perishability of product and time is of the essence testing. 3. The laboratory analyst can discuss the possible consequences of insufficient data quality. 4. The laboratory analyst can discuss the short term and long-term public health impacts of test results.

4. Level 5 Competency: Describe the limitations of test data in informing regulatory decisions.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can recognize that test data has limitations in its application. 2. The laboratory analyst has an awareness of the implications of false positives and false negatives. 3. The laboratory analyst can recognize the importance of confidence limits in interpreting test results. 4. The laboratory analyst has an awareness that the statistical uncertainty of test results may be insufficient for regulatory needs. 5. The laboratory analyst has an awareness of the impact of test data coming from a non-validated method on regulatory decisions. 6. The laboratory analyst has an awareness of the timeliness of test data on informing regulatory decisions. 7. The laboratory analyst can recognize the impact of exceeding the required statistical confidence in: a. Analytical uncertainty b. Laboratory sampling error c. Primary sampling error d. Global estimation error 8. The laboratory analyst can recognize the absence of incorporating quality control in all processes may jeopardize the defensibility of the test results. 9. The laboratory analyst can recognize how confidence in analyte identification can impact regulatory decisions. 10. The laboratory analyst can recognize the role of the laboratory in the interpretation of results (consulting on data interpretation).	1. The laboratory analyst can calculate positive predictive value and negative predictive value from the test data. 2. The laboratory analyst can discuss the impact of modified methods on test data. 3. The laboratory analyst can discuss that there may be a disconnect when regulatory standards and test data limits do not align: a. Tolerance b. Regulatory limits c. Defect action levels d. High detection limit vs low regulatory limit 4. The laboratory analyst can discuss the quality of test results when using methods with limited validation. 5. The laboratory analyst can suggest ways to reduce error. 6. The laboratory analyst can discuss the implications of preliminary data in informing regulatory decisions. 7. The laboratory analyst can discuss the role of laboratory and regulatory decision-making (consulting on data interpretation).

11. The laboratory analyst can recognize the relationship between result limits, precision and accuracy on regulatory decision-making.	

Environmental Contamination Types

BRAINSTORM

- Spills/kills
- Pathogens
- Contamination from spills or natural disasters
- Intentional contamination
- Organic and inorganic contaminants
- Drift
- Off target
- Onsite investigations
- Plant uptake
- Naturally occurring toxins/contaminants
- Marine toxins
- Pesticides in water, vegetation, soil, drift
- Spills (oil, fertilizer, manure, etc.)
- Unknowns (i.e. white powder)
- Outbreaks
- Hotel and restaurant illnesses
- Salad bar contamination
- Cleaning product contamination
- Food contact contamination
- Halloween candy
- Poisoning
- Baby food questions
- Drug contamination
- Fire
- Radiological
- Food plant processing contamination

Definition: Types of environmental contamination impacting food safety.

Level 4 Competency: Discuss environmental contamination impacting food safety.

1. Level 5 Competency: Identify classes of contaminants.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
1. The laboratory analyst can list classes of contaminants: a. Metals b. Pesticides c. Pathogens d. Toxins e. Poisons	1. The laboratory analyst can discuss contaminants that might result from a specific incident.

f. Dioxins g. Radiological h. Drugs i. Extraneous material (foreign objects, metal chips, plastics, animals, insects, kill step) j. Filth k. Cleaning product l. Dyes m. Unknowns n. Naturally occurring	
2. Level 5 Competency: Describe incidents leading to environmental contamination.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can list several incidents leading to environmental contamination: a. Salad bar contamination. 2. The laboratory analyst can generally describe: a. The origin of salad bar contamination. b. How a spill can lead to contamination. c. How a fire can lead to contamination. d. How a food processing incident can lead to contamination. e. How a transportation incident can lead to contamination. 3. The laboratory analyst is aware of the origins of radiological contamination.	1. The laboratory analyst can describe how contamination from unknowns are discovered. 2. The laboratory analyst can describe how naturally occurring toxins or contaminants are a result of environmental incidents: a. Flood b. Fire 3. The laboratory analyst can describe a few of the following: a. Pesticide drift scenario b. Food processing contamination scenario c. Spill scenario d. Drug contamination scenario e. Conditions for accumulation of toxic elements in food f. Climatic conditions for accumulation of nitrates and prussic acid in forages g. Contaminants resulting from a fire.

	h. Contamination of drinking water (public and private well)
3. Level 5 Competency: List examples of naturally occurring contaminants.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can list examples of natural contaminants: a. Excess metals in soil b. Mercury in fish c. Nitrates in forages d. Cyanide in forages e. Pathogens in water and soil	1. The laboratory analyst can describe bioaccumulation. 2. The laboratory analyst can recognize emerging contaminants: a. Pathogens
4. Level 5 Competency: Describe how human and animal food is impacted by environmental contamination.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can describe how animal food contamination impacts food safety. 2. The laboratory analyst can describe how a contaminant in the food chain can impact human and animal health. 3. The laboratory analyst is aware of how pesticide drift can impact food products.	1. The laboratory analyst can list one or two human and/or animal food environmental incidents: a. Melamine in pet food and infant formula b. Aflatoxins in corn c. PFOA/PFOS d. Toxins in shellfish due to flooding e. Oil spill – Deep Horizon f. Nitrates/prussic acid accumulation g. Radiological contamination from nuclear power plants (Fukushima)
5. Level 5 Competency: Describe how production processes can contaminate food.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst has an awareness that mechanical devices can wear and cause contamination.	1. The laboratory analyst can identify the different types of contaminants that can be introduced by source water a. Pathogens

2. The laboratory analyst has an awareness that humans working at the production plant can cause contamination: a. Bottle brushes b. Hair/hair nets c. Cigarette butts d. Working while ill 3. The laboratory analyst has an awareness that inadequate clean-out and incompatible processes (cross-contamination) can cause contamination. 4. The laboratory analyst has an awareness that source water can cause contamination. 5. The laboratory analyst has an awareness that blunders can cause contamination: a. Wrong ingredient added b. Wrong ingredient concentration added c. Math errors	b. Pesticides c. Polyaromatic hydrocarbons (PAH)

Environmental Materials

BRAINSTORM

- Sources of water
- Drinking water
- Plant uptake
- Vegetation
- Air
- Swabs
- Clothing
- Dead animals
- Human and animal food
- In-field water
- In-process water
- Irrigation water (ground water and runoff)
- Soil
- Manufacturing facility
- Retail facility
- Transportation
- Distribution
- On-farm

Definition: The relationship of environmental materials to contamination investigations.

Level 4 Competency: Recognize the relationship of environmental materials to contamination investigations.

1. Level 5 Competency: Identify environmental materials that might be submitted to the laboratory.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst is aware of a variety of possible environmental materials that may be submitted to the laboratory: a. Soil b. Air c. Water (ground, surface, drinking, irrigation, runoff) d. Hazardous waste e. Surface swab (chemical and micro testing) f. Materials from manufacturing process (process water, incoming ingredients, machine parts) 2. The laboratory analyst can list materials/specimens that may be submitted to the laboratory as possible indicators of environmental damage or contamination: g. Vegetation h. Dead or injured animals i. Contaminated clothing or materials j. Product (e.g. cereal, raw milk, pasteurized milk, meat, sprouts) 3. The laboratory analyst can recognize that unusual environmental materials may be sampled as part of an investigation. 4. The laboratory analyst can differentiate between different sources of water (surface, ground, etc.).	1. The laboratory analyst can recognize that the number and types of environmental materials to be submitted may be unknown until an investigator assesses the sampling site. 2. The laboratory analyst can recognize that environmental materials can be sampled from anywhere in the chain of commerce (retail, on farm, distribution, transportation, manufacturer).
2. Level 5 Competency: Explain the benefits of testing specific environmental materials.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can differentiate objectives among regulatory testing, routine testing, enforcement testing, and data-gap filling.	1. The laboratory analyst can explain the relationship between the investigation type and the environmental materials tested. 2. The laboratory analyst can recognize the limitations of the inferences derived from the environmental materials.

2. The laboratory analyst recognizes that the One Health approach results in the testing of non-food and environmental materials to benefit human and animal health. a. Biomonitoring b. Exposure data c. Hazard identification	a. Not the whole picture b. Non-representative samples c. Perishability

Methodology

BRAINSTORM

- Chemical oxygen demand
- Test method unavailability
- Precision
- Record keeping
- Data analysis
- Fit-for-purpose
- Experienced analyst
- Filtering
- Technology-driven
- Blanks and spikes
- Biological oxygen demand
- Metals
- Broad analyte types
- Disposal methods
- Hazardous waste
- Dioxin
- Error!
- PCBs
- Instrumentation
- Screening methods
- Trace analysis
- Standard Methods
- LOD/LOQ
- Method extensions/modifications
- Organic and inorganic contaminants
- Complex scope
- Standard methods
- SOPs
- pH
- EPA SW846
- Multi-analyte methods
- Separations
- Extractions
- Matrices
- Non-target analysis
- Non-routine analysis
- Chemistry of target analyte
- Cross-contamination
- Fast validation/verification

Definition: Method selection and development in environmental testing.

Level 4 Competency: Relate method selection to environmental testing.

1. Level 5 Competency: Identify recognized method sources.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can list recognized method sources: a. EPA b. AOAC c. Standard Methods for the Examination of Water and Wastewater (AWWA) d. FDA BAM	**Note:** Reference Method Resources content area in Entry Level Core.
2. Level 5 Competency: Describe the limitations of recognized methods.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can explain how a drinking water method may not be fit for purpose for surface water, irrigation water or vegetation. 2. The laboratory analyst can recognize that methods may not have been validated for use on unusual materials. 3. The laboratory analyst can recognize methods may not be applicable to non-target analytes. 4. The laboratory analyst is aware that method may have a narrow scope of application. 5. The laboratory analyst is aware that methods may be outdated. 6. The laboratory analyst can list several possible limitations of methods: a. Accuracy b. Specificity c. Available instrumentation	1. The laboratory analyst can discuss impact of matrix on limit of quantitation. 2. The laboratory analyst can explain that using recognized methods for unusual materials may give a false sense of confidence in test results. 3. The laboratory analyst can list some advantages and limitations of screening methods and multi-analyte methods: a. Possible detection limits b. Quick run time c. Compromise in quantitation d. Compromise of time and sensitivity **Note:** Reference Method Resources content area in Entry Level Core.

3. Level 5 Competency: Describe fit-for-purpose testing.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can discuss different testing needs for different environmental materials. 2. The laboratory analyst is aware that methods may require modifications for complex matrices. 3. The laboratory analyst is aware that a fit-for-purpose method is designed to meet specifications for detecting the target analyte at: a. Required range of concentration b. Required sensitivity (LOQ/LOD) and specificity c. Required precision d. Absence of bias e. Required TAT f. Cost g. Flexibility h. Available instrumentation i. Multi-analyte v. single analyte method 4. The laboratory analyst can recognize that fit-for-purpose methods may need to be created from scratch.	1. The laboratory analyst can recognize that cleanup techniques may reduce matrix effects. 2. The laboratory analyst can recognize when a method needs to be modified. 3. The laboratory analyst can suggest method modifications to meet fit-for-purpose. 4. The laboratory analyst can recognize that data objectives are focused on addressing the problem at hand. **Note:** Reference Method Resources content area in Entry Level Core.
4. Level 5 Competency: Relate non-target analysis to environmental testing.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can explain the need for non-target analysis. 2. The laboratory analyst is aware that the target analyte (cause of the contamination) may be unknown. 3. The laboratory analyst can describe some general aspects of a non-target analysis. 4. The laboratory analyst is aware that multiple screening methods may need to be performed to rule out the presence of contaminants.	1. The laboratory analyst can discuss the limitations of non-target analysis: a. Expensive b. Time-consuming 2. The laboratory analyst can recognize challenges and limitations of non-target analysis methods: a. Inefficient extraction of unknown analytes (percent recovery) b. May not detect everything (limited scope)

5. The laboratory analyst is aware that non-target analysis is used to identify contaminants of concern. 6. The laboratory analyst can recognize that non-targeted analysis is typically a role for experienced analysts.	3. The laboratory analyst can describe some techniques for non-target analysis. 4. The laboratory analyst may suggest additional screening methods to rule out presence of contaminants. 5. The laboratory analyst has an awareness of the laboratory's capabilities for performing non-target analysis (instrumentation) 6. The laboratory analyst can suggest follow-up test method(s) for quantifying detected analytes of interest.
5. Level 5 Competency: Differentiate rapid response method development from routine method development.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can define rapid response method development. 2. The laboratory analyst can recognize when rapid response method development is necessary. 3. The laboratory analyst can recognize that use of rapid response methods may require more rigorous method development for confirmation and/or long-term use. 4. The laboratory analyst can recognize factors to consider in rapid response method development: a. Time constraints b. Fast TAT c. High sample volume capabilities d. Use of existing equipment 5. The laboratory analyst can differentiate fitness for purpose for rapid response methods from fitness for purpose for routine methods. 6. The laboratory analyst is aware that compromises may be made in development of methods for rapid response.	1. The laboratory analyst can recognize that quality assurance practices may differ in rapid response development: a. Fewer validation steps b. Emphasis on identification v. precision/recovery/accuracy 2. The laboratory analyst can recognize that rapid response methods generally may not be implemented for routine analysis. 3. The laboratory analyst can recognize the limitations of inferences that might be made from rapid response methods.

Routine Monitoring		
BRAINSTORM		
• Water quality • Well monitoring • Water disinfectants • Organic food monitoring • Run-off monitoring	• Air testing • Catfish testing • Shellfish testing • Farm fish testing • Aquaculture	• Hemp • Mycotoxins in corn • Establishing baseline • TAT • Scheduled samples • Radiological monitoring

Definition: Routine testing of environmental materials.

Level 4 Competency: Discuss routine monitoring activities.

1. Level 5 Competency: List routine monitoring activities.

Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can list examples of routine monitoring activities: a. Well monitoring b. Organic food monitoring c. Shellfish testing d. Radiological monitoring	1.

2. Level 5 Competency: Recognize the importance of routine monitoring.

Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst is aware that routine monitoring is a benefit to human and animal health: a. Biomonitoring b. Exposure data c. Hazard identification d. Establishing baselines e. Research prevention strategies f. Public health information	1.

2. The laboratory analyst can recognize that routine monitoring may be implemented in recovery activities following an environmental incident.	
3. Level 5 Competency: Compare routine monitoring activities with contamination investigations.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can list differences between routine monitoring activities with contamination investigations: a. Number of samples b. Variety of environmental materials c. Scheduling of sampling d. Rapid testing e. TAT f. Reporting deadlines g. Reporting mechanisms (formal report v. email) 2. The laboratory analyst can contrast urgency of routine monitoring activities with contamination investigations: a. Scheduled v. non-scheduled	1. The laboratory analyst is aware that contamination investigations are driven by a complaint or observation whereas routine monitoring activities result from programmatic requirements.
4. Level 5 Competency: Recognize when routine monitoring triggers a contamination investigation.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst is aware that routine monitoring data may trigger a contamination investigation: a. Trends b. Frequency of analyte occurrence c. Unexpected changes in concentration d. Unexpected analytes detected 2. The laboratory analyst Is aware that contamination investigations can be triggered from routine monitoring due to investigator observations.	1. The laboratory analyst can recognize that outside partners can communicate issues found during routine monitoring activities that can trigger contamination investigations.

Non-routine Sampling Handling		
BRAINSTORM • Sample handling • Error! • Sample integrity	• Sample prep • SOPs • Many samples	• Precision • Primary sampling
Definition: Considerations for non-routine environmental sampling. **Level 4 Competency:** Discuss the challenges of non-routine environmental sampling.		
1. Level 5 Competency: Discuss sampling considerations for non-routine materials.		
Based on Level 5 competency – Not an all-inclusive list		
BEHAVIORAL ANCHORS Average		**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst is aware that sampling considerations for non-routine materials are generally the same as for routine materials. 2. The laboratory analyst can recognize challenges for non-routine material sampling that may impact the laboratory: a. Limited mass availability b. Large sample number c. SQC may be poorly communicated d. Storage availability e. Perishability concerns (analyte integrity) f. Analyte integrity may be difficult to maintain g. Unknown analyte h. Environmental conditions during sample collection 3. The laboratory analyst can recognize that inspectors may not have sampling tools and/or methods applicable to what they encounter on site: a. Not representative		1. The laboratory analyst can discuss the possible limitations for sampling non-routine materials.

2. Level 5 Competency: Discuss the challenges of laboratory sampling as it relates to environmental materials.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can list challenges of laboratory sampling of environmental materials: a. Selecting a test portion from multi-phase material (liquid, solid, gas) b. Limited mass availability c. Unknown analyte 2. The laboratory analyst is aware that sampling methods may not be applicable to materials submitted. 3. The laboratory analyst is aware of the need for safety precautions due to potential exposure to unknown toxic materials. 4. The laboratory analyst can recognize that communication of the decision unit is essential: a. Targeted sub-sampling (sampling visual spots on vegetation) 5. The laboratory analyst is aware that the splitting of a sample may compromise representivity: a. Splitting between programs within the laboratory b. Splitting between other agencies	1. The laboratory analyst can describe that fit-for purpose sampling methods may need to be developed based on data objectives and material properties.
3. Level 5 Competency: Discuss the limitations of test results when sample representivity is questionable.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can recognize that test results are compromised when representivity is questionable. 2. The laboratory analyst can recognize that results require context when the representivity is questionable: a. Documentation b. Reporting statement (i.e. may be present but not detected) c. Identification v. quantitation d. Data quality requirements	1. The laboratory analyst is aware that when global estimation error (GEE) is high, sample representivity is questionable. 2. The laboratory analyst is aware that the presence of high GEE prevents making clear inferences from those results: a. High GEE means you cannot distinguish result from zero.

e. Discussion with customer 3. The laboratory analyst can recognize that compromising representivity generally results in underestimating the contaminant: a. Lower probability of detection b. Lower concentration of analyte	b. High false negative rate.

Basic Chromatography

Definition: The basic principles of chromatography as an analytical tool, the theory behind the instrumentation, different detectors, applications and general maintenance.

Level 2 Course TLO: Discuss the use of chromatography in the laboratory.

Level 3 Course ELOs:

- Communication
  - Explain the principles of chromatography.
- Leadership
  - Demonstrate that instrument systems meet quality criteria.
- Programmatic
  - Describe quality assurance requirements for chromatographic analysis.
- Technical
  - Apply the principles of chromatographic analysis.

Theory	Based Upon Leve 5 Competencies – Not an all-inclusive list	
	PI Average Performance	**PI High Performance**
Definition: The principles of chromatography. **Level 4 Module TLO:** Explain the theory of separation of a mixture of chemical compounds using partitioning between mobile and stationary phases. **Level 5 Module ELOs:** 1. Explain separation using partitioning between	The laboratorian can define relevant terminology: • chromatography • chromatograph • chromatogram • retention time • stationary phase • mobile phase • resolution	The laboratorian can describe the chemistry involved in separating analytes. The laboratorian can describe the impact that matrix effects have on chromatography. The laboratorian can explain the chemistry related to obtaining optimal analyte

mobile and stationary phases. 2. Relate solubility and partition coefficients to chromatography separation. 3. Describe the use of integration to quantitate chromatographic analytes. 4. Explain the importance of polarity in the stationary phases. 5. Explain the difference between gas and liquid mobile phases.	The laboratorian can generally describe partitioning of an analyte in a stationary phase when carried by a mobile phase. The laboratorian can explain the difference between mobile and stationary phase. The laboratorian can explain the importance of chromatographic resolution. The laboratorian can explain the solubility of an analyte of interest within a mobile phase. The laboratorian can describe the general mechanism of analyte retention on a stationary phase. The laboratorian can discuss when manual integration of chromatographic peaks may be necessary: • Co-elution • Tailing • Interference The laboratorian can explain how to adjust a baseline to	resolution using Van Deemter equation. The laboratorian can explain how buffers affect efficiency of retention and chromatographic resolution of the analyte of interest. The laboratorian can demonstrate ability to choose the optimal stationary phase for a given system to achieve improved resolution. The laboratorian can discuss the misapplication of manual integration: • Quantitation errors • Ethical implications The laboratorian can list the different types of columns and explain the differences between them. The laboratorian can articulate the conditions that go into selecting the stationary phase and mobile phase necessary to optimize peak resolution.

	correct for chromatographic imperfections. The laboratorian can discuss the importance of column polarity on retention of a given analyte. The laboratorian can describe the mechanisms of gas and liquid mobile phases and when each is applied. The laboratorian can list the different mobile phases used for each application: • Hydrogen vs. Helium • Aqueous vs. Organic	The laboratorian can select the appropriate liquid or gas phase for a given analyte. The laboratorian can describe why either gas or liquid phase is chosen for the analysis of a given compound.

Application	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: The application of chromatography. **Level 4 Module TLO:** Explain the application of separation science. **Level 5 Module ELOs:**	The laboratorian can discuss the interaction between mobile phase, stationary phase, and analyte of interest. The laboratorian can recognize when resolution needs improvement: k. Split Peaks	The laboratorian can identify column that would be most appropriate for analyte/mobile phase system. The laboratorian can discuss the adjustment of temperature programs and LC gradients to optimize peak resolution.

1. Explain how to optimize chromatographic resolution. 2. Explain how to control matrix effects. 3. Describe sources of chromatographic interferences. 4. Recognize the effect of matrix interference for analyte quantitation.	l. Wide Peaks m. Fronting/Tailing n. Ghost Peaks The laboratorian can discuss how optimizing extraction procedures can minimize co-extracted interferences The laboratorian can discuss that the contamination of system parts can cause matrix effects: • injection ports • columns • syringes • detectors The laboratorian can discuss the utilization of guard columns for GC and LC: • Replaces guard columns when matrix interference is encountered The laboratorian can list possible sources of interference: • Column bleed • Co-extracted matrix	The laboratorian can describe the role buffers play in improving resolution. The laboratorian can describe the common causes of poor resolutions: • improper mobile phase • improper mobile phase gradient • improper or degraded column • interactions with co-extracted matrix The laboratorian can describe how modifying GC injection port temperature and split volumes can eliminate matrix interference The laboratorian can describe how adjusting LC mobile phase concentrations using gradients can maximize separation of analyte from matrix interference. The laboratorian can suggest corrections to chromatographic interferences:

	• Contaminants in mobile phase/carrier gas • Compounds with similar structure • Closely eluting compounds The laboratorian can recognize that the region of the peak of interest needs to be free of matrix signal response (also known as a blob) for analyte quantitation.	• Recognize symptoms of contaminated gas or liquid mobile phases • Match column separation characteristics to analyte separations • Change guard column The laboratorian can differentiate between properly operating system and improperly operating system.

Instrument Platforms	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: Foundational knowledge of chromatography instrument platforms. **Level 4 Module TLO:** Describe the characteristics of instrument platforms. **Level 5 Module ELOs:** 1. Identify the components of chromatography instrument systems.	The laboratorian can Identify basic components of chromatographic instruments: • Injector • Chromatographic column • Detector • Mobile Phase • Data System/Software The laboratorian has knowledge of the use of temperature in gas chromatography.	The laboratorian can identify various detectors used in gas chromatography: • ECD • FID • NPD • FPD • MS • ELCD The laboratorian can Identify various detectors used in LC: • UV/VIS

2. Differentiate the application of liquid chromatography (LC) v gas chromatography (FC). 3. Describe the applicability of various detectors. 4. List types of chromatography instrument systems. 5. Differentiate reverse phases from normal phase.	The laboratorian has knowledge of the role of mobile phase concentrations in liquid chromatography. The laboratorian can describe that gas chromatography is used for compounds of interest that can be volatilized without degradation. The laboratorian can describe that liquid chromatography is used for thermally labile compounds that would degrade under high temperature. The laboratorian can describe that for gas chromatography an analyte is solubilized in a gaseous mobile phase. The laboratorian can list the different mobile phases used for each application: • Hydrogen vs. Helium • Aqueous vs. Organic The laboratorian can describe the characteristics of the various detectors and applicability as related to the chemical structure of the analyte of interest:	• PDA • Fluorescence • MS The laboratorian can determine when an LC or GC is used based on the characteristics of the analytes of interest. Describe the mechanisms by which specific detectors function: • Ionization • Absorption • Wavelength • Measurement of Current 1. Differentiate the benefits of using one instrument type over the other: • Reduction of retention time between UPLC and HPLC • Benefit of molecular structure using MS vs. Selective Detector • Screening vs. Confirmation

	• ECD-Chlorinated Compounds • NPD-Nitrogen/Phosphorous Compounds • MS-Fingerprint Confirmation • UV-Organic Compounds The laboratorian can identify commonly used instruments: • GC, GC-MS, GC-MS-MS, GC-HRMS • UPLC • HPLC, HPLC-MS, HPLC-MS-MS, HPLC-HRMS • Ion Chromatography • HPLC-ICP-MS The laboratorian can explain that reverse phase/normal phase are applicable to LC. The laboratorian can differentiate the columns used for reverse phase as opposed to normal phase. The laboratorian can describe stationary phase attributes	• Specificity of selective detector systems The laboratorian can match the molecular characteristics of the compound with the mobile phase to achieve separation. The laboratorian can categorize mobile phases as either normal phase or reverse phase.

	specific to revers phase of normal phase. The laboratorian can explain that normal phase involves the use of nonpolar mobile phases and reverse phase involves the use of polar mobile phases.	

Identification/Quantitation	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: Identification and quantitation of analytes. **Level 4 Module TLO:** Explain the quantification of the identified analytes. **Level 5 Module ELOs:** 1. Explain the identification of analytes. 2. Describe the use of standards in chromatographic analysis. 3. Describe the purpose of instrument calibration.	The laboratorian can match the retention time of the standard to the retention time of the analyte of interest. The laboratorian can match the mass spectra of the standard to the mass spectra of the analyte of interest. The laboratorian can match the wavelength spectrum of the standard to the wavelength of the analyte of interest. The laboratorian can explain the differences in:	The laboratorian can explain the use of an internal standard to correct for retention time drift over the course of the run. The laboratorian can explain how to optimize the frequency of external standard checks to account for retention time drift over a run. The laboratorian can discuss how ion ratios and acceptability ranges impact identification. The laboratorian can describe the advantages/disadvantages

4. Evaluate signal to noise ratio to determine level of detection. 5. Determine the limit of quantitation for the analyte of interest.	• External standards in solvents • External standards in matrix • Use of internal standards The laboratorian can describe how standards are used to create a calibration curve. The laboratorian can describe how external standards are used. The laboratorian can describe how internal standards are used. The laboratorian can describe how a single point standard is used. The laboratorian can describe calibration standards to determine retention time. The laboratorian can describe use of calibration standards to identify mass spectra of analyte of interest.	of using a single point standard. The laboratorian can describe how to use periodic calibration standards to monitor the stability of a calibration curve. The laboratorian can describe how R^2 is used to assess calibration linearity The laboratorian can explain why a quadratic equation would be applicable The laboratorian is able to identify problems such as the need for instrument maintenance or degraded standards. The laboratorian can differentiate between determined LOD and reporting limit. The laboratorian can discuss uncertainty of quantitation for analytes detected between LOD and LOQ; LOD (qualitative) LOQ (quantitative).

	The laboratorian generally describes the purpose of instrument calibration: • Accurately quantify analytes(s) of interest • Determine when sample dilution is needed • Determine if the instrument performance is stable • Define range of quantitation for a given run The laboratorian can explain the concept of electronic baseline noise. The laboratorian can recognize a reportable peak which is resolved from baseline noise. The laboratorian can calculate LOD using area counts/height counts of noise and analyte peak The laboratorian can differentiate between LOD and LOQ. The laboratorian can describe the determination of LOQ using	

	formulas and iterative injections of a standard. The laboratorian can describe the determination of LOD and LOQ by spiking at the LOD and performing an analysis.	

Operations/Maintenance	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: The steps to operate chromatographic instruments. **Level 4 Module TLO:** Identify steps in operation of chromatographic instruments. **Level 5 Module ELOs:** 1. Describe the elements of an instrument maintenance plan. 2. Describe system suitability. 3. Identify safety considerations.	The laboratorian has an awareness of analyst role in instrument maintenance. The laboratorian can describe daily maintenance activities. The laboratorian can List tools needed to perform daily maintenance. The labor can describe procedural aspects of an instrument maintenance plan: • Written procedures • Documented schedule of maintenance • Records of completion of required maintenance	The laboratorian can differentiate required tasks for monthly, semi-annual, and annual maintenance. The laboratorian can troubleshoot based on acceptance criteria deficiencies. The laboratorian can describe lockout-tag out procedures. The laboratorian can list reasons equipment is out-of-service.

	• Identifies qualified maintenance staff The laboratorian can verify resolution, column efficiency, and repeatability of instrument. The laboratorian can describe acceptance criteria. The laboratorian can follow method SOP. The laboratorian can describe how to power off equipment. The laboratorian can use required PPE. The laboratorian has knowledge fume hood usage.	

Basic Spectroscopy

Definition: The basic principles of spectroscopy.

Level 2 Course TLO: Discuss the applications of spectroscopy.

Level 3 Course ELOs:

- Communication
  - Articulate issues related to spectroscopic instrument performance.
- Leadership
  - Demonstrate initiative in optimizing spectroscopic method performance.
- Programmatic
  - Recognize how spectroscopic analysis relates to regulatory goals.
- Technical
  - Apply spectroscopic technologies in daily operations.

Identification	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: Use of spectroscopic data to identify an analyte. **Level 4 Module TLO:** Describe the use of spectra to identify an analyte. **Level 5 Module ELOs:** 1. Describe the use of spectral libraries to identify an analyte.	The laboratorian can describe existing libraries that can be used in analyte identification: • Raman • FTIR • NMR • UV/VIS The laboratorian can explain that spectral data can be used in determining the structure of a compound.	The laboratorian is aware that libraries can provide specific spectral features for compound identification. The laboratorian is aware that specific spectral features can provide information for determining compound identification • Functional groups for FTIR: o Double bonds

2. Discuss the use of spectral data to determine compound structure.		o Carboxyl groups o Amines NH o Alcohols OH

Principles	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: Basic principles that serve as the foundation of spectroscopic analysis. **Level 4 Module TLO:** Describe spectroscopic analysis principles. **Level 5 Module ELOs:** 1. Describe the role of wavelength as it applies to spectroscopy. 2. Describe how absorption spectra are created. 3. Describe how emission spectra are created.	The laboratorian is aware of the region of the spectrums that are applicable to a particular instrument type. The laboratorian is aware that a compound of interest will absorb or emit a wavelength of light that is related to its structure. The laboratorian is aware that the abundance of its absorption or emission is related to its concentration.	The laboratorian can explain how Beer's Law is applied in a UV/VIS analysis. The laboratorian can describe which equipment matches different regions of the electromagnetic spectrum. The laboratorian can differentiate the functionality of UV/VIS from photo diode array. The laboratorian can differentiate between the

	The laboratorian can describe how different types of equipment utilize different regions of the electromagnetic spectrum. The laboratorian can describe how absorption spectra is a function of the difference between transmitted light and emitted light. The laboratorian can describe how emission spectra is a function of an excitation wavelength and an emission wavelength: • Emission abundance can be used for analyte quantitation The laboratorian can describe how different types of emission spectra can be generated: • Excitation wavelength • Plasma	different types of emission spectra: • Fluorescence • OES

Equipment/hardware	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: Equipment and components that are used in	The laboratorian can list the different lamp types and the	The laboratorian can associate a lamp type to an element of interest when performing AA.

spectroscopic analytical methods. **Level 4 Module TLO:** Describe the types of equipment applied in spectroscopic methods. **Level 5 Module ELOs:** 1. Describe how different light sources are applied for specific analytical requirements. 2. List different types of sample holders/containers used in spectral methods. 3. Describe how different detector types are applied in specific spectral methods. 4. Describe how detectors are used to convert signals to outputs.	wavelengths associated with each: • Deuterium • Tungsten • Xenon The laboratorian can correlate the specific wavelength needed to determine an analyte of interest. The laboratorian can identify a cuvette and a flowcell: • Quartz • Glass • Plastic • Graphite tube The laboratorian can describe proper placement of the cuvette in the light path. The laboratorian can list the different detector types: • UV/VIS • PDA • Fluorescence • Refractive index • FTIR • OES • AA • Graphite furnace	The laboratorian can describe the reasons why one would choose a particular type of sample holder. The laboratorian can describe an application of each of the detector types: • UV/VIS • PDA • Fluorescence • Refractive index • FTIR • OES • AA • Graphite furnace The laboratorian can describe the theory behind a photo multiplier tube.

	The laboratorian can describe the function of a photo multiplier tube.	

Method	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: Method selection issues. **Level 4 Module TLO:** Describe issues related to methods selection. **Level 5 Module ELOs:** 1. Recognize the limitations of spectral analysis techniques.	The laboratorian can discuss the importance of wavelength choice: • Spectral interferences • Detector saturation • Physical interferences • Wavelength sensitivities • Chemical interferences • Memory interferences (carryover)	The laboratorian can describe how interferences affect analysis: • Spectral interferences • Detector saturation • Physical interferences • Wavelength sensitivities • Chemical interferences • Memory interferences (carryover)

Considerations	**Based Upon Leve 5 Competencies – Not an all-inclusive list**	
	PI Average Performance	**PI High Performance**
Definition: Considerations which can affect spectroscopic methodologies.	The laboratorian can discuss the importance of maintaining	The laboratorian can recognize the symptoms of environmental

Level 4 Module TLO: Explain considerations which can affect spectroscopic methodologies. **Level 5 Module ELOs:** 1. Recognize the impact of environmental conditions.	consistent conditions for instrument performance: • Temperature • Humidity • Power quality • Ventilation • Dedicated building circuitry	conditions on instrument performance.

Basic Separation/extraction Techniques

Definition: The theory and application related to current techniques to extract compounds from test portions.

Level 2 Competency: Discuss the science of isolating compounds from matrices.

Level 3 Competencies:

- Describe the chemistry principles for isolating compounds from a matrix. - Communication
- Apply knowledge of separation chemistry to optimize efficiency. - Leadership
- Recognize reasons for testing compounds of interest. - Programmatic
- Apply principles of separation chemistry to daily operations. - Technical

Principles

BRAINSTORM

- Solubility
- Partition efficiency
- pH
- Solute/solvent considerations
- Column capacity
- Sample size
- Polarity
- Solvent suitability
- Phase separation
- Partition/coefficient
- Relative solubility
- Mass to solvent ratio
- Column technology
- pk_a
- redox

Definition: Principles of separation and extraction.

Level 4 Competency: Describe the principles for maximizing extraction efficiency.

2. Level 5 Competency: Describe the role of partition efficiency in maximizing analyte extraction.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
6. The laboratory analyst can define partition coefficient. 7. The laboratory analyst can describe the use of partition coefficients in analyte separation.	1. The laboratory analyst can describe why a particular solvent is used in a method based on partition coefficients.

3. Level 5 Competency: Describe how solute/solvent interactions impact extraction efficiency.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
7. The laboratory analyst can differentiate a solute from a solvent. 8. The laboratory analyst can describe how the solubility of an analyte dictates choice of an extraction solvent.	1. The laboratory analyst can describe the principles of solute/solvent interaction: a. Polarity b. Ionic strength c. Aqueous vs organic.
4. Level 5 Competency: Describe effect of pH on an extraction.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can describe how each step of an extraction affects the pH of an analyte. 2. The laboratory analyst can describe the adsorption/desorption process as it relates to pH.	1. The laboratory analyst can describe the principles of the effect of pH on an extraction.
5. Level 5 Competency: Discuss how column capacity impacts analyte recovery.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can recognize that there is a maximum amount of analyte retention capability for a given amount of sorbent. 2. The laboratory analyst can describe the conditions necessary to maximize column capacity: a. Flow rate b. Conditioning.	1. The laboratory analyst can describe additional conditions necessary to maximize column capacity: a. Analyte concentration b. Sample volume.

Techniques		
BRAINSTORM		
• Liquid/liquid	• Precipitation/crystallization	• Liquid/solid
• Quechers	• Gas phase	• Salting out
• Solid phase extraction	• Evaporate	• Elution
• Chelation	• Distillation	• Partitioning
• Enzymes	• Preparatory column	• Miscibility
• Florisil	• Thin layer chromatography (TLC)	• Acids
• Fat removal	• Solvent exchange	• Solvents
• Acid digestion	• Buffers	• Osmosis
• Measurement techniques		• Membrane separation

• Filtering	• Coagulation • Concentrate • Ashing	• Vacuum distillation

Definition: Techniques for the separation of chemical analytes from a test portion.

Level 4 Competency: Describe techniques to separate an analyte of interest from a test portion.

2. Level 5 Competency: Describe the use of solvents to separate an analyte from a matrix.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
2. The laboratory analyst can describe how to generate a phase separation using liquids with different chemical properties: a. Buffers b. Salts. 3. The laboratory analyst can identify the phase in which an analyte will reside at a given point in a procedure.	1. The laboratory analyst can describe how to approach troubleshooting an extraction procedure.

6. Level 5 Competency: Describe matrix destruction techniques.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
2. The laboratory analyst can describe the basics of digestion: • Microwave • Hot plate • Ashing • Block digestion.	1. The laboratory analyst can describe an approach to optimize digestion conditions.

7. Level 5 Competency: Describe separation of analyte using preparatory chromatography techniques.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
1. The laboratory analyst can describe the function of each step in the process: a. Sample loading b. Wash c. pH adjustment d. Elution.	1. The laboratory analyst can describe the chemical process involved in each step: a. Sample loading b. Wash c. pH adjustment

	d. Elution.

Equipment

BRAINSTORM

- Block digester
- Kuderna Danish
- Microwave digester
- Centrifuge
- Balance
- Glassware
- Extraction instruments
- Heating equipment
- Filter types
- ASE
- Soxhlet
- Shaker
- Pipette
- Pipette tips
- Gas cylinders
- Concentrator
- Cylinders
- Rotovap
- Vol flask
- Ultrasonic bath
- Solid phase extraction

Definition: Equipment used for analyte extraction.

Level 4 Competency: Identify equipment used for analyte extraction.

3. Level 5 Competency: List equipment/specialized labware for analyte extraction procedures.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
1. The laboratory analyst can list general extraction equipment: a. Block digestor b. Centrifuge c. Rotovap d. Balance e. Filtration apparatus i. Filters f. Ultrasonic bath g. Vacuum manifold i. Solid phase extraction cartridge h. Heating i. Hot plates ii. Water baths i. Evaporator-Turbovap j. Shaker k. Vortex mixer.	1. The laboratory analyst can identify the extraction mechanism of a Rotovap. 2. The laboratory analyst can identify the separation characteristics of SPE cartridges. 3. The laboratory analyst can describe the functionality of each piece of specialized labware: a. Separatory funnels (liquid:liquid) b. Round bottom flask c. Condenser d. Soxhlet e. Kuderna Danish (KD) (seldom used) f. Kjeldahl flasks (seldom used).

2. The laboratory analyst can list the specialized labware used in specific conditions: a. Separatory funnels (liquid:liquid) b. Round bottom flask c. Condenser d. Soxhlet e. Kuderna Danish (KD) (seldom used) f. Kjeldahl flasks (seldom used).	

3. **Level 5 Competency:** Identify instrumentation used for analyte extraction.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
1. The laboratory analyst can list the instrumentation used to automate extraction: a. Automated solvent extraction (ASE) b. Microwave digester c. Automated block digester d. Automated solid phase extractor.	1. The laboratory analyst can describe the performance characteristics of automated extraction equipment.

Considerations

BRAINSTORM

- Interferences
- Separate analyte from matrix
- Analyte integrity
- Emulsions
- Analyte stability
- Extract storage
- Aliquot
- Azeotropes
- Volatiles
- Contamination
- Test portion mass
- Sample matrix
- Cross-contamination
- Cleaning
- Individual analyst technique
- Standard integrity
- Storage

Definition: Considerations that impact analyte extraction.

Level 4 Competency: Explain considerations that can affect analyte recovery.

6. Level 5 Competency: Explain ways to resolve incomplete phase separation.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
2. The laboratory analyst can describe techniques to mitigate liquid:liquid phase separation problems a. Centrifugation b. Addition of salt c. Ultrasonic bath.	1. The laboratory analyst can describe techniques used to prevent emulsions from occurring: a. Prefilter sample b. Modifying extraction technique.
7. Level 5 Competency: Describe how to minimize contaminants/contamination.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
7. The laboratory analyst can describe processes to minimize contaminates: a. Labware cleaning i. Dishwasher ii. Kiln iii. Solvent rinses b. Work area cleaning c. Apparatus changed or cleaned d. Wearing clean personal protective equipment (PPE) e. Appropriate work environment.	4. The laboratory analyst can describe the reasons for having written cleaning protocols for extraction operations. 5. The laboratory analyst can identify the need to analyze solvent blanks to identify contamination. 6. The laboratory analyst can describe the use of correct solvent purity. 7. The laboratory analyst can describe the use of the appropriate purity of gases used in evaporation processes.
8. Level 5 Competency: Explain how analyst technique can impact analyte recovery.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
5. The laboratory analyst has an awareness of areas where technique can negatively impact recovery: a. Poor pipette usage b. Use of improper equipment c. Incomplete analytical transfer d. Incomplete extraction time e. Incorrect extraction temperatures f. Failure to plan your work prior to starting extraction process.	5. The laboratory analyst can describe the necessity to perform temperature homogeneity on heating equipment. 6. The laboratory analyst is aware of the need to observe proper extraction techniques from more experienced analysts.
9. Level 5 Competency: Describe how to minimize analyte loss.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**

1. The laboratory analyst can describe techniques to minimize analyte loss: a. Controlling temperature b. Ensuring complete analytical transfer c. Using applicable gas flow rates d. Controlling extraction time e. Not letting the solid phase extraction (SPE) cartridge go dry.	2. The laboratory analyst can describe partitioning characteristics of analyte/solvent combination (complete extraction requires an understanding of partition efficiency).

Basic Mass Spectrometry

Definition: The basic principles of spectrometry.

Level 2 Competency: Discuss the applications of spectrometry.

Level 3 Competencies:

- Articulate issues related to mass spectrometry instrument performance. - Communication
- Demonstrate initiative in optimizing mass spectrometry method performance. - Leadership
- Recognize how mass spectrometry analysis relates to regulatory goals. - Programmatic
- Apply mass spectrometry technologies in daily operations. - Technical

Identification

BRAINSTORM

- Reference libraries
- Specificity
- Electromagnetic spectrum
- Compound/analyte structure
- Fingerprint
- De convolution
- Mass accuracy
- Parent ion
- Daughter ion
- Confirmation criteria
- Spectral identification criteria
- Identification points

Definition: Use of mass spectral data to identify an analyte.

Level 4 Competency: Describe the use of spectra to identify an analyte.

3. Level 5 Competency: Describe the use of spectral libraries to identify an analyte.

Based on Level 5 competency – Not an all-inclusive list

BEHAVIORAL ANCHORS Average	BEHAVIORAL ANCHORS Outstanding
8. The laboratory analyst can describe spectral libraries. 9. The laboratory analyst can describe how to compare the reference spectrum to the unknown analyte spectrum. 10. The laboratory analyst can recognize that data generated under unique conditions is not transferable between instrument types.	2. The laboratory analyst can describe the value of spectral libraries to increase the confidence in compound identification. 3. The laboratory analyst can discuss the advantage and limitation to using a library match: a. Is aware that GC/MS canned library searches may not provide an accurate library match

	b. Can describe that building spectral libraries in-house provides an opportunity to accurately identify compounds.
4. Level 5 Competency: Discuss the use of spectral data to determine compound structure.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
9. The laboratory analyst is aware that spectral fragmentation patterns are related to compound structure.	1. The laboratory analyst can discuss how fragmentation patterns are unique to compounds.
6. Level 5 Competency: List mass spectrometry criteria used to identify analyte.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
3. The laboratory analyst can list general criteria that must be satisfied in order to determine positive identification: a. Parent-daughter ion ratios (MS/MS) b. High resolution exact mass match c. Library matching.	2. The laboratory analyst can discuss specific criteria that must be satisfied in order to determine positive identification: a. Parent-daughter ion ratio quantitative limits to confirm an unknown compound b. Mass error limitations in using high resolution data to confirm compound identity c. Interpretations of library matches.

Principles		
BRAINSTORM		
• Ionization • M/charge • Ion trap • Ion capture	• Accurate mass in instrumentation • Quadrapole • Time of flight • Select ion monitoring	• Electrospray ionization (ESI) • Atmospheric-pressure chemical ionization (APCI) • Transitions • Electron ionization (EI)
Definition: Basic principles that serve as the foundation of mass spectral analysis. **Level 4 Competency:** Describe mass spectral analysis principles.		
3. Level 5 Competency: Differentiate between types of mass analyzers.		
Based on Level 5 competency – Not an all-inclusive list		
BEHAVIORAL ANCHORS Average		**BEHAVIORAL ANCHORS Outstanding**

4. The laboratory analyst can discuss the different types of mass analyzers: a. Quadrupole b. Tandem MS c. Ion trap d. Time of flight e. Magnetic sector f. Fourier-transform infrared spectroscopy (FTIR) g. Matrix assisted laser desorption/ionization (MALDI/TOF) h. Inductively coupled plasma mass spectrometry (ICP/MS)	2. The laboratory analyst can describe advantages and disadvantages of each type of analyzer: a. Quadrupole b. Tandem MS c. Ion trap d. Time of flight e. Magnetic sector f. FTIR g. MALDI/TOF h. ICP/MS
8. Level 5 Competency: Discuss the operation of different spectrometer ionization sources.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can list the different types of spectrometer ionization sources: a. Electron b. Chemical c. Electrospray d. Atmospheric pressure chemical e. Atmospheric pressure photo.	2. The laboratory analyst can describe the advantages and disadvantages of the different types of spectrometer ionization sources: a. Electron b. Chemical c. Electrospray d. Atmospheric pressure chemical e. Atmospheric pressure photo

Equipment/hardware

BRAINSTORM

- Orbitrap
- Matrix assisted laser desorption/ionization (MALDI/TOF)
- Optics
- Mass analyzer
- Ion detector
- Lens types
- Tandem MS
- Ion source
- Photo multiplier
- Software

Definition: Equipment and components that are used in mass spectral analytical methods.

Level 4 Competency: Describe the types of equipment applied in mass spectral methods.

4. Level 5 Competency: Describe how different detector types are applied in specific spectral methods.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
The laboratory analyst can describe the general usage of the following mass analyzers: a. Matrix assisted laser desorption/ionization (MALDI/TOF) b. Quadrupole c. Tandem MS d. Ion trap e. Time of flight f. Magnetic sector g. Inductively coupled plasma mass spectrometry (ICP/MS)	The laboratory analyst can give one example of an application of each of the following mass analyzers: a. MALDI/TOF b. Quadrupole c. Tandem MS d. Ion trap e. Time of flight f. Magnetic sector g. ICP/MS

Method		
BRAINSTORM		
• Multi analyte • Method selection • Systems suitability • Qualitative v. quantitative	• Calibration curve • Instrument calibration • Standards • QA/QC • Applications	• Attenuation • Test portion preparation • Test portion purity • Gasses Diluents • Ion selection
Definition: Method selection issues. **Level 4 Competency:** Describe issues related to methods selection.		
10. Level 5 Competency: Discuss the limitations of quantitation over a broad concentration range.		
Based on Level 5 competency – Not an all-inclusive list		
BEHAVIORAL ANCHORS Average		**BEHAVIORAL ANCHORS Outstanding**
3. The laboratory analyst can describe that calibration curves may not be linear over a broad concentration range.		1. The laboratory analyst can describe that at low concentrations the spectra found may be inaccurate.
11. Level 5 Competency: Describe the advantage of using mass spectrometer for multi-analyte determination.		
Based on Level 5 competency – Not an all-inclusive list		
BEHAVIORAL ANCHORS Average		**BEHAVIORAL ANCHORS Outstanding**

8. The laboratory analyst can describe that when paired with chromatography instruments, the chromatograph resolution does not need to be optimized. 9. The laboratory analyst has an awareness that a large number of compounds can be identified from a single injection.	8. The laboratory analyst can describe that the mass spec allows for analysis and identification for many classes of compounds in one analysis.
12. Level 5 Competency: Differentiate inorganic spectral analysis from organic spectral analysis.	
Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
6. The laboratory analyst can describe that the inductively coupled plasma mass spectrometry (ICP/MS) is used for inorganic spectral analysis. 7. The laboratory analyst can describe that the gas chromatography-mass spectrometry (GC/MS) and liquid chromatography-mass spectrometry (LC/MS) are used for organic spectral analysis. 8. The laboratory analyst has an awareness that inorganic analysis identifies an element. 9. The laboratory analyst has an awareness that organic analysis identifies a compound.	7. The laboratory analyst can match a compound/element to the applicable mass spectrometer for the analysis of that compound/element. **Note: Potential job aids from validation survey comments** - clean a source for GCMS, knowing when and why to rinse out an LC-MS source, know when the mass spec is operating correctly (heaters are on, source gas is flowing, filament turns on for GC MS, etc.), How to place a GC column in a MS, how to check nitrogen generators for operation, know how to keep his system running,

Considerations		
BRAINSTORM		
• Interference • Limitations • Environmental/ background impacts	• Detection limit • Carry over • Trouble shooting • Maintenance	• Room temperature • Safety • Mass to charge interference
Definition: Considerations which can affect mass spectral methodologies. **Level 4 Competency:** Explain considerations which can affect mass spectral methodologies.		
5. Level 5 Competency: Recognize the impact of environmental conditions.		

Based on Level 5 competency – Not an all-inclusive list	
BEHAVIORAL ANCHORS Average	**BEHAVIORAL ANCHORS Outstanding**
1. The laboratory analyst can discuss the importance of maintaining consistent conditions for instrument performance: 2. Temperature 3. Humidity 4. Power quality 5. Ventilation 6. Dedicated building circuitry.	3. The laboratory analyst can recognize the symptoms of environmental conditions on instrument performance.