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Radiological Data Assessment Guidance for Emergency Response

December 2022

Eric Becker
Angela Moore
Jonathan Napier
Kenneth Thomas
Nicole Benker

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Acronyms and Abbreviations

ANSI	American National Standards Institute
CBRN	chemical, biological, radiological, and nuclear
cpm	counts per minute
cps	counts per second
DHS	U.S. Department of Homeland Security
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DQA	data quality assessment
DQO	data quality objective
DRLs	derived response levels
EOC	emergency operations center
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GM	Geiger-Mueller (counter)
MQOs	measurement quality objectives
NORM	naturally occurring radioactive material
NCRP	National Council on Radiation Protection and Measurements
NUSTL	National Urban Security Technology Laboratory
PAGs	protective action guides
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity (parameters)
PNNL	Pacific Northwest National Laboratory
PRD	personal radiation detector
QA	quality assurance
QC	quality control
RDD	radiological dispersion device
RIID	radioisotope identification device
ROSS	radiological operations support specialist
SLTT	state, local, tribal, and territorial
V&V	verification and validation

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1.0 Introduction

Timely decisions depend on having the correct information at the right time. When the stakes are high during a nuclear or radiological event, information presented can overwhelm even seasoned response leaders and result in decisions that are hard to make in a timely manner (e.g., shelter versus evacuation, medical countermeasures, resource deployment). Applying data quality practices adds meaning, confidence, and defensibility to the data that inform decisions. Quality data lead to better decisions, whether those decisions are about when to evacuate, when farmers can sell their grain, how much longer until a park can be reopened for recreation, and so much more. Data quality practices provide a sound technical basis for a decision when the public or stakeholders challenge a decision. However, the data quality process was designed for site remediation and recovery operations and might not be appropriate during an emergency response because of the time and resource limitations.

This document provides guidance on how to apply data quality practices to measurements and information collected during the response and recovery to a radiological release. The process of applying data quality practices to measurement data is called data assessment. All data quality practices applied during a radiological incident response must balance the rigorous and time-consuming process normally applied to, for example, site decommissioning and decontamination, with the time- and resource-constraints present during emergency response. The guidance in this document presents the application of data quality practices for data assessment in a graded approach, where the recommended rigor increases as the response continues through its phases and as time and resource constraints relax.

What are data anyway?

In this document, data, information, and measurements are defined as follows:

Data is the term for collections of both quantitative and qualitative facts and observations. For example, “9 mR/hr” and “Jane Smith” and “the corner of Cherry and 9th Ave.” are data. Data require context to be actionable, at which point they are transformed into information.

Information is the term for collections of data that have been organized into a meaningful and useful context. For example, the data, “9 mR/hr” and “Jane Smith” and “the corner of Cherry and 9th Ave.” can be transformed into information by tying them together: “Jane Smith measured 9 mR/hr at the corner of Cherry and 9th Ave”.

A **measurement** is the term for the data generated by the act of detecting or quantifying physical phenomena. In this guidance, a measurement specifically refers to the act of detecting or quantifying radiological emissions.

More definitions can be found in the Glossary in Appendix A.

Beneficiaries of Data Quality Practices

The term "**data assessor**" in this guidance refers to any individual who has been assigned to perform data assessment tasks, regardless of their other duties or official title. The role of data assessor is filled by individuals who hold other titles or fill other roles during a radiological response. Such individuals might sit in an emergency operation center or be special advisors to elected and appointed government officials concerning radiological hazards during an incident. For example, an incident commander or state official may assign a Radiological Operations Support Specialist (FEMA 2022) the responsibility for data assessment. A data assessor might also be a radiation reachback specialist or a technical radiation expert on call.

For the purposes of this guidance, data analysis includes data assessment, as well as operations like converting between measurement units, calculating derived values, and other data manipulation tasks that fall outside of data assessment.

The term "**response leaders**" in this guidance refers to section leaders, incident commanders, and elected and appointed officials. Each of these response leaders will make decisions during a radiological incident. Section leaders and incident commanders may make decisions about how to direct the response. Elected and appointed officials at all levels of government may decide on and order the implementation of protective action decisions.

Data are often requested to support both kinds of decisions, and the data assessors provide one of the many inputs to response leaders to make their decisions. The response leader may weigh several other (sometimes conflicting) considerations, such as the dose that emergency responders may receive versus the urgency of the decision that will be supported, or the potential risks of an evacuation versus the projected radiation dose to the population.

1.1 What is in this Guidance?

This guidance document includes the following sections after this introduction:

1. Section 2.0, The Data Life Cycle, describes the process for applying data quality practices. It provides important foundational information about what data quality means and three principles that practitioners should keep in mind.
2. Section 3.0, **Error! Reference source not found.**, describes the assessment process that data assessors should practice during a radiological incident response. This section provides data assessors with a method for constructing the criteria by which data should be assessed so that they can be used to support the response objectives.
3. Section 4.0, Early Phase, includes two examples of data assessment practices applied to specific Early Phase response objectives. These examples can be used as templates for data assessors to apply and modify to fit their specific needs.
4. Section 5.0, Intermediate Phase, includes six examples of data assessment practices applied to specific Intermediate Phase response objectives. The examples in this section can be used as templates for data assessors to apply and modify to fit their specific needs.
5. Appendix A,– Glossary, provides a set of terms and their definitions used throughout this guidance document.

6. Appendix B,– Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, provides guidance on how to translate flags used by other applications and processes to those provided in this guidance.
7. Appendix C, – Comparison of Data Collected for Each Response Objective, compares the data types applicable to the response objectives in Sections 4.0 and 5.0.
8. Appendix D,– Early Phase Objectives Job Aids, provides examples of job aids that could be used by data assessors to quickly assess data supporting Early Phase objectives in Section 4.0.

Note that section, figure, and table numbers are selectable and link the reader to the corresponding location in the document.

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2.0 The Data Life Cycle

The data life cycle is the process for applying data quality practices. The records generated during the data life cycle provide traceability and a basis for decisions made during the response. The **data life cycle** is a process that includes **three phases: planning, implementation, and assessment**, which occur before, during, and after data collection, respectively. These phases are illustrated in Figure 1. This guidance document only covers the data assessment phase of the data life cycle, which is expanded in Figure 1.

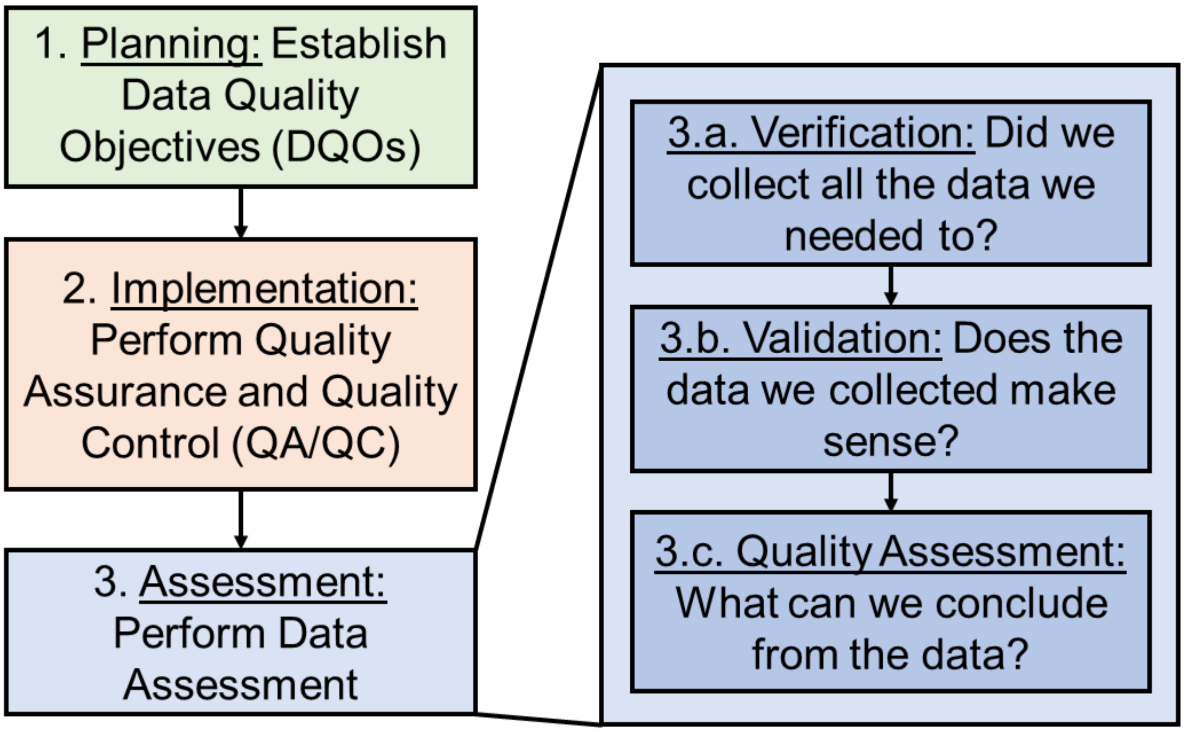

Figure 1. The data life cycle, focusing on the steps within data assessment.

The data life cycle comprises three principles.

There is no absolute measure of data quality; data quality is always measured relative to the question the data answer. Put another way, "data quality, as a concept, is meaningful only when it relates to the intended use of the data" (EPA 2000). This principle means that there is no absolute measure of good or bad data quality, and that data quality must be assessed independently each time the measurement values are used to answer a new question, or the same question at a different time. One example of this principle is to consider a set of measurements made with a Geiger-Mueller (GM) counter, provided in counts per minute (cpm). These measurements might be considered as having sufficient quality to determine whether any radioactive contamination is present but would not be sufficient for identifying or quantifying specific radionuclides present in the contamination. Some questions may even seem to be asking the same thing but are not. For example, consider a set of GM counter measurements that are made in a particular neighborhood and then are used to answer a question about that neighborhood. If the same question arises, but is focused on a different neighborhood, those measurements are likely not appropriate and new measurements may need to be collected.

The data life cycle provides a set of conclusions about the available data; the data life cycle does not provide a set of prescribed decisions that a commander or elected or appointed official must make. Throughout the data life cycle, potential conclusions that may be drawn from the information provided are identified. Some conclusions may also include potential actions that may be taken based on the question asked. However, these should always be considered actions that *might* be taken and not actions or choices that *must* be made. Other factors can affect decision-making, such as resource availability, cost, human factors, and hazards other than radiation. Therefore, the output of the data life cycle is just one input to a decision and must be considered in combination with other information and factors. For example, radiological measurement values might support a decision to reopen a city park for recreation, while other factors (e.g., the presence of asbestos) might support a decision that the park remain closed.

The data life cycle is iterative; some steps in the process may be repeated depending on the data collected and the conclusions provided. Although the phases and steps of the data life cycle and the assessment phase, are presented in a specific order, the outcome of one step will sometimes be to return to an earlier step, or even a step in an earlier phase in the assessment process. For example, during the assessment phase, one may discover that many of the measurements collected are not of sufficient quality. In such cases, one may need to revisit the data quality objective (DQO) and quality assurance (QA)/quality control (QC) steps to establish the type, accuracy, and amount of relevant information needed and then make sure that the data are collected and reported with sufficient quality.

The following sections provide descriptions of each phase of the data life cycle.

2.1 Planning

The planning phase starts with the DQO process, which asks: "What information is needed to answer the question that has been asked?" DQOs are the performance and acceptance criteria for radiological measurement data relating to a specific objective. For example, the DQOs for deciding whether to administer potassium iodide tablets following a nuclear reactor accident are different from those for deciding whether to evacuate a neighborhood's residents. The objective may support a decision or estimate a radiological impact. Each decision or estimation objective may have different types of DQOs.

DQOs are then considered in conjunction with data quality indicators to derive the measurement quality objectives (MQOs), which are the set of measurement performance criteria that must be met for each data quality indicator. Data quality indicators can be broadly summed up as precision, accuracy, representativeness, completeness, comparability, and sensitivity, often referred to as the PARCCS parameters. MQOs are then chosen for each of the PARCCS parameters required of the measurement processes to achieve the DQOs. MQOs can be quantitative or qualitative, depending on the DQOs they support. MQOs for radiological measurements will often include which radiation types must be measured (completeness), a detection limit value for each isotope to be met (sensitivity), and the allowable uncertainty on individual measurements (precision) (Multi-Agency 2004).

More information about the DQO process can be found in:

- Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4) (EPA 2006a)
- Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (Multi-Agency 2000).

The PARCCS Parameters

Precision – "How much variation is there between measurements?" This parameter describes the reliability by which an investigator can reproduce the sample results. It measures the amount of dispersion among series of measurements and is often provided as a standard deviation.

Accuracy – "How close is each measurement to the true value?" This parameter describes the comparison of a result to a consensus value, generally expressed in terms of an error, either as an absolute value or percentage, where the measurement is compared to a mean or known true value (the latter is usually for laboratory sample analysis).

Representativeness – "Do the measurements come from the same area?" This data parameter describes how well a sample characterizes or describes a specific population and is generally reported on a qualitative basis. This can be evaluated, for example, by checking whether measurements were taken on the same kind of terrain, or within a certain distance from each other.

Completeness – "Did we collect all the data we planned for each measurement?" This parameter describes the completeness of the data collected for each individual measurement. The measurement value and units are of primary importance, but other parameters, such as the height of the measurement, the location of the measurement, when the measurement was taken, and who took it are often just as critical.

Comparability – "Can the measurement be compared to other measurements?" This parameter describes whether the measurement can be compared to other measurements based on the instrument used, the type of measurement, the units used, and the question being answered. This is generally a qualitative parameter.

Sensitivity – "Are the instruments used sensitive enough to detect what we are looking for?" This parameter describes at what threshold value an instrument can detect radiation. Instruments may have several different sensitivity thresholds for different radiation types and for different specific radionuclides.

2.2 Implementation

The implementation phase includes QA and QC processes. Most organizations group QA and QC together as "QA/QC" by convention. The QA/QC processes describe the management system and technical activities, respectively, used during data collection to collect measurements that meet the MQOs. The QA process encompasses the data management system used to capture and record the data life cycle, such as documentation and data collection. The QC process encompasses the technical activities performed in a QA program that measures and records applicable data quality indicators, such as instrument calibration and sample splitting for analysis by multiple laboratories. The QA/QC processes broadly emphasize the PARCCS parameters in data collection, as well as an awareness of instrument detection limits and measurement range, and the practice of taking extra samples, called QC samples. Effective QA/QC ensures that MQOs are met (EPA 1996).

More information about the QA/QC processes can be found in:

- Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium (SW-846), Chapter 1 (EPA 2014)
- The Volunteer Monitor's Guide To Quality Assurance Project Plans (EPA 1996).

2.3 Assessment

The assessment phase of the data life cycle includes three main steps: verification, validation, and data quality assessment (DQA). Verification and validation are often grouped together as "V&V" by convention, but they are separate processes and should be treated separately. In this section, each step of the assessment phase is described. These steps may be undertaken by one or more data assessors. A data assessor is an individual who performs one or more of the data assessment steps.

2.3.1 Verification

Data verification asks the question: "Did all of the requested data get collected?" The purpose of data verification is to make sure that the records associated with a specific set of radiological measurements reflect all of the processes and procedures used to generate that dataset. In ideal circumstances, a list of all data types and fields that were developed as part of the planning phase and requested during the implementation phase is provided and can be compared to the information that was collected. Reviewing such documentation is part of regular operating procedure at analytical laboratories that receive samples from the field. These laboratories typically use well-understood chemical separation methods to separate particular isotopes of interest from a larger sample and then quantify the concentration based on radiation detection instrumentation. The records of sample collection and analysis, chain-of-custody, and instrument calibration records must all be maintained as part of the incident file to show that the measurement was performed as intended, in case decisions based on these measurements are challenged (EPA 2002; ANSI 2012).

Field measurements may also have a specific set of requested information fields to which measurements can be compared. For example, measurements for the objective of determining whether radioactive contamination is present will require multiple measurements including the measurement value and units, the location, the background radiation level at the location of interest, and the time and day of the measurement, among other things. If this basic information is not available, then a data assessor might consider the measurement data of insufficient quality to address the objective.

2.3.2 Validation

Data validation asks the question: "Were the MQOs achieved for each measurement and as a whole?" The purpose of data validation is to compare measurements to the PARCCS parameters and determine if the requirements for those parameters have been achieved by the individual measurements being considered. Much like verification, in ideal circumstances, measurement results can be compared to a list of all MQOs established during the planning and implementation phases. For example, when trying to measure the radionuclide concentration in an area, a measurement from a personal radiation detector (PRD) may not have the precision required to estimate the concentration of different radionuclides with sufficient uncertainty. As another example, an instrument's range selection switch may have been set too high to accurately detect the quantity of radiological material of concern. In each case, a data assessor might then consider the measured values invalid for the objective being addressed.

If an individual measurement does not meet one of the MQOs, or if other observations about the available information are made, a signifier or flag is typically applied to the measurement to indicate the particular issue or observation about the available information (EPA 2002; ANSI 2012). This means that some type of label has been applied to the measurement to facilitate review against its intended use. This type of labeling also helps in the review process when multiple individuals are involved.

When flagged data are transferred from the person performing validation to quality assessment or other analysis, the person receiving the data will be able to review the flags on each data point to determine if the quality of the available information regarding the collection of that measurement value is suitable for their needs. The specific nomenclature of the flags that are applied to data may vary between organizations. For example, the American National Standards Institute (ANSI) and the American Nuclear Society have produced a standard for "verification and validation of radiological data for use in waste management and environmental remediation" (ANSI 2012) in which an (R) flag indicates that a measurement is rejected or unusable, and a (J) flag indicates that a measurement is estimated. In other cases, case narratives, which provide validation information in an explanatory form, will be included with measurement results. Flags and case narratives are sometimes generated for field measurements but are much more commonly applied to results from analytical laboratories.

2.3.3 Data Quality Assessment

DQA asks the question: "Can the available information be used to address the objective, and what conclusions can be drawn?" The purpose of a quality assessment is to determine whether the measurements collected can be used to address the objective based on the results of the verification and validation steps. If so, measurements can be used to draw conclusions based on the available information (EPA 2000). The entire assessment phase of the data life cycle may sometimes be referred to as DQA, but this is not technically correct because it omits the distinct verification and validation steps.

Using Statistical Methods

Statistical methods are used to **estimate a value across an entire population** (e.g., the dose rate at every square meter in a square kilometer, a total population of 1,000,000 dose rate values) **without measuring every member of that population** (e.g., without needing to measure all 1,000,000 values). Such methods are not needed when the entire population of items is measured. It is also important to keep in mind that **the outcomes of such statistical methods are estimates**. One-hundred percent certainty can only be achieved by measuring every single member of the population. However, statistical methods are useful since measuring every member of a population is often impractical.

The DQA step of the assessment phase may use statistical tests to draw specific conclusions about a set of measurements with a certain percent confidence, and false positive and false negative error rates, given a certain amount of standard deviation in the measurement set.

When applicable and practical, such statistical testing can be a powerful and defensible method for drawing conclusions about a set of measurements (EPA 2000). However, using such methods also requires careful translation of statistical concepts and meaning to response officials who may not have a technical background. In addition, depending on the confidence and error rates specified, such methods may require a large number of measurements or samples, which may be cost-, resource-, and time-prohibitive for some applications. Finally, sometimes statistical methods simply may not support, be applicable, or be practical to the objective at hand. Analysts and decisions makers would not depend on using statistical methods to draw conclusions about a set of measurements when complete scanning of an object is possible, measuring an entire area or each quantity. For example, when surveying small items, such as a personal bag, to be released from an area, statistical methods are not required because the entire item can be surveyed. In such cases, DQA may be reduced in scope to a review of the outputs of the verification and validation processes and a flow chart or check list for the data assessor to help draw conclusions.

This is the final step of the overall data life cycle, but as discussed above, it may result in a return to earlier assessment phase steps, or even a return to earlier data life cycle phases (EPA 2000). For example, a data assessor may be trying to determine whether an area is contaminated with radioactive material or not, by comparing measurement values to an action level of concern. For this example, it is decided that the action level is three times the background radiation level. Upon completing the verification and validation steps, the data assessor reviews the radiological measurement data and determines that the background radiation levels in the area are not well known, but proceeds with the assessment anyway, assuming an average value. Upon completion of the analysis, the data assessor discovers that many measurement values are nearly three times the estimated background, and some are greater. An individual data assessor may draw different conclusions, as follows.

- The data assessor may conclude that because some values are greater than three times background, the area should be considered contaminated.
- The data assessor may conclude that, because the background is not known and was estimated based on average background levels from other locations, a better estimate of the background radiation level for the area should be obtained before drawing a conclusion about whether the area should be considered contaminated.
- The data assessor may conclude that some areas are contaminated, and some are not, and that more measurements should be conducted in the area to help distinguish the part of the area that is contaminated from the part that is not.
- The data assessor might combine all three conclusions: the area should be considered contaminated until a better background estimate can be obtained, and more measurements can be taken.

Whether or not these actions are taken is typically left to incident command, who are usually different individuals than the data assessor.

3.0 Data Assessment General Practice

During a radiological incident response, data assessors should complete all data assessment steps (verification, validation, and DQA) for each response objective the data will support. These three steps should be applied for every new objective, no matter how similar it is to other objectives, and for all data, whether the data have been subjected to the data assessment process for other objectives.

For example, Jane is a data assessor during a response to a radiological release event in an urban area. Jane has just completed the data assessment process for a response objective: to determine whether instrument readings at one street corner—the corner of Elm St. and Lincoln St.—indicate the presence of radiological contamination. Jane has now been tasked with assessing data for a new objective: determining whether instrument readings at a different street corner—the corner of Park St. and Willard Pl.—indicate the presence of radiological contamination. The new location (Park and Willard) is approximately one mile from the previous location (Elm and Lincoln). Jane has the new data collected at Park and Willard, and still has access to the other data from Elm and Lincoln. Even though Jane has already completed the data assessment process for the data from Elm and Lincoln, she should assess the data for the new objective concerning Park and Willard because the new objective concerns a new location, even though the general purpose (determine if the readings indicate contamination) is the same.

Figure 2 shows the recommended data assessment process for use during radiological incident response. Each step from this process is described in detail below. An example is also provided to show how this process is applied.

3.1 Review Objective

The data assessor reviews the response objective that the data will support. The response objective may be a decision (e.g., Is a specific area of interest ready for re-occupation by its residents?) or an estimation (e.g., What is the dose rate in a specific area of interest?). The data assessor should review any DQOs that have already been established. If none are available, the data assessor should review the conditions of the response and what the purpose of the response objective is. The data assessor should then either:

Select a response objective from Section 4.0 or 5.0 of this guidance that matches their objective, or

Develop their own set of DQOs based on their best judgement.

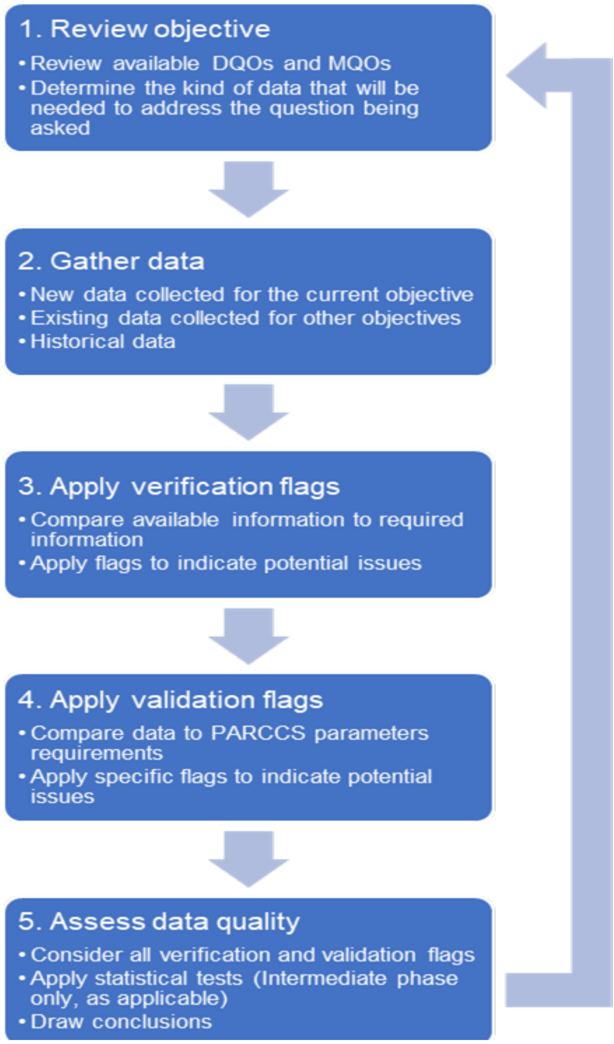

Figure 2. The recommended steps for data assessment during radiological incident response.

In the case that option B is chosen, the data assessor should consider the following:

1. Is the response objective to *support a decision* or to *estimate a value*?
   - Response objectives involving a decision compare measured values to an incident action level.
   - Response objectives involving an estimation only require a calculation of the estimated value and the estimated uncertainty, and do not require comparison to other values.
2. What ***radiation types*** are expected?
   - Alpha, beta, gamma, and neutron-emitting radionuclides may all be present during a given type of incident. The presence of radionuclides during a specific incident depends greatly on the nature of the incident itself—a radiological dispersal device (RDD) incident may involve only a single radionuclide while a nuclear power plant incident may involve many radionuclides emitting alpha, beta, gamma, and neutron radiation.
   - The radiation types expected will dictate the types of measurements and instruments that are needed to detect the different emission types.

3. Are ***background*** measurements or estimates needed?
   - For response objectives that compare measured values to protective action values, background is of less concern.
   - For response objectives that involve comparing measured values to known preexisting radiation levels such as background conditions or normal elevated radiation fields (e.g., due to naturally occurring radioactive material [NORM] or source storage), either background measurements or estimates prior to the incident are critical.
4. ***Where*** is radioactive contamination expected to have spread, and ***when*** did it spread there?
   - The extent and direction of airborne releases are highly dependent on current and future weather patterns. Wind direction is especially important to note.
   - Measurements collected in areas that may have been contaminated after the radionuclide release should not be considered background.
   - Measurements collected upwind of the release may be useful for background depending on the nature of the incident and the composition of the area.
   - Measurements collected farther away than the expected contamination spread provide situational awareness of the farthest extent of contamination and complete a site characterization.
   - Radionuclide decay may need to be considered, depending on the specific radionuclides released. For example, the contamination remaining after a release of technetium-99 would be expected to decrease significantly over the course of a few hours, while the contamination remaining after a release of cesium-137 would be expected to remain steady for years without remediation efforts.
5. ***How many measurements*** are needed?
   - Early in the response, few measurements may be available. Therefore, because of the time restrictions of incident response, decisions or estimations may need to be made based on only a few measurements. In general, at least two measurements in a relevant location are recommended before any decision or estimation is made about that location.
   - Later in the response, more measurements will be needed to characterize the area and provide more confidence and precision in decisions and estimations. Therefore, statistical methods should be used to determine how many measurements are required, based on the desired confidence and likelihood of error.
6. What ***type of measurements*** are needed?
   - Types of measurements include samples, surveys (also called in situ measurements), dose readings, count readings, and energy spectra.
   - The response objective being addressed may require a specific measurement type. For example, when determining if water is safe to drink, a water sample may be necessary since state, local, tribal, and territorial (SLTT) personnel would need sampling results to determine whether water is safe to drink. Large volumes of water may shield much of the radiation emitted by contamination in the water making it difficult to detect.
   - The type of measurement needed will also inform the type of instrument capable of collecting such a measurement.

The data assessor should generate a list or table of all the data fields that should be included with each measurement, as in the following example. This list or table will facilitate other steps of the data assessment process.

Note that this example applies to an objective similar to Section 4.1 but which has purposefully been made different here to illustrate the process. It is also recognized that the example may not follow current practices but is rather intended as an example of the recommended general process.

General Process Example: Review Objective

An explosion occurred in downtown Anytown, USA, on January 1, 2022, at 10:00 a.m. at the corner of 9th and Columbia. It is suspected that the device may have been a RDD. The device is suspected to have included cesium-137 and cobalt-60. Reports and radiation measurements have been transmitted to the emergency operations center (EOC).

An Anytown Public Health Department employee, Rosa, has been assigned the role of data assessor to determine whether any elevated radiation levels are present (greater than three times background). Rosa notes that no DQOs have been established for this response objective. Therefore, she will need to generate her own. Rosa then considers the following six questions:

1. Is the response objective to support a decision or to estimate a value?
   - Rosa decides that her response objective is to support a decision because she is comparing measurements to an incident action level (three times background).
2. What radiation types are expected?
   - Based on the suspected radionuclides from her briefing, Rosa knows that beta and gamma radiation types are expected.
   - Rosa decides that she does not need beta radiation measurements because she knows that cesium-137 and cobalt-60 emit both beta and gamma radiation, and that the gamma radiation that both radionuclides emit is easier to detect.
3. Are background measurements needed?
   - The incident action level is three times the background, so Rosa knows she will need background estimates.
4. Where is radioactive contamination expected to have spread, and when did it spread there?
   - Rosa knows the approximate location of the explosion, so if any radionuclides were released, they should be present near the corner of 9th and Columbia.
   - Rosa has not been provided a plume model, but she knows that the wind is blowing south. She looks for the intersection north of 9th and Columbia, which is 9th and Marion. She decides that anything north of 9th and Marion is unlikely to be contaminated. However, Rosa requests that additional measurements at intersections farther north of 9th and Marion to confirm the extent of contamination.
   - The explosion occurred at 10:00 am, so Rosa decides that any measurements taken before 10:00 a.m. will only be useful as background measurements.
5. How many measurements are needed?
   - Since the incident is a possible RDD, Rosa decides to use the *Radiological Dispersal Device (RDD) Response Guidance: Planning for the First 100 Minutes* (DHS 2017). Based on this guidance, she knows she will need two measurements with two different instruments at two different locations to confirm the presence of radioactive contamination.

General Process Example: Review Objective (contd.)

6. What type of measurements are needed?
   - Rosa decides that the gamma measurements can come from surveys, taken from handheld dose meters, PRDs, spectrometers, or most any other gamma-sensitive instruments.
   - Rosa needs to know which type of instrument (e.g., ion chamber versus energy-compensated GM versus NaI PRD, etc.) and which instrument model (e.g., Ludlum Model 14, SN 14325 with 133-7 probe, SN 3285) was used to collect each measurement she will be reviewing. Factors such as the calibration, range selection, and sensitivity for each specific instrument can affect how that instrument performs and the measurement it provides.

Based on her answers above, Rosa establishes the following DQOs:

1. Measurements near the explosion from gamma- or beta-sensitive instruments collected today after 10:00 a.m. are needed to determine if any cesium-137 and cobalt-60 contamination is present.
2. Background measurements, ideally near the explosion location and collected before 10:00 a.m. today or upwind of the explosion, are needed for comparison to gamma radiation measurements.
3. Two measurements, both indicating elevated (greater than three times background) levels of radiation, at least 50 feet apart, with two different instruments are required to determine that radioactive contamination is present, per the *Radiological Dispersal Device (RDD) Response Guidance: Planning for the First 100 Minutes* (DHS 2017).

Based on these DQOs, Rosa generates a list of the data she will be looking for from each measurement (below).

1. She would like to have the name and organization of each individual who collects each measurement in case she needs to ask clarifying questions.
2. She will need the location of each measurement to determine what locations might be contaminated.
3. She will need the date and time of each measurement to make sure they took place following the explosion.
4. She will need the instrument make and model for each measurement to determine if the instrument can measure beta and gamma radiation levels, and whether the value and units reported make sense.
5. She will need the value and units of each measurement to determine whether contamination is present.
6. She will need the value and units of background measurements representative of the area to compare to the measurements of possible contamination.
7. She would like to have the calibration information, serial number, and range selection of each instrument used to collect measurements to determine if the value and units reported make sense.

Rosa generates a table that can be filled out for any measurements available, based on the list.

Data	Measurement Data
Name of the individual	
Organization of the individual (if applicable)	
Location	
Time of day the measurement was taken	
Date the measurement was taken	
Instrument make and model, and of associated probes	
Measurement value	

Data	Measurement Data
Measurement unit	
Background value	
Background unit	
Pre-deployment calibration check[(a)]	
Instrument serial number, and serial number of associated probes	
Instrument range selection	

(a) Per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies,” Tier 3. (NCRP 2022)

END EXAMPLE TEXT

3.2 Gather Data

The data assessor gathers the measurement data available for making the assessment. In this context, a “measurement” refers to the measured value and units (e.g., 1 mR/hr) and other data associated with that value, such as the instrument that was used to perform the measurement, the person who made the measurement, and where the measurement was made. Data that support the objective may include:

- New data collected for the specific purpose of supporting the objective at hand
- Existing data collected for other objectives
- Historical data collected as part of other activities not related to the response.

The data assessor gathers data by downloading it from services like chemical, biological, radiological, and nuclear (CBRN) Responder, exporting files from other databases, and transferring files and forms from field personnel who collect data. These data should be gathered to the same location, whether on a computer or on paper forms, such that the data assessor has easy access. The data assessor should then fill out the table generated in the previous Review Objective step based on the measurement data collected. Alternatively, if data are present in CBRN Responder or otherwise stored on a computer, then the data assessor could download the data, copy it into a spreadsheet-type software, and skip to the “Apply Verification Flags” step.

General Process Example: Gather Data

Rosa requests data from all measurements collected so far. She receives information on just two measurements. Rosa fills out the table she developed in the Review Objective step with the information from the two measurements. The filled-out table is below.

Data	Measurement 1	Measurement 2
Name of the individual	Jane Smith	John Smith
Organization of the individual (if applicable)	Anytown Fire Department	Anytown Police Department
Location	Corner of Cherry and 9th Ave.	47.606, -122.326
Time of day the measurement was taken	10:05 am	
Date the measurement was taken	January 1, 2022	January 1, 2022
Instrument make and model, and of associated probes		BNC NukeALERT
Measurement value	9	2
Measurement unit	mR/hr	
Background value		
Background unit		
Pre-deployment calibration check		Passed
Instrument serial number, and serial number of associated probes		
Instrument range selection setting		

END EXAMPLE TEXT

3.3 Apply Verification Flags

The data assessor applies a flag to a measurement when data are missing from that measurement. The flag applied depends on how important the missing data are for understanding the measurement. It is recommended that data assessors use two flags: “Suspicious” and “Incomplete.”

- The “Suspicious” flag indicates that a data assessor might have a reasonable objection to using the measurement, but the missing data are not strictly necessary for the use of the measurement to support the objective.
- The “Incomplete” flag indicates cases where the absence of data for a measurement may significantly influence a protective action decision or worker safety; therefore, any missing data must be resolved prior to that measurement’s use.
- If data about a measurement is missing, but those data have no influence on the public protection or safety objective currently being addressed, the data assessor may choose not to apply a flag. Note that if the same measurement is used to address a different objective, it should be reviewed again. In such a case, that same missing data may have an influence on the objective and may need to be flagged.

When each measurement has been verified, multiple “Suspicious” or “Incomplete” flags may have been applied to it. The application and relevance of these flags to various missing data may change based on the response phase and the specific response objective.

For example, it might not be vitally important to know the name of the person performing a survey or the agency they report to in the Early Phase. Therefore, measurements lacking this information might be flagged as “Suspicious.” On the other hand, a survey result of “574” cannot be evaluated or used at all unless the units are reported because of the possible difference in significance of the value, as follows:

- 574 μR/hr is elevated, but calls for few radiological safety measures.
- 574 mR/hr requires a degree of care to minimize exposure.
- 574 R/hr is dangerous and should not be entered.
- 574 cpm might call for decontamination.

Therefore, a measurement with a value of “574” might be flagged as “Incomplete” until the data assessor can ascertain what units belong with the measurement value.

General Process Example: Apply Verification Flags

First, Rosa decides what flags should be applied to what data when it is missing from a measurement. She generates the following table:

Data	Flag, if Data are Missing
Name of the individual	Suspicious
Organization of the individual (if applicable)	Suspicious
Location	Incomplete
Time of day the measurement was taken	Incomplete
Date the measurement was taken	Incomplete
Instrument make and model, and of associated probes	Incomplete
Measurement value	Incomplete
Measurement unit	Incomplete
Background value	Incomplete
Background unit	Incomplete
Pre-deployment calibration check	Suspicious
Instrument serial number, and serial number of associated probes	Suspicious
Instrument range selection setting	Suspicious

Next, Rosa applies the verification flags (red, bold below) to the two measurements available.

Data	Measurement 1	Measurement 2
Name of the individual	Jane Smith	John Smith
Organization of the individual (if applicable)	Anytown Fire Department	Anytown Police Department
Location	Corner of Cherry and 9th Ave.	47.606, -122.326
Time of day the measurement was taken	10:05 am	**Incomplete**

Data	Measurement 1	Measurement 2
Date the measurement was taken	January 1, 2022	January 1, 2022
Instrument make and model, and of associated probes	**Incomplete**	BNC NukeALERT
Measurement value	9	2
Measurement unit	mR/hr	**Incomplete**
Background value	**Incomplete**	**Incomplete**
Background unit	**Incomplete**	**Incomplete**
Pre-deployment calibration check	**Suspicious**	Passed
Instrument serial number, and serial number of associated probes	**Suspicious**	**Suspicious**
Instrument range selection setting	**Suspicious**	**Suspicious**

END EXAMPLE TEXT

3.4 Apply Validation Flags

The data assessor applies additional flags to the measurements related to the PARCCS parameters. The PARCCS parameter requirements are a set of conditions the data should meet. Each measurement is evaluated against the requirements individually to determine if each condition is met or not. If a condition is not met or other important context regarding that measurement should be noted, the data assessor may flag the measurement to signify what the particular issue or observation about the measurement is. Validation flags will be more varied than verification flags to describe specific issues with, or observations of, the measured data. The validation condition checks should be organized by PARCCS parameters for clarity. Note that the PARCCS parameters in the example below are intended to be plausible but may not reflect real parameters generated for an event.

General Process Example: Apply Validation Flags

First, Rosa develops a set of conditions that support her DQOs as well as the measurements she knows have been provided, to which she will compare each measurement, based on the PARCCS parameters. She generates the following table.

PARCCS Parameter	Action	Conditions	Flag if condition is True
Precision	Review the instrument information and measurement value and units.	The instrument does not provide a dose readout, but the value is representative of a dose range instead.	Imprecise
Accuracy	Check whether pre-deployment calibration check was performed.	1. Meter failed pre-deployment calibration check. 2. No calibration information is available. 3. Meter passed pre-deployment response check.	If 1: Out of Calibration If 2: Suspicious Context If 3: No Flag

PARCCS Parameter	Action	Conditions	Flag if condition is True
Representativeness	Review measurement location against a map of the area of interest.	Measurement location is well beyond the farthest expected spread of contaminated material and useful background measurements (a 50-mile “relevancy radius” has been established).	Invalid
Completeness	Review the number of “Suspicious” flags applied to the measurement.	Three or more “Suspicious” flags have been applied.	Suspicious Context
Comparability	Compare each measurement reading to the typical background level measured on that instrument, converting from integrated counts to count rate and accounting for the speed of the survey, if necessary.	A given measurement is less than three times the typical background for the area with the type of instrument used.	Background
Sensitivity	Compare the instrument range selection setting (for example the scale, range, and so on) to the measured value.	The measured value is in the lower 5% of the full-scale range.	Invalid

Next, Rosa applies the validation flags (red, bold below) to the two measurements available.

Condition	Measurement 1	Measurement 2
The instrument does not provide a dose readout, but value representative of a dose range instead.	**none**	**Imprecise** *(due to reporting method of instrument used)*
1. Meter failed pre-deployment calibration check. 2. No calibration information is available. 3. Meter passed pre-deployment response check.	**Suspicious Context** (no pre-deployment check)	**none** *(Pre-deployment response check passed)*
Measurement location is within the established event radius for which data are relevant (a 50-mile “relevancy radius” has been established).	**none** *(measurement is within 50 miles from release point)*	**none** *(measurement is within 50 miles from release point)*
Three or more ”Suspicious” flags have been applied.	**Suspicious Context** (three Suspicious flags)	**none** (only two Suspicious flags)
A given measurement is less than three times the typical background for the area with the type of instrument used.	**none** *(no background measurement)*	**none** *(no background measurement)*

Condition	Measurement 1	Measurement 2
The measured value is in the lower 5% of the full-scale range.	**none** *(instrument model not provided)*	**none** *(instrument measured at 10% of full range)*

END EXAMPLE TEXT

3.5 Assess Data Quality

The data assessor evaluates the quality of the data collected to support the response objective. The data assessor must:

1. Decide to include or reject individual measurements based on flags applied during the previous steps (e.g., “None of the flags for this measurement concern me, I’ll accept this dose rate measurement”).
2. Decide on the suitability of the measurement data as a whole (e.g., “It looks like the measurement is from the right area and are of the type requested, so we can use it”).
3. Draw conclusions about the available information and the state of the incident (e.g., “25 R/hr is pretty high, but not above the established incident action levels”).
4. Present these conclusions to response officials.

Some of the things a data assessor should consider in this step are:

- What flags have been applied to the measurements? Do any of those flags or does the number of flags mean those measurements cannot be used for this response objective?
- Do measurements located close together in space and time give values that make sense overall? For example, co-located dose rate meter readings should show similar values.
- Are the instruments used capable of measuring the type(s) of radiation expected in the release? (e.g., Are alpha meters being used to measure for alpha radiation?)
- How much confidence in the conclusions drawn is required to support a decision? (e.g., How sure does the response leader making the decision need to be that we have sufficiently characterized the area?)
- How much uncertainty is allowable to support an estimate? (e.g., Does it make a difference the actual dose rate might be up to 20% higher?)
- How many measurements are needed to support a conclusion (e.g., Are we sure we have measured enough of the area and have not missed any hotspots or other outliers?)

Additionally, in the Intermediate Phase of the response, the data assessor should consider whether performing a statistical test is appropriate for supporting conclusions with a specified amount of statistical confidence based on a larger number of measurements. Data assessors must select a statistical test with care because these tests involve assumptions about the nature of the measurement distribution (i.e., how the measurements are spread across all possible values and the likelihood of having the measurement given the conditions). These assumptions should be validated first by calculating statistical parameters (e.g., mean, median, standard deviation) and plotting data to ascertain whether a given statistical test is valid for the data at hand. Section 5.0 of this document includes instructions for applying different applicable statistical tests. These tests are relatively straightforward to apply, require few assumptions, and do not require complex calculations. Additional statistical methods and guidance on how to select and apply them can be found in the EPA document *Data Quality Assessment: Statistical Methods for Practitioners* (EPA 2006b).

During the Assess Data Quality step, a data assessor may not be able to make a determination about the objective with the measurement data provided. This is perfectly normal. In such cases, the data assessor may decide to do any of the following:

- Make reasonable assumptions about missing information (e.g., background radiation exposure values are likely similar to what we measured when we turned the instruments on about 5 miles away).
- Seek additional information about existing measurements (e.g., the type of PRD our emergency responders use normally read a background of about 10-15 microR/hr).
- Request additional measurements to support or replace existing measurements (e.g. “Hey Chief – can you send someone over to 5th and Elm with a PRD and ask them to make radiation measurements every 50 meters between there and 7th and Elm and upload to CBRN Responder?).

The time and resource limits that exist during incident response mean that all of the approaches above should be explored when possible. If a data assessor must make conclusions based on unreliable data, they should include a statement about the nature of the data upon which their conclusions are based, to be able to properly inform response leaders of the situation.

For example, an evacuation decision may need to be made in an hour. The data assessor is unable to completely clear all “Suspicious” and “Incomplete” flags from their verification step by the deadline to make the evacuation decision, but a decision must still be made. It appears to the data assessor that the radiological conditions in one area are not above the evacuation action level, but some measurements from imprecise instruments indicate the conditions are close to the evacuation action level. Therefore, the data assessor reports to response leaders that it appears as if most of the area is below the evacuation action level, but that some measurements may indicate levels above the evacuation action level. Response leaders may then decide to:

a. Not evacuate the population of the area because the evacuation action level is conservative anyway;
b. Evacuate only part of the population in the area where measurements are close to the level because this errs on the side of protection; or
c. Evacuate the entire population of the area because they do not want to be accused of a lack of concern for public health.

In any case, once the conclusions have been presented, the decision about what to do is beyond the responsibilities of the data assessor role the data assessor should move on to the next task. Of course, if the data assessor is, for example, presented with the three options above and asked their opinion by response leaders about what decision should be made, they should do so.

General Process Example: Assess Data Quality

Rosa needs to decide whether to accept or reject measurements for their use in analysis based on the flags applied in the previous two steps and whether the measurements are suitable as a whole, and then draw conclusions from them related to the response objective, which is to determine whether any of the measurements indicate elevated radiation levels, defined as greater than three times background radiation levels.

Rosa decides to construct a single table that incorporates all the Assess Data Quality steps (below). Since the incident is a possible RDD, Rosa is also using the *Radiological Dispersal Device (RDD) Response Guidance: Planning for the First 100 Minutes* (DHS 2017). Tactic 2 in the guidance indicates that at least two measurements, spaced 50 feet apart with two different instruments, should be collected to confirm the presence of radioactive contamination. Rosa adds those requirements to the table (numbers 7 and 8). These were not part of the validation step because they refer to the set of measurements, rather than the individual measurements.

Next, Rosa checks all the conditions in the table she constructed to the two measurements she has gathered and the flags she has applied.

Condition	Conclusions
1. The “Imprecise” flag has been applied to an individual measurement.	**Measurement 2 has the Imprecise flag.** • **The NukeALERT displays a number representing a dose range.**
2. The “Out of Calibration” flag has been applied.	No measurements with the Out of Calibration flag.
3. The “Invalid” flag has been applied to an individual measurement.	No measurements with the Invalid flag.
4. Every measurement in the dataset has had the “Background” flag applied to it.	No measurements with the Background flag.
5. The “Incomplete” flag has been applied to an individual measurement.	**Measurements 1 and 2 have the Incomplete flag.** • **Measurement 1 is missing the instrument make and model.** • **Measurement 2 is missing the units of the measurement.** • **Measurements 1 and 2 are both missing background measurement values and units.**
6. The “Suspicious Context” flag has been applied to a measurement.	**Measurement 1 has the Suspicious Context flag.**
7. Only one instrument was used to make all valid measurements.	**Unknown – make and model of the instrument used for Measurement 1 not provided.**
8. All measurements are within 15 meters (50 feet) of one another.	The two measurements are more than 50 feet apart (Rosa calculates the distance using online maps as approximately 157 feet).
9. None of the above conditions is true.	Some of the above conditions are true.

General Process Example: Assess Data Quality (contd.)

Based on her assessment, Rosa concludes that neither measurement is usable as is, and that more information is needed. She takes the following actions:

1. Rosa consults the "Job Aids for Using Preventive Radiological/Nuclear Detection Equipment for Consequence Management" guidance and manufacturer information for the BNC NukeAlert, which provides the corresponding units and dose rate from the supplied value.
    a. Rosa discovers that the instrument does not provide units for its reading display. She clears the Measurement 2 "Incomplete" flag for measurement units.
    b. Rosa discovers that the instrument does not have user-adjustable range selection. She clears the Measurement 2 "Suspicious" flag for range selection.
2. Rosa contacts Jane to collect additional information.
    a. Jane informs Rosa that she used a Polimaster PM1703GN to collect Measurement 1. Rosa clears the "Incomplete" flag for the Measurement 1 make and model.
    b. Jane is also able to provide her instrument's serial number. Rosa clears the "Suspicious" flag for the Measurement 1 serial number.
    c. Jane informs Rosa that she did perform a pre-deployment calibration check with her instrument, which passed. Rosa clears the "Suspicious" flag for the Measurement 1 calibration.
    d. Jane is unable to recall the instrument's range selection setting. Rosa leaves the "Suspicious" flag for the Measurement 1 instrument range selection setting in place.
    e. Jane did not collect a background before arriving at the incident scene. However, based on previous experience, she estimates the background at approximately 20 μR/hr. Rosa notes this and removes the "Incomplete" flags for Measurement 1 background value and background unit. However, because the value is based on Jane's memory, even though it seems reasonable, Rosa applies a single new "Suspicious" flag to the background value.
3. Rosa contacts John to collect additional information but is unable to reach him.
    a. Rosa decides to use the same background estimate that Jane provided for John's instrument. Rosa uses *Using Preventive Radiological/Nuclear Detection Equipment for Consequence Management, Operational Job Aids* (DHS and DOE 2017) to determine that John's instrument was reading between 0.035 mrem/hr and 0.040 mrem/hr.
    b. Based on Jane's estimate of 20 μR/hr, Rosa estimates that the background would be approximately 17.7 μrem/hr, or 0.0177 mrem/hr. Therefore, John's reading is not greater than three times the background, which would be 0.053 μrem/hr.
    c. Rosa removes the "Incomplete" flag and applies a "Background" flag based on the validation table. Rosa also applies a "Suspicious" flag to the background value since it was an assumption.
4. Rosa reevaluates the verification table with the new information (below).

Data	Measurement 1	Measurement 2
Name of the individual	Jane Smith	John Smith
Organization of the individual (if applicable)	Anytown Fire Department	Anytown Police Department
Location	Corner of Cherry and 9th Ave.	47.606, -122.326
Time of day and date the measurement was taken	10:05 am, January 1, 2022	January 1, 2022
Instrument make and model, and of associated probes	Polimaster PM1703GN ~~Incomplete~~	BNC NukeALERT

Data	Measurement 1	Measurement 2
Measurement value	9	2 (0.035 – 0.040 mrem/hr)
Measurement unit	mR/hr	N/A ~~Incomplete~~
Background value	20 **Suspicious** ~~Incomplete~~	0.0177 **Suspicious** ~~Incomplete~~
Background unit	μR/hr ~~Incomplete~~	mrem/hr ~~Incomplete~~
Pre-deployment calibration check	Passed ~~Suspicious~~	Passed
Instrument serial number, and serial number of associated probes	A123456 ~~Suspicious~~	**Suspicious**
Instrument range selection setting	**Suspicious**	none ~~Suspicious~~
Instrument range selection setting	**Suspicious**	none ~~Suspicious~~

5. Rosa then re-evaluates the validation table with the new information (below).

Condition	Measurement 1	Measurement 2
The instrument does not provide a dose readout, but value representative of a dose range instead.	**none**	**Imprecise**
1. Meter failed pre-deployment calibration check 2. No calibration information is available. 3. Meter passed pre-deployment response check	**none** – instrument is calibrated.	**none** – instrument is calibrated.
Measurement location is within the established event radius for which data are relevant (a 50-mile “relevancy radius” has been established).	**none** – measurement is within 50 miles from release point	**none** – measurement is within 50 miles from release point
Three or more ”Suspicious” flags have been applied.	**none** – only 2 Suspicious flags ~~Suspicious Context~~	**none** – only 2 Suspicious flags
A given measurement is less than three times the typical background for the area with the type of instrument used.	**none** – no background measurement	**none** – no background measurement
The measured value is in the lower 5% of the full-scale range.	**none** *(instrument measured at 30% of full range)*	**none** *(instrument measured at 10% of full range)*

General Process Example: Assess Data Quality (contd.)

6. Rosa re-evaluates her conclusions (below).

Condition	Conclusions
The “Imprecise” flag has been applied to an individual measurement.	**Measurement 2 has the Imprecise flag.** • **The NukeALERT displays a number representing a dose range.**
The “Out of Calibration” flag has been applied.	No measurements with the Out of Calibration flag.
The “Invalid” flag has been applied to an individual measurement.	No measurements with the Invalid flag.
Every measurement in the dataset has had the “Background” flag applied to it.	No measurements with the Background flag.
The “Incomplete” flag has been applied to an individual measurement.	No measurements have the Incomplete flag. ~~**Measurements 1 and 2 have the Incomplete flag.**~~ • ~~**Measurement 1 is missing the instrument make and model.**~~ • ~~**Measurement 2 is missing the units of the measurement.**~~ • ~~**Measurements 1 and 2 are both missing background measurement values and units.**~~
The “Suspicious Context” flag has been applied to a measurement.	No measurements have the Suspicious Context flag. ~~**Measurement 1 has the Suspicious Context flag.**~~
Only one instrument was used to make all valid measurements.	Two different instruments were used to perform the measurements. ~~**Unknown – make and model of the instrument used for Measurement 1 not provided.**~~
All measurements are within 15 meters (50 feet) of one another.	The two measurements are more than 50 feet apart (Rosa calculates the distance using online maps as approximately 157 feet).
None of the above conditions is true.	Some of the above conditions are true.

7. Rosa makes several conclusions.
    a. Rosa concludes that Jane’s measurement strongly indicates increased radiation exposure levels above background.
    b. Rosa concludes that, even aside from the imprecise nature of and number of Suspicious flags applied, John’s measurement likely does not indicate increased radiation exposure levels above background.
    c. Rosa concludes that at least one additional measurement should be collected near the location Measurement 2 was collected, or somewhere else near where Measurement 1 was collected (but still 50 feet away from the Measurement 1 location).

General Process Example: Assess Data Quality (contd.)

8. Rosa presents these conclusions to her section chief or response leaders.

At this point, Rosa might recommend that the Operations Section assign someone to take a reading with their instrument near Jane's position (but still 50 feet away, toward the explosion, if possible). Alternatively, other measurements may have been reported during the time the data were being assessed, and Rosa might first assess those to see if they are suitable for this response objective. In any case, Rosa should apply verification and validation (steps 3 and 4 in Figure 2) to any new measurements that are collected, and then assess the data quality of the new measurements and the original measurements together again (step 5 in Figure 2).

Rosa may find, upon reviewing additional measurements, that there does appear to be radioactive contamination at the scene. Now Rosa is directed to confirm the zones established by the incident command per the *Radiological Dispersal Device (RDD) Response Guidance: Planning for the First 100 Minutes (DHS 2017)*. This is a different objective than the one she just completed and has different data quality requirements. Rosa's new objective is to determine if there are dose rates above a certain action level. Now, Rosa must collect any new data available and begin reviewing the data again under the requirements for the new objective.

END EXAMPLE TEXT

3.6 Using the Guidance

Sections 4.0 and 5.0 provide additional examples of how to implement the guidance above based on common objectives that need to be addressed using radiological data during a response. These sections are intended as guidance, not prescriptive processes. Because each response is unique, it is not possible to cover every possible scenario or anomaly that the data may present. The data assessor will need to explore the data and their assumptions about it to resolve issues. For example, a situation may arise where two different sets of measurements overlap spatially, but their measurement values do not appear to agree. It may be the case that some measurement values were entered incorrectly for one set, or the time entered was incorrect. In such cases, the data assessor will need to decide if any valid conclusions can be drawn, or if new measurements need to be collected. This must also be balanced against the state and pace of the response. There may not be resources available to collect additional measurements, or other incident or environmental conditions might prevent measurement collection in the same area. In such cases, the data assessor may need to provide their best guess at the conditions, which should err on the side of caution. However, the data assessor can also make it clear to response leaders that the data are of poor quality for addressing this response objective and should be used with caution.

For example, if an instrument's calibration expiration has passed or if the instrument had trouble with its calibration, it is still possible the measurements it recorded were still within a 20% tolerance (NCRP 2022). When operating with limited data, these values may still provide valuable information and should be considered for use, though with caution. For measurements that do not all come from the same area or cannot be said to be representative of the same area, it may be possible to regroup and separate measurement sets into smaller, more localized areas such that all measurements assigned to that area can be said to be representative of that area. These regrouped measurements could then be reevaluated using the same process. Measurements that are too far from the area in question to be useful for the objectives should not be used to support drawing conclusions, or they may be used for background if they are considered representative of background for the affected area.

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4.0 Early Phase

The Nuclear/Radiological Incident Annex (DHS 2016) describes the Early Phase of the response as:

> *The period from the beginning of the incident when immediate decisions for effective protective actions are required. There may be little or no information available on the actual releases or field measurement data. Protective actions in the Early Phase are aimed at avoiding inhalation of gases or particulates in a plume and minimizing external exposure.*

During the Early Phase of a response, first responders may not have time to rigorously assess data since decisions may need to be made quickly to protect the public, responders, and the environment, and to maintain doses as low as reasonably achievable (ALARA). The guidance presented in this section (Section 4.0) may not be as easily applied or met in the first few hours following a radiological release as the primary objectives are to collect data, mark the area, and assess the level of impact while ensuring public and personnel health. In that scenario, flawed data will exist and the data assessment role may not be easily filled by the first teams on-site. Also, under these conditions, it is unlikely that data assessors could request or reconcile incomplete or suspicious flags on the data, which would have to come at a later point when more time and resources are available. Instead, an assessor might need to evaluate how much missing and incorrect field data can be accepted while still making effective decisions.

Data assessment is still important in the Early Phase to avoid drawing false conclusions and ultimately basing important and costly decisions on incomplete or invalid data. As the response progresses, the guidance outlined in this section can be more easily applied. The assessment methods provided in this section are intended to be performed quickly to make some basic conclusions about whether radioactive contamination is present and how much of a hazard it is.

A data assessor could be a health physicist, a technical subject matter expert, an on-call individual, or someone that has training as a radiological operations support specialist (ROSS). Data assessment is not required to be limited to individuals with these specific roles, but it is likely that those individuals would be able to perform the data assessment as part of their responsibilities. Depending on the duration of the Early Phase, federal personnel may not be present and therefore unable to provide data assessment support during this phase.

4.1 Assess Reports of Elevated Radiation Levels

Objective: Assess reports on the presence of radioactive contamination by elevated radiation levels at an incident.

4.1.1 Review Objective

Applicability: In some emergencies (e.g., a nuclear reactor incident), first responders may immediately identify that a release of radioactive materials occurred. In other emergencies (e.g., a transportation accident or an unexplained explosion), the presence or absence of a release may be unclear. In such cases, initial reports of elevated radiation levels, contamination, and/or the presence of radioactive materials would likely be made by first responders with PRDs. Data assessors should carefully examine the reports to validate whether a radioactive material release occurred.

The data assessor applies verification, validation, and DQA to the initial reports to determine whether radioactive materials have been released. The data assessor may receive reports from several sources. First responders send reports to local commanders while members of the public would likely call emergency services (9-1-1). First responders and the public would provide their report about their suspicions or provide a confirmation of an unexpectedly high radiation level. The data assessor investigates further. Whatever the source of the report, the data assessor should discuss the report with the source to determine the validity of the report, if possible. By listening to the concerns of the first responder or member of the public and how they arrived at their conclusion, the data assessor gains insights on the validity of the data. The data assessor should take sufficient notes to complete their evaluation and identify details that would warrant a follow up or gathering of additional data.

Assumptions: If the assumptions listed here do not apply to the objective being addressed, note that some of the DQA conditions and conclusions outlined below may need to be adjusted.

- Data assessors should apply this method to initial reports of elevated radiological readings, data, or alarms that have been received from emergency responders, including firefighters and police, using survey equipment and who are primarily focused on lifesaving activities and not radiological detection and measurement. Initial reports may also be submitted by members of the public who have been credentialed or otherwise accepted as being able to assist in the aftermath of a radiological or nuclear emergency.
- Data assessors may apply the guidance in this objective to determine whether elevated radiation levels are present. If confirmed, the presence of elevated radiation levels will prompt additional data assessment to quantify the radiological conditions at the scene for establishing hazard zones and comparing to protective action levels. Data assessment guidance for quantifying radiation levels and comparing them to an incident action level is covered in Section 4.2.
- The initial reports discussed above are likely to be based on readings from PRDs.
- All measurements discussed herein refer to those that have been collected after the radionuclide release. Measurements collected for use as background values may be collected before the radionuclide release, and should follow a similar process, but are not addressed here.
- The data assessor will compare data using specific units for specific data types (e.g., for dose use mR/hr, for counts use cpm).

4.1.2 Gather Data

All of the listed data elements in Table 1 could be provided in this objective and phase by responders. The successive sections will detail the data assessment process for these possible data types.

Table 1. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	
Samples	
Dose rate measurements	✓
Spectral measurements	-
Raw count rates	✓
Background dose rates	✓
Background spectra	

4.1.3 Apply Verification Flags

The data assessor should gather the details listed in Table 2 for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing.

Table 2 Verification Data and Flags

Data	Flag, if Missing
Background measurement	Suspicious
Date the measurement was taken	Incomplete
Distance of instrument to surface being measured	Suspicious
If a moving survey method was used, the approximate speed of the meter or vehicle the meter was in	Suspicious
Instrument and type of detector used (manufacturer and model number) (e.g., “Ludlum Model 2241 with a model 133-6 energy-compensated GM”)	Incomplete
Location	Incomplete
Measurement unit (if applicable). Some instruments give numbers which correspond to dose rate ranges. See *Using Preventative Radiological Nuclear Detection Equipment for Consequence Management Missions, Operational Job Aids* (DHS and DOE 2017)	"Incomplete if dose or count reading; none if from a BNC NucAlert or D-Tect MiniRad-D "
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual (if applicable)	Suspicious
Orientation of instrument (e.g., parallel, perpendicular, at an angle) to nearby surfaces	Suspicious
Survey method – stationary or scanning (an instrument in a moving vehicle is considered a scan)	Suspicious
Pre-deployment calibration check[a]	Suspicious
Instrument range selection	Suspicious

(a) Per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies”, Tier 3. (NCRP 2022).

4.1.4 Apply Validation Flags

Using Table 3 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 3. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Action for this Objective	Conditions	Flag if Condition is True
Precision	Review the instrument information and measurement value and units.	The instrument does not provide a dose readout, but the value is representative of a dose range instead.	Imprecise			
Accuracy	Check whether pre-deployment calibration check was performed.	1. Meter failed pre-deployment calibration check. 2. No calibration information is available. 3. Meter passed pre-deployment response check.	If 1, Out of Calibration If 2, Suspicious Context If 3, No Flag			
Representative-ness	Review measurement location against a map of the area of interest.	Measurement location is well beyond the farthest expected spread of contaminated material and useful background measurements.	Invalid	Note the time of the measurement and compare to any information about the release, if available.	1. The time of the measurement precedes the expected release. 2. If the measurement is indicated as a background measurement and the time coincides with other elevated readings.	If 1 or 2: Invalid
Completeness	Review the number of "Suspicious" flags applied to the measurement.	1. Five or more "Suspicious" flags have been applied.	Suspicious Context			
Comparability	Note the units of the measurement, and available conversion factors.	The measurement is not reported in either mR/hr or cpm.	Invalid			

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Action for this Objective	Conditions	Flag if Condition is True
Sensitivity	Compare the instrument range selection to the measured value.	1. The measured value is lower than, or at the lower limit of, the instrument's sensitivity range. 2. The instrument is not able to measure less than 2 mR/hr.	If 1 or 2: Invalid			

4.1.5 Assess Data Quality

Using Table 4 as a guide, the data assessor reviews the data and how they are flagged from both the verification and validation steps. Possible conclusions are presented in Table 4, given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 4 should be used as a starting point. For example, a radiation dose rate of 1 mR/hr emanating from beneath a pile of rubble in one instance might lead to the conclusion that there might be a moderate or high-activity source buried beneath the rubble, possibly calling for dosimetry and constant dose rate monitoring while excavating the rubble. On the other hand, the same dose rate measured in the middle of a large open field might lead to the conclusion that there might be high levels of contamination in the area, possibly calling for personal protective equipment and air sampling. The conclusions from these tables will inform which measurements to include in the final analysis and assessment of the collected data to relay to response leaders.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, can be used to translate CBRN Responder data flags into the “Suspicious” and “Incomplete” data flags used here as well as the additional flags applied during validation.

Table 4. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The “Imprecise” flag has been applied to an individual measurement.	• If a background measurement from the same instrument is available, compare the two measurements. If the response value is greater than three times the background value (e.g., if the background value is 1 and the response value is 3), then radioactive contamination may be present. • If no background measurement with the same instrument is available, a background measurement should be performed away from any areas suspected of elevated background levels. • If a background measurement with the same instrument cannot be performed, additional confirmatory measurements near the same locations should be performed. • If a background measurement with the same instrument cannot be performed, an additional “Suspicious” flag may be applied to this measurement.
The “Out of Calibration” flag has been applied in regards to instrument calibration information.	• An additional confirmatory measurement should be performed with a different instrument that is calibrated in the same location. • If an additional confirmatory measurement with the same instrument cannot be performed, an additional “Suspicious” flag may be applied to this measurement.

Condition	Possible Conclusions
The “Invalid” flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • It may be necessary to collect a new measurement to replace the invalid one.
The “Incomplete” flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements in the same locations should be performed.
A ”Suspicious Context” flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other nearby measurements with fewer than five “Suspicious” flags are available. • Additional confirmatory measurements in near same location as the original measurement should be performed.
The number of ”Suspicious” flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements in the same area should be performed.
Fewer than two measurements, spaced at least 15 meters (50 feet) apart outside or a minimum of 3 meters (10 feet) apart indoors, were collected.	• Any measurement that has been disregarded or is considered “not usable” does not count toward the required number of measurements. • Additional measurements may be sought with appropriate spacing.
Only one instrument was used to make all valid measurements.	• Additional confirmatory measurements in locations close by should be performed with a different instrument.

Data Assessment Conclusions

Condition	Possible Conclusions
The measurement is consistent with an elevated background, and any identified isotopes are consistent with naturally occurring radioactive material (NORM).	• It is unlikely that there is a radiation hazard at the location. • Additional confirmatory measurements may be sought, including gamma spectroscopy measurements, and surveys for alpha and beta contamination.
A given measurement is less than three times the typical background for the area with the type of instrument used.	• It is unlikely that there is a radiation hazard at the location. • Additional confirmatory measurements may be sought, including gamma spectroscopy measurements, and surveys for alpha and beta contamination.

Condition	Possible Conclusions
None of the above conditions is true.	• It is likely that an elevated radiation hazard is present at the location. • Compare the radiation measurements to an incident action level.

4.2 Compare to an Incident Action Level

Objective: Estimate an average value for an area and compare it to an incident action level for action.

4.2.1 Review Objective

Applicability: Once a radiation release has been confirmed, it is also crucial to measure the radiation exposure levels to compare them to incident action levels (e.g., derived response levels [DRLs], protective action guides (PAGs) (EPA 2017), or other levels) for responder protection and public protective actions. Depending on the radiation exposure levels, the response priorities may include implementing protective actions for the public and first responders within the areas defined by the contamination and balancing the need for immediate first aid to those affected and the deployment of decontamination resources.

Action Level Guidance

There several guidance documents that provide recommended thresholds for various actions. Four of those are listed here:

- *The Radiological Dispersal Device (RDD) Response Guidance* (DHS 2017) – provides guidance for establishing cold, hot, and dangerous radiation zones.
- ***Protective Action Guides (PAGs)*** (EPA 2017) – provides guidance for public protective actions.
- *Population Monitoring in Radiation Emergencies* (CDC 2014) – provides guidance for monitoring individuals who may have been exposed to radiation during an incident.
- *Surface and Volume Radioactivity Standards for Clearance* (ANSI/HPS 2013) – provides guidance on clearing items and materials for release from controlled areas.

The data assessor will be provided an action level to compare to measured values by their supervisor through the incident command structure. While decisions regarding the execution of protective actions is the responsibility of response leaders and elected and/or appointed officials, data assessors may proactively compare measurements to various action levels as a means of assessing the severity of an event, and present findings to response leaders. To determine the priority, type, and extent of potential protective actions, the data assessor may require jurisdiction-specific action levels as well as national protective action levels. These actions levels are based on generally accepted rules and can be applied on a graded approach.

Assumptions: If the assumptions listed here do not apply to the objective being addressed, note that some of the data quality assessment conditions and conclusions outlined below may need to be adjusted.

- Data assessors may apply guidance in this objective to any situation in which radiation or contamination levels have been determined through field survey methods.

- This section applies to personnel that the incident command or authorities direct to perform additional analysis to compare contamination levels to an incident action level.
- This objective includes measuring radiation to establish the Cold, Hot, and Dangerous Radiation Zones, for emergency responder protection.
- The objective includes measuring radiation and contamination levels to compare to incident action levels for public protective action.
- The data assessor has access to relevant counting efficiency as a function of energy (and therefore isotope) information available to them for all instruments used.
- The data assessor will compare data using specific units for specific data types (e.g., for dose, use mR/hr; for counts, use cpm).
- The data assessor has been provided an incident action level to compare to measurements. Selecting the appropriate incident action level is outside the scope of this guidance.

4.2.2 Gather Data

All of the listed data elements in Table 5 could be provided in this objective and phase by responders. The successive sections will detail the data assessment process for these possible data types.

Table 5. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	✓
Samples	
Dose rate measurements	✓
Spectral measurements	✓
Raw count rates	✓
Background dose rates	✓
Background spectra	✓

4.2.3 Apply Verification Flags

The data assessor should gather the details listed in Table 6 for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing.

Table 6. Verification Data and Flags

Data	Flag, if Missing
Background measurement	Suspicious
Date the measurement was taken	Incomplete
Distance of instrument to surface being measured	Suspicious
If a moving survey method was used, the approximate speed of the meter or vehicle the meter was in	Suspicious

Data	Flag, if Missing
Instrument and type of detector used (manufacturer and model number) e.g., “Ludlum Model 2241 with a model 133-6 energy-compensated GM”	Incomplete
Location	Incomplete
Measurement unit (if applicable – some instruments give numbers which correspond to dose rate ranges – see *Using Preventative Radiological Nuclear Detection Equipment for Consequence Management Missions, Operational Job Aids* [DHS and DOE 2017])	"Incomplete if dose or count reading; none if from a BNC NucAlert or D-Tect MiniRad-D "
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual (if applicable)	Suspicious
Orientation of instrument (e.g., parallel, perpendicular, at an angle) to nearby surfaces	Suspicious
Survey method – stationary or scanning (an instrument in a moving vehicle is considered a scan)	Suspicious
Time of day the measurement was taken	Incomplete

Flags Unique to this Objective

Data	Flag, if Missing
Pre-deployment calibration check[(a)]	Incomplete
Instrument make and model, and of associated probes	Incomplete
Instrument serial number	Suspicious
Instrument range selection	Suspicious
Type of material on nearby surfaces relative to the detector	Suspicious

(a) Per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies”, Tier 2. (NCRP 2022).

4.2.4 Apply Validation Flags

Using Table 7 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 7. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Action for this Objective	Conditions	Flag if Condition is True
Precision	Review the instrument information and measurement value and units.	The instrument does not provide a dose readout, but the value is representative of a dose range instead.	Imprecise	Consult the job aid for the instrument model used from *Using Preventative Radiological Nuclear Detection Equipment for Consequence Management Missions, Operational Job Aids* (DHS and DOE 2017)	The instrument is not suitable for Radiation Survey in the appropriate dose rate zone.	Invalid
Accuracy	Check whether pre-deployment calibration check was performed.	1. Meter failed pre-deployment calibration check 2. No calibration information is available. 3. Meter passed pre-deployment response check.	If 1: Out of Calibration If 2: Suspicious Context If 3: No Flag			
Representative ness	Check measurement location against a map of the area of interest.	Measurement location is well beyond the farthest expected spread of contaminated material and useful background measurements.	Invalid	Note the time of the measurement and compare to any information about the release, if available.	The time of the measurement precedes the expected release. If the measurement is indicated as a background measurement and the time coincides with other elevated readings.	Invalid
Completeness	Review the number of “Suspicious” flags applied to the measurement.	Five or more ”Suspicious” flags have been applied.	Suspicious Context			

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Action for this Objective	Conditions	Flag if Condition is True
Comparability	Note the units of the measurement, and available conversion factors.	The measurement is not reported in either mR/hr or cpm and cannot be converted to comparable units.	Invalid			
Sensitivity	Compare the instrument range selection to the measured value.	1. The measured value is less than or at the lower limit of the instrument's sensitivity range. 2. The measured value is greater than or at the upper limit of the instrument's sensitivity range.	If 1: use minimum scale as value. If 2, Invalid.			

4.2.5 Assess Data Quality

Using Table 8 as a guide, the data assessor reviews the data and how they were flagged from both the verification and validation steps. Possible conclusions are presented in Table 8, given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 8 should be used as a starting point. The conclusions from these tables will inform which measurements to include in the final analysis and assessment of the collected data to relay to response leaders.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, can be used to translate CBRN Responder data flags into the "Suspicious" and "Incomplete" data flags used here as well as the additional flags applied during validation.

Table 8. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The "Imprecise" flag has been applied to an individual measurement.	• If a background measurement from the same instrument is available, compare the two measurements. If the response value is greater than the background value by three (e.g., if the background value is 1 and the response value is 3), then radioactive contamination may be present. • If no background measurement with the same instrument is available, a background measurement should be performed away from any areas suspected of elevated background levels. • If a background measurement with the same instrument cannot be performed, additional confirmatory measurements near the same locations should be performed. • If a background measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Out of Calibration" flag has been applied.	• An additional confirmatory measurement should be performed with a different instrument in the same location. • If an additional confirmatory measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Invalid" flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • It may be necessary to collect a new measurement to replace the invalid one.

Condition	Possible Conclusions
A given measurement is less than three times the typical background for the area with the type of instrument used.	• It is unlikely that there is a radiation hazard at the location. • Additional confirmatory measurements from first responders may be sought, including a nuclide identification (ID) with a radioisotope identification device (RIID) and/or removable survey for alpha and/or beta contamination.
The measurement is consistent with an elevated background, and any identified isotopes are consistent with naturally occurring radioactive material (NORM).	• It is unlikely that there is a radiation hazard at the location. • Additional confirmatory measurements from first responders may be sought, including a nuclide ID with a RIID and/or survey for alpha and/or beta contamination.
The “Incomplete” flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements in the same locations should be performed.
A ”Suspicious Context” flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other nearby measurements are available. • Additional confirmatory measurements in near same location as the original measurement should be performed.
The number of ”Suspicious” flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements in the same area should be performed.
The number of measurements is less than the requested number (e.g., at least 18).	• For establishing zones, if there are <4 valid measurements each in a different direction, request additional measurements. • For protective action guides (PAGs): – If there are <10 measurements in an area that appears to be less than the PAG, request additional measurements be made. – If there are no measurements in an area that appears to be greater than the PAG, request that at least one measurement be collected in each area to which the PAG will be applied. • For other incident action level types, if there are <2 measurements that apply, request additional measurements.

Condition	Possible Conclusions
All measurements have been grouped and separated by date and time collected, and decay correction factors have been applied to all measurements for a predetermined point in time.	• An average count rate or dose rate should be calculated for each of these groups of measurements. • The greatest time difference between individual measurements in each group should be less than the half-life of the shortest-lived isotope, if known. • If the time difference appears to exceed the reported isotope's half-life, disregard. Additional confirmatory measurements in near same location as the original measurement should be performed.

Data Assessment Conclusion

Condition	Possible Conclusions
One or more measurements are greater than the incident action level.	• It is likely that an elevated radiation hazard is present at the location. • Additional measurements may be sought to further characterize the area, including gamma spectroscopy measurements, and surveys for alpha and beta contamination . • Predictive models should be consulted to determine isotopic composition and anticipated duration of impact. • If the measurements greater than the incident action level are not adjacent to measurements less than the incident action level, this may indicate hotspots, shielding conditions, instrument error, or a variety of other field conditions. It is still recommended that measurements greater than the incident action level be treated as such, but additional measurements be collected to better characterize the area.
All measurements are less than the incident action level.	• Any radiation hazards that may be in the area are likely below the incident action level. • Additional confirmatory measurements may be sought, including gamma spectroscopy measurements, and surveys for alpha and beta contamination .

5.0 Intermediate Phase

The Nuclear/Radiological Incident Annex (DHS 2016) describes the Intermediate Phase of the response as:

> *The Intermediate Phase may overlap with or follow the Early Phase response within as little as a few hours and can last for weeks or months. This phase is assumed to begin after the incident source and releases have been brought under control and protective action decisions can be made based on measurements of exposure and radioactive materials that have been deposited. Protective actions in the Intermediate Phase are intended to reduce or avoid dose to the public, control worker exposures and the spread of contamination, and prepare for late-phase cleanup.*

As a response continues, response leaders may need to start considering longer-term impacts of the radiological release, such as impact to crops and animal products, water, and conducting a more thorough characterization of the affected area. These response objectives will require a higher degree of certainty than those considered in the Early Phase, and traceable, defensible methods and results supporting any decisions.

During the Intermediate Phase of a response, decisions may be made at a slower pace than those in the Early Phase. The guidance presented in this section are intended to be applied during the Intermediate Phase. Some actions listed in Section 4.0 could occur during the transition between the Early and Intermediate Phases. Under these conditions it is likely that data assessors could request or reconcile incomplete or suspicious flags on data from the Early Phase. Reconciliation could be accomplished via direct requests to data providers, secondary sampling, or other additional information relating to the objective.

A data assessor is a person that might act in any of several roles during an incident. A data assessor could be a health physicist, a technical subject matter expert, an on-call individual, or someone that has training as a ROSS. Data assessment is not required to be completed by those with these specific roles, but it is likely that those individuals would be able to perform the data assessment as part of their responsibilities. It is also expected that federal personnel will be present and therefore able to provide data assessment support by the Intermediate Phase.

5.1 Screen Items

Objective: Collect and screen potentially contaminated materials and equipment.

5.1.1 Review Objective

Applicability: During the Intermediate Phase, response leaders decide to start the process of releasing some items that may have been contaminated from areas affected by the radionuclide release. These items may be of importance to the public and can be, but are not limited to, personal or business belongings, research material, valuables, or other items. To release items, workers need to survey the items with handheld instruments. In addition, if workers decontaminate an item, repeat measurements are needed to confirm that the item meets the requirements for release.

The data collected and used to make the determination for release need to be complete and provide a valid representation of the radiological conditions of the items. In the absence or inability to validate the data sufficiently, response leaders should err on the side of caution and not release an item rather than releasing an item that may not meet release requirements.

Assumptions: If the following assumptions do not hold for the objective being addressed, note that some conditions of the data assessment flags and conclusions outlined below may need to be changed.

- This section is intended for the survey and release of materials and equipment from controlled areas.
- This section applies to survey data on items that may need to be relocated or released from the affected areas or will require immediate mitigation activities to restore their use or preserve them.
- These items may have significant intrinsic value to commerce, the public, the humanities, or public services. Examples of these are ambulances, fire trucks, works of art, power generation equipment, and construction equipment.
- These materials have not previously been surveyed and they will be screened and decontaminated in an iterative process.
- This section does not cover land area or buildings – use Section 5.2 instead.
- Individual items will be surveyed, which may themselves contain smaller subsets of items (e.g., a vehicle containing personal property). In general, however, since individual item screening is the focus, a sampling plan will be unnecessary, though survey policies (such as vehicle areas or the outside of containers) will likely be in place.
- Surveys, for both fixed and removable contamination, are considered. Sampling is not considered here.
- Alpha, beta, and gamma radiation are all considered for this objective.
- The assessor has contaminant-specific efficiency conversions for each instrument used to collect the data.
- These data are promptly assessed after an item has been surveyed.
- The quality assessment criteria assume surveys are performed to meet release criteria for removable contamination rather than for fixed contamination as in the more conservative case.
- The radionuclides released have already been identified so that data assessors know what radiation emission types to expect.

5.1.2 Gather Data

All of the listed data elements in Table 9 could be provided in this objective and phase by responders. The successive sections will detail the data assessment process for these possible data types.

Table 9. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	✓
Samples	
Dose rate measurements	✓
Spectral measurements	
Raw count rates	✓
Background dose rates	✓
Background spectra	

5.1.3 Apply Verification Flags

Using Table 10 as a guide, the data assessor reviews each measurement and applies flags for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing.

Table 10. Verification Data and Flags

Data	Flag if Missing
Background measurement	Incomplete
Date the measurement was taken	Incomplete
Distance of probe/instrument to surveyed surface	Suspicious
Instrument calibration or certification records	Incomplete
Instrument counting efficiency (the value of this conversion factor will depend on the instrument and what units the detector reports in and the units needed for assessment)	Incomplete
Instrument calibration or certification records[a]	Incomplete
Instrument make and model, and of associated probes	Incomplete
Instrument serial number	Incomplete
Instrument range selection	Incomplete
Location	Incomplete
Measurement unit	Incomplete
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual (if applicable)	Suspicious
Orientation of probe or instrument to surveyed surface	Suspicious
Survey method and area	Suspicious
Time of day the measurement was taken	Incomplete
Type of material on nearby surfaces relative to the detector	Suspicious

Flags Unique to this Objective

Data	Flag if Missing
A map or image showing the survey location on the item	Suspicious
Description of the location of each survey on the item	Incomplete

(a) It is recommended that the calibration records be consistent with at least Tier 2 equipment maintenance records (annual quantitative source check) per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies”. (NCRP 2022).

5.1.4 Apply Validation Flags

Using Table 11 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 11. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Precision	Review the instrument information and measurement value and units.	The instrument does not provide a readout in activity units.	Imprecise			
Accuracy	Review instrument calibration records.	1. Meter is past calibration date. 2. The instrument had an issue with calibration. 3. No calibration information is available. 4. Consistent response check performed and passed.	If 1 or 2: Out of calibration If 3: Incomplete If 4: No Flag			
Representativeness	Check measurement location against a representation of the item.	Measurement location does not reflect the item in question.	Invalid			
Completeness	Review the number of "Suspicious" flags applied to the measurement.	Three or more "Suspicious" flags have been applied.	Suspicious context	Review the survey of the item.	Portions of the item exposed to the environment were inaccessible during the survey.	Incomplete
Comparability	Note the units of the measurement, and available conversion factors.	The measurement is not reported in cpm.	Invalid			
Sensitivity	Compare the instrument range selection to the measured value.	The lower range of sensitivity is higher than the release limit.	Invalid	Review the meter used for the survey.	The meter is not sensitive to the known contaminant.	Invalid

5.1.5 Assess Data Quality

Using Table 12 as a guide, the data assessor reviews the data and how they are flagged from both the verification and validation steps. One possible conclusion is presented in Table 12, given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 12 should be used as a starting point. The conclusions from these tables will inform which measurements to include in the final analysis and assessment of the collected data to relay to response leaders.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, can be used to translate CBRN Responder data flags into the "Suspicious" and "Incomplete" data flags used here as well as the additional flags applied during validation.

Table 12. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The "Imprecise" flag has been applied to an individual measurement.	• If a background measurement from the same instrument is available, compare the two measurements. If the response value is greater than the background value by three (e.g., if the background value is 1 and the response value is 3), then radioactive contamination may be present. • If no background measurement with the same instrument is available, a background measurement should be performed away from any areas and items suspected of elevated background levels. • If a background measurement with the same instrument cannot be performed, additional confirmatory measurements of the item should be performed. • If a background measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Out of Calibration" flag has been applied.	• An additional confirmatory measurement should be performed with a different instrument for the same item. • If an additional confirmatory measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Invalid" flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • It may be necessary to collect a new measurement to replace the invalid one.

Condition	Possible Conclusions
The “Incomplete” flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements for the item should be performed.
A ”Suspicious Context” flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other measurements are available. • Additional confirmatory measurements for the item should be performed.
The number of ”Suspicious” flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements for the item should be performed.
The number of measurements is less than the requested number.	• For small items that are easily carried or transported, if there are <2 measurements that apply request additional measurements. • For larger items such as power generation equipment or ambulances, a relevant sampling procedure should have been generated and followed to produce the minimum number of required surface locations that must be surveyed.

Data Assessment Conclusion

Conditions	Possible Conclusions
One or more measurements are greater than the threshold of concern.	• It is likely that the item does not meet the release threshold. • Compare the radiation measurements to an actionable threshold. • Decontamination may be needed and another screening of the item should take place before release.
None of the above conditions are true.	• It is unlikely that the item is contaminated.

Statistical analysis of the collected data is not required for this objective to reach these conclusions. It is crucial to make sure the correct number of measurements have been taken or that the proper applicable standard operating procedure is followed to survey the item in question. These measurements can then be used promptly to reach conclusions regarding necessary decontamination or releasing the item by following the outlined data assessment process.

5.2 Release Areas

Objective: Determine whether the estimated affected area can be reduced, and areas may be released for the return of the public.

5.2.1 Review Objective

Applicability: This objective applies to decisions about whether contamination or radiation levels in a representative area can be said to be below an incident action level. Data assessors review the observed data and compare them against the determined release criteria. The release criteria could be based on DRLs that the incident response team developed based on the specific nuclides present, the dispersal and transport of the release, the respective decay of the nuclide(s) present, or other criteria agreed upon by the response leaders. Hence, the data presented and used to make the decisions need to be precise, complete, and provide a valid representation of the conditions within the restricted area (e.g., the Hot Zone) that response leaders could restrict access to non-radiation workers.

To make timely decisions, authorities need to know if PAGs or DRLs will be exceeded should the public or workers return, and whether there are sufficient resources to ensure that the public or workers will not stray into those contaminated areas where access could pose significant health risks. Greater levels of exposure are allowable for workers and volunteers in controlled areas, where the duration of time they may remain in the controlled areas is dictated by the measured levels and PAGs or DRLs.

Assumptions: If the assumptions listed here do not hold for the specific scenario being addressed, note that some conditions of the data assessment flags and conclusions outlined below may need to be changed.

- Administrative entry or access restrictions have been implemented on an area during the Early Phase based on suspected contamination.
- Preliminary surveys, samples, or both have been conducted in an area of interest, the area was initially characterized with a certain level of contamination, and now the incident response personnel need to determine how likely it is that subsections of this area are below incident action level and can be released for public use again.
- The areas of interest may be in a region where radiation exposure levels are elevated but insufficiently elevated to be required to be administratively controlled.
- Restricted areas are assumed to be larger than the confirmed contaminated areas, and the restricted area will fully contain these contaminated areas, including hot spots.
- An incident action level has been established to compare to measured values.
  - In this example, we assume the incident action level is a DRL, and the value is 100 pCi/cm^2 of cesium-137.
- These methods are intended to be used to release the area for unrestricted use, but the same methods would apply to incremental confirmation and stepwise clearing of administratively controlled areas.
- After the Early Phase, response personnel will identify those minimally affected or unaffected areas and then determine the feasibility to reduce the restricted area size based on the extent and level of contamination.

- Data collection could be a combination of scan (moving) and static (non-moving) surveys as well as samples for removable contamination for collection and analysis, depending on the sensitivity required.
- The assessor is provided with relevant efficiency as a function of energy (and therefore radionuclide) information available to them for all instruments used to collect the data.
- A survey plan was designed for a contiguous subsection of a controlled area (not individual items) and completed as intended.
- The concentration of cesium-137 activity per unit area is calculated for all survey measurements using calibrated instrument efficiency values. Methods for performing such calculations are outside the scope of this guidance.

5.2.2 Gather Data

All of the data elements listed in Table 13 could be provided for use in addressing this objective. The following sections will detail the data assessment process for these possible data types.

Table 13. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	✓
Samples	✓
Dose rate measurements	
Spectral measurements	✓
Raw count rates	
Background dose rates	
Background spectra	✓

5.2.3 Apply Verification Flags

Using Table 14 as a guide, the data assessor reviews each measurement and applies flags for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing.

Table 14. Verification Data and Flags

Data	Flag if Missing
Background measurement (should have already been obtained in the Early Phase or from planning/preparation by civil authorities)	Suspicious
Date of collection	Incomplete
Distance of instrument to surface being measured	Suspicious
Instrument calibration or certification documents	Incomplete
Instrument efficiency (the value of this conversion factor will depend on the instrument and what units the detector reports in and the units needed for assessment)	Incomplete
Instrument calibration or certification records[a]	Incomplete
Instrument make and model, and of associated probes	Incomplete

Data	Flag if Missing
Instrument serial number	Suspicious
Instrument settings	Suspicious
Location of the survey or sample collection	Incomplete
Measurement unit	Incomplete
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual	Suspicious
Orientation of instrument to nearby surfaces	Suspicious if survey results, none otherwise
Sample collection procedure	Suspicious if sampling results, none otherwise
Time of day and date of analysis	Incomplete if sampling results, none otherwise
Type of material on nearby surfaces relative to the detector	Suspicious if survey results, none otherwise

Flags Unique to this Objective

Data	Flag if Missing
Alarm type (if applicable)	None
Batch ID number	Suspicious if sampling results, none otherwise
For collected samples, shipping manifest (if applicable)	None
If a moving survey method was used, the approximate speed of the meter or vehicle the meter was in	Suspicious if survey results, none otherwise
If sent to lab, chain of custody (COC) documentation	Suspicious if sampling results; none otherwise
If survey, method – stationary or scanning (an instrument in a moving vehicle is considered a scan)	Suspicious if survey results, none otherwise
If used, flow/volume meter identification (ID) number	Incomplete if sampling results, none otherwise
If used, sample equipment ID numbers	Suspicious if sampling results, none otherwise
Isotope identification confidence (radioisotope identification device [RIID] or laboratory testing certainty)	Suspicious
Isotopes identified (RIID, shipping paper, other identifier)	Suspicious
Lab analysis flag indicators	Suspicious if sampling results, none otherwise
Sample analysis method	Incomplete if sampling results, none otherwise
Sample depth (i.e., surface, bottom, specific depth with measurement)	Suspicious if sampling results, none otherwise
Sample ID number	Incomplete if sampling results, none otherwise
Sample preservation method (or if N/A)	Suspicious if sampling results, none otherwise
Sample size (or sample volume)	Incomplete if sampling results, none otherwise

Data	Flag if Missing
Sample storage method	Suspicious if sampling results, none otherwise
Sampling position (i.e., shoreline, grass, asphalt, instream	Suspicious if sampling results, none otherwise

(a) It is recommended that the calibration records be consistent with at least Tier 1 equipment maintenance records (annual quantitative source check) per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies”. (NCRP 2022).

5.2.4 Apply Validation Flags

Using Table 15 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 15. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Precision	Review the instrument information and measurement value and units.	The instrument does not provide a readout in activity units.	Imprecise	For surveys, review the instrument information and measurement value and units.	Instrument cannot reliably detect contaminant of interest.	Imprecise
Precision				For samples, review the sample results.	The sample results do not achieve an uncertainty of 10% or less.	Imprecise
Accuracy	Review instrument calibration records, if available.	1. Meter is past calibration date. 2. The instrument had an issue with calibration. 3. No calibration information is available. 4. Consistent Response Check performed and passed.	If 1 or 2: Out of Calibration If 3: Incomplete If 4: No Flag			
Representativeness	Review measurement location against a map of the area of interest.	Measurement location is well beyond the farthest expected spread of contaminated material and useful background measurements.	Invalid	Review the survey map or sampling plan.	The measurement does not fall within the planned survey or sample area.	Suspicious Location
Representativeness				Note the time of the measurement and compare to any information about the release, if available.	The time of the measurement precedes the expected release.	Invalid
Representativeness				Note the radionuclide ID results, if present.	The radionuclide ID results do not include cesium-137.	Suspicious Context

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Completeness	Review the number of "Suspicious" flags applied to the measurement.	Three or more "Suspicious" flags have been applied.	Suspicious Context			
Comparability	Note the units of the reported sample results.	The units are not equivalent to release criteria or reported in anything other than activity per area (e.g., pCi/cm^2).	Invalid	Note the units of the reported survey concentration calculation results.	The units are reported in anything other than activity per area (e.g., pCi/cm^2).	Suspicious Units
Comparability				Note whether a representative background value is available.	No representative background value is available.	Background Missing
Sensitivity	For surveys, compare the instrument settings (for example the scale, range, and so on) to the measured value.	The measured value is lower than, or at the lower limit of, the instrument's sensitivity range, but higher than the threshold for release.	Invalid	For samples, compare the reported measurement value to the reported minimum detectable activity (MDA).	The reported measurement value is less than the calculated MDA, but higher than the release threshold.	Invalid

5.2.5 Assess Data Quality

Using Table 16 as a guide, the data assessor reviews the data and how they are flagged from both the verification and validation steps. One possible conclusion is presented in the following Table 16, given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 16 should be used as a starting point. The conclusions from these tables will inform which measurements to include in the final analysis and assessment of the collected data to relay to response leaders.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, can be used to translate CBRN Responder data flags into the "Suspicious" and "Incomplete" data flags used here as well as the additional flags applied during validation. Additionally, laboratory analysis will oftentimes apply its own data quality flags as established in ANSI/ANS-41.5-2012 (ANSI 2012). Appendix B also provides guidance for translating ANSI/ANS-41.5-2012 flags into the flags provided in this guidance.

Table 16. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The "Imprecise" flag has been applied to an individual measurement.	• If a background value from the same area is available, compare the two values. If the response value is greater than three times the background value (e.g., if the background value is 5 pCi/cm^2 and the response value is 15 pCi/cm^2), then radioactive contamination may be present. • If no background value from the same area is available, a background measurement should be performed away from any areas suspected of elevated background levels. • If a background sample or a background measurement with the same instrument cannot be performed, additional confirmatory samples or measurements near the same locations should be performed. • If a background sample or a background measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Out of Calibration" flag has been applied.	• An additional confirmatory measurement should be performed with a different instrument in the same location. • If an additional confirmatory measurement with the same instrument cannot be performed, an "Invalid" flag may be applied to this measurement.

Condition	Possible Conclusions
The "Invalid" flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • For sample results, an explanation for the result should be sought from the responsible analysis laboratory. • It may be necessary to collect a new measurement to replace the invalid one.
The "Suspicious Location" flag has been applied to an individual measurement.	• An explanation for the deviation from the plan should be sought from the individual who collected the measurement. • If the location of the measurement is similar in terms of materials (e.g., same building materials for surveys or same sample media for samples) and representative of the population of interest, it may be considered valid. • If the location of the measurement is too dissimilar in terms of materials (e.g., same building materials for surveys or same sample media for samples) or is not representative of the population of interest, it may be considered Invalid. • It may be necessary to collect a new measurement to replace the invalid one.
The "Suspicious Units" flag has been applied to an individual measurement.	• An explanation for the incorrect units should be sought from individual who performed the survey concentration calculation. • If an explanation cannot be provided or is not satisfactory, the calculation results should be disregarded for this analysis. • If a mistake in the calculation is found and able to be corrected, the result should be reviewed again.
The "Background Missing" flag has been applied to an individual measurement.	• The background value from a similar instrument and location may be used. • A new background measurement may be collected from an area outside any contaminated areas but still representative of the area of interest.
The measurement indicates elevated radiation readings but identified isotopes are consistent with naturally occurring radioactive material (NORM).	• Additional scrutiny should be applied to the measurement to determine whether all of the elevated radiation readings can be attributed to background. • Additional confirmatory measurements from first responders may be sought using a nuclide identification (ID) with a radioisotope identification device (RIID) and/or survey for alpha and/or beta contamination. • If the elevated readings can be entirely attributed to background, the measurement should be considered valid, but not used for the data quality assessment (DQA) section of this objective. Additional measurements may be required to be collected.

Condition	Possible Conclusions
The “Incomplete” flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements in the same locations should be performed.
A ”Suspicious Context” flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other nearby measurements are available. • Additional confirmatory measurements in near same location as the original measurement should be performed.
The number of ”Suspicious” flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements in the same area should be performed.
The measurement time of a spectroscopic measurement appears to exceed the reported isotope’s half-life.	• The measurement should be disregarded for this analysis. • Additional confirmatory measurements in near same location as the original measurement should be performed.

Before drawing conclusions, the data assessor should perform a one-sided, non-parametric upper tolerance limit test. The data assessor should use Equation 1:

$$P = exp\left(\frac{\ln\left(1-\frac{C}{100}\right)}{n}\right) \quad \text{(Eq. 1)}$$

where: *n* is the number of measurements making up the distribution, *C* is the percent confidence level (e.g., “95” for the 95% confidence level), and *P* is the fraction of the area (a percentile of the distribution, e.g., 95% of an area is expressed as 0.95) (Figure 3).

Put into words, the result of this calculation can be described as follows:

> “Given *n* measurements, we can be *C* percent confident that *P*100* percent of the area is below the action level.”

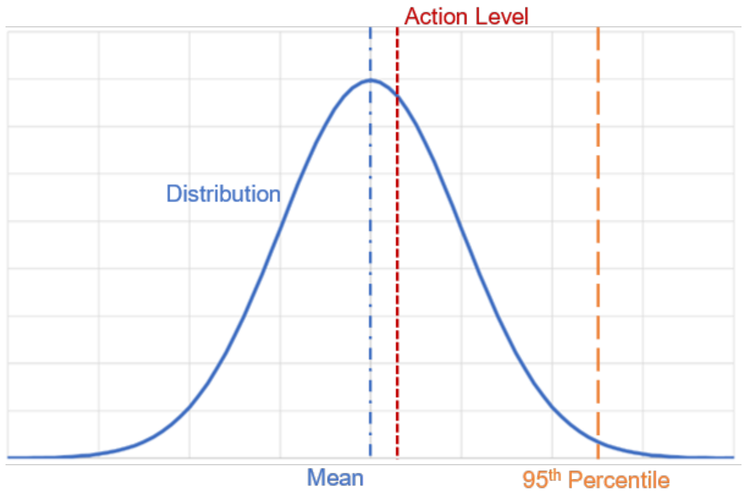

Figure 3. Comparison of the mean and 95th percentile of a distribution compared to a possible action level. It is possible for the mean to be below the action level while a significant part of the distribution is above the action level.

This method may be used in three ways:

1. Given the percent confidence desired (*C*) and the number of acceptable measurements (*n*), the data assessor may determine the percentage of the area (*P*) that can be proven to be lower than the action level;
2. Given the percent confidence desired (C) and the percentage of the area (P) that must be proven to be lower than the action level for release, the data assessor may determine the number of acceptable measurements that must be available (n); or
3. Given the number of acceptable measurements available (n) and the percentage of the area (P) that must be proven to be lower than the action level for release, the data assessor can calculate the percent confidence (C) of that analysis.

The way in which the data assessor should use this equation depends on the information requested by response leaders. See the example below. In all cases, the data assessor should be careful to state the results of this calculation similar to the phrase provided.

In theory, the size of the area that can be addressed by this calculation does not have a limit. Practically:

1. The area should contain terrain that is roughly homogeneous throughout the area. For example, the area should not contain both city blocks and forested areas. If this is the case, the area should be split into two or more areas.
2. The area does not include regions with different suspected levels of contamination. For example, a single area should not include parts that are suspected of being Dangerous Radiation Zones, a Hot Zones, and a Cold Zones. If this is the case, the area should be split into a different area for each zone.

Example: Response leadership wants to decrease the restricted area size by comparing them to a release threshold. Data have been taken in this area according to a predetermined sampling plan to compare the measured level of contamination against previous background reading samples of the area to release it. Response leadership wants to limit the likelihood that measurements in a certain percentage of the area of interest are greater than 100 pCi/cm² to 5%. This means that response leadership wishes to have 95% confidence (100% − 5% likelihood limit). Twenty-one measurements are collected to support this evaluation, and none are greater than 100 pCi/cm². The data assessor then performs the calculation, where C = 95 and n = 21:

$$P = exp\left(\frac{\ln\left(1-\frac{C}{100}\right)}{n}\right) = exp\left(\frac{\ln\left(1-\frac{95}{100}\right)}{21}\right) = 0.867$$

$$P * 100 = 0.867 * 100 = 86.7\%$$

The data assessor can then state that at the 95% confidence level, 86.7% of the area in question is below the threshold of 100 pCi/cm² given the 21 measurements.

Response leadership is responsible for deciding what action to take following this finding.

Data Assessment Conclusion

One or more measurements are greater than the incident action level.

- It is likely that at least some portion of the surveyed area is not able to be released.
- If the cesium-137 concentration is decreasing over time, the predictive models should be consulted to determine isotopic composition and anticipated duration of impact.
- For any cesium-137 concentrations reportedly increasing over time, additional confirmatory measurements in near same location as the original measurement should be performed.
- If a measurement greater than the incident action level is surrounded by measurements less than the incident action level, this may indicate the presence of a hotspot, materials (e.g., rubble) shielding the source, instrument error, or a variety of other field conditions. It is still recommended that measurement locations greater than the incident action level of concern be treated as such, but that additional measurements be collected to better characterize the area.

No measurements are greater than the incident action level.

- Perform a one-sided, non-parametric upper tolerance limit test.
- When possible, a percent confidence or percentage of the area of concern should be specified and provided to the data assessor.
- Once the data assessor has completed the calculation, they should state their answer as “Given n measurements, we can be C percent confident that P*100 percent of the area is below the action level.”

5.3 Scan for Hotspots

Objective: Identify hot spots by comparing measured contamination levels as a function of location.

5.3.1 Review Objective

Applicability: Small variations in wind currents, building air intakes and outlets, static electricity, landscaping, and temperatures may cause uneven deposition of contamination in any area. The areas with high radiation measurements compared to the background levels or adjacent areas indicate hotspots. Hotspots are localized areas of greater activity relative to surrounding areas and must be handled accordingly for responders and release. A hotspot can be as low as three times local background or at predetermined dose rate or activity levels.

For most response scenarios, measurements collected using predetermined spacing (e.g., transects) are used to understand the average and distribution of activity across an area compared to an actionable limit. However, some hotspots are relatively small when compared to the larger surveyed area, and the data assessors should be less concerned with the measurements being far apart or evenly spaced. Hence, the data assessor should consider having two measurements from two different instruments more important in verification and validation than having multiple measurements from different locations.

In this context, the workers will directly survey an area of interest where they suspect a hotspot exists or may exist. The measurements they take may require conversion from counts to disintegrations per minute (dpm) and the worker will use the instrument's counting efficiency to convert the measurement (e.g., dpm = (cpm – background)/counting efficiency). The data assessor can compare the measurements to the surrounding measurements and determine whether the hotspot exists and which mitigative activities will reduce exposures to workers.

Assumptions: If the assumptions listed here do not hold for the objective being addressed, some conditions of the data assessment flags and conclusions outlined below may need to be changed.

- The area of interest was initially characterized with a certain level of contamination, and now the incident response personnel need to perform additional surveys to identify any possible hotspots in the area due to suspected uneven deposition.
- Survey teams may suspect or find small areas where the level of radiation contamination is measurably greater than background in an easily definable area as compared to the area of interest as a whole. Radiation workers and health physicists refer to these areas as hotspots.
- The radiation level considered to indicate a hotspot will be relative to the average radiation level of the area of interest. For example, a hotspot in an area where the average radiation level is background might be defined as any locations at three times the background level. How hotspots in a contaminated area may have a different definition that is based on the average amount of contamination in the area.
- This objective does not apply to identifying locations of higher activity on an object for decontamination.
- For the purposes of the example, this section only applies to a gamma-emitting isotopes and applicable radiation instruments.

- Data are collected in a continuous fashion where the survey meter is held at waist height (approximately 1 meter) above the ground, not accounting for surface roughness. Ideally, measurement values will have been recorded every second to generate a nearly continuous "line" of measurements along each transect. However, it may be the case that only an average or maximum reading for each transect is recorded. The data assessment method in this section can be applied to both types of data collection.
- A background or average non-hotspot level of radiation is known for the area of interest and instrument used.
- It is recommended that a transect be walked every 2 meters to provide appropriate coverage to find localized hotspots that may only be slightly above an incident action level. If 2-meter transects are not possible, then the closest possible spacing should be used.
- The data assessor will use comparable units for specific data types (e.g., for dose use mR/hr, for counts use cpm).
- The assessor has relevant detection efficiency as a function of energy (and therefore isotope) information available to them for all instruments used to collect the data.
- Sampling is not considered for this objective.
- Other areas may have been grouped into this general restricted area that are below action levels. The previous section should be used to address releasing any areas that may fall below the action level, taking into account their proximity to these hotspots.

5.3.2 Gather Data

All of the listed data elements in Table 17 could be provided in this objective and phase by responders. The successive sections will detail the data assessment process for these possible data types.

Table 17. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	✓
Samples	
Dose rate measurements	✓
Spectral measurements	
Raw count rates	✓
Background dose rates	✓
Background spectra	

5.3.3 Apply Verification Flags

Using Table 18 as a guide, the data assessor reviews each measurement and applies flags for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing. In a few cases where the missing data has no influence on safety decisions, the data assessor has the option to not flag the data.

Table 18. Verification Data and Flags

Data	Flag if Missing
Background measurement (should have already been obtained in the Early Phase or from planning/preparation by civil authorities)	Suspicious
Date the measurement was taken	Incomplete
Distance of instrument to surface being measured	Suspicious
Instrument calibration or certification documents[(a)]	Incomplete
Instrument efficiency (the value of this conversion factor will depend on the instrument, in what units the detector reports, and the units needed for assessment)	Incomplete
Instrument make and model, and of associated probes	Incomplete
Instrument serial number	Suspicious
Instrument range selection	Suspicious
Location	Incomplete
Measurement units	Incomplete
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual	Suspicious
Orientation of instrument to nearby surfaces	Suspicious
Survey method – stationary or scanning (an instrument in a moving vehicle is considered a scan)	Incomplete
Time of day the measurement was taken	Incomplete
Type of material of nearby surfaces relative to the detector	Suspicious

Flags Unique to this Objective

Date	Flag if Missing
Alarm type (if applicable)	None
If a moving survey method was used, the approximate speed of the meter or vehicle the meter was in	Incomplete
Isotope identification confidence (if applicable)	None
Isotopes identified (if applicable)	None

(a) It is recommended that the calibration records be consistent with at least Tier 2 equipment maintenance records (annual quantitative source check) per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies” (NCRP 2022).

5.3.4 Apply Validation Flags

Using Table 19 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 19. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Precision	Review the instrument information and measurement value and units.	The instrument does not provide a dose readout, but the value is representative of a dose range.	Imprecise	Review the instrument information and measurement value and units.	Instrument does not report in comparable units. (e.g., mr/hr not cpm).	Invalid
Accuracy	Review instrument calibration records, if available.	1. Meter is past calibration date. 2. The instrument had an issue with calibration. 3. No calibration information is available. 4. Consistent response check performed and passed.	If 1 or 2: Out of calibration If 3: Incomplete If 4: No flag			
Representativeness	Review measurement location against a map of the area of interest.	Measurement location is well beyond the farthest expected spread of contaminated material and useful background measurements.	Invalid	Review the survey map or sampling plan.	The measurement does not fall within the planned survey or sample area.	Suspicious location
Completeness	Review the number of “Suspicious” flags applied to the measurement.	Three or more ”Suspicious” flags have been applied.	Suspicious context			

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Comparability	Note the units of the measurement, and available conversion factors.	The measurement is not reported as dose rate (mR/hr) or count rate (cpm).	Invalid			
Sensitivity	Compare the instrument range selection to the measured value.	The measured value is lower than, or at the lower limit of, the instrument's sensitivity range.	Invalid	Review the meter used for the survey.	The meter is not sensitive to the known contaminant.	Invalid
Sensitivity				Note the height of the measurement.	The distance from the ground is not known.	Invalid

5.3.5 Assess Data Quality

Using Table 20 as a guide, the data assessor reviews the data and how they are flagged from both the verification and validation steps. One possible conclusion is presented in Table 20 given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 20 should be used as a starting point. The conclusions from this table will inform which measurements to include in the final analysis and assessment of the collected data to relay to decision makers.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, can be used to translate CBRN Responder data flags into the "Suspicious" and "Incomplete" data flags used here as well as the additional flags applied during validation.

Table 20. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The "Imprecise" flag has been applied to an individual measurement.	• If a background measurement from the same instrument is available, compare the two measurements. If the response value is greater than the background value by three (e.g., if the background value is 100 cpm and the response value is 300 cpm), then radioactive contamination may be present. • If no background measurement with the same instrument is available, a background measurement should be performed away from any areas suspected of elevated background levels. • If a background measurement with the same instrument cannot be performed, additional confirmatory measurements near the same locations should be performed. • If a background measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Out of Calibration" or "none" flag has been applied in regards to instrument calibration information.	• An additional confirmatory measurement should be performed with a different instrument in the same location. • If an additional confirmatory measurement with the same instrument or same type of instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Invalid" flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • It may be necessary to collect a new measurement to replace the invalid one.

Condition	Possible Conclusions
The "Incomplete" flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements in the same locations should be performed.
The "Suspicious Location" flag has been applied to an individual measurement.	• from the individual who collected the measurement. • If the location of the measurement is similar in terms of materials (e.g., same building materials for surveys or same sample media for samples) and representative of the population of interest, it may be considered valid. • If the location of the measurement is too dissimilar in terms of materials (e.g., building materials for surveys or same sample media for samples are different) or is not representative of the population of interest, it may be considered Invalid. • It may be necessary to collect a new measurement to replace the invalid one.
A "Suspicious Context" flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other representative measurements are available. • Additional confirmatory measurements in near same location as the original measurement should be performed.
The number of "Suspicious" flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements in the same area should be performed.

Before drawing conclusions, the data assessor should estimate what the greatest undetected activity could be. The largest possible undetected hotspot can be estimated using measurement values from the transects, triangulation, and geometric efficiency. The left side of Figure 4 shows the assumed transect method viewed from above: straight lines covering the area of interest that have an even spacing. The right side of Figure 4 depicts a triangle that can be drawn between the instrument location (100 cm above the ground), a given transect line on the ground (Point A), and the transect spacing. The horizontal distance between the survey instrument and Point B in Figure 4 is defined as one-half of the transect spacing (e.g., for a transect spacing of 200 cm, the horizontal distance would be 100 cm). The method is based on a specific set of one or more radionuclides of concern producing a known detector response (e.g., a count rate or dose rate) at a known distance. This way, the efficiency of the instrument need not be known.

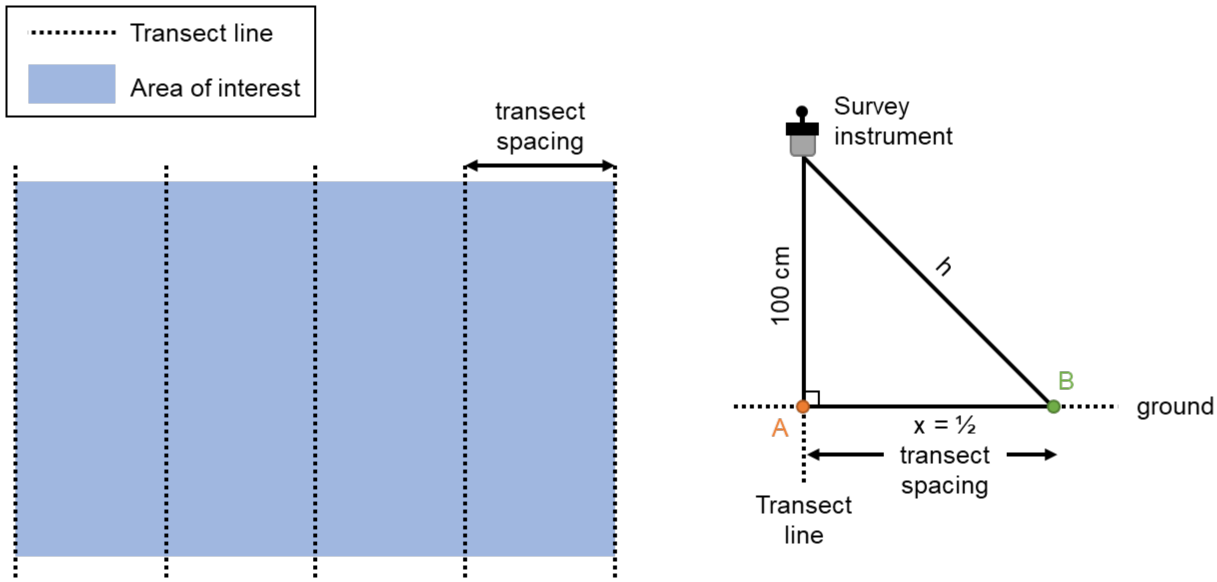

Figure 4. Illustration of transect lines and spacing covering an area of interest (left). Illustration of the geometry of a survey instrument and possible hotspot locations (A and B) in relation to the transect line (right).

The method should be enacted as follows:

1. Define the detector response threshold of concern based on the incident action level. This may be accomplished in different ways, depending on how the incident action level is defined. For example, if the action level is defined as a certain concentration of specific radionuclides, the detector response threshold may be defined as the average detector response (e.g., dose rate or count rate) that would be measured if the detector were positioned 100 cm directly above a point source that includes the radionuclides of concern. If the action level is defined, for example, as three times the background, then the detector response threshold may be defined as three times the normal detector response measured in a background area.
2. Compute the hypotenuse of the triangle shown in Figure 4. The hypotenuse is computed using Equation 2:

$$h = \sqrt{(100\ cm)^2 + x^2}, \quad \text{(Eq. 2)}$$

   where h is the hypotenuse and x is equal to half of the transect spacing (e.g., if the transect spacing is 200 cm, then x = 100 cm).
3. Compute the detector hotspot threshold based on Equation 3:

$$D_{hotspot} = D_{response}\frac{(100\ cm)^2}{h^2} \quad \text{(Eq. 3)}$$

   where $D_{hotspot}$ is the detector hotspot threshold, $D_{response}$ is the detector response threshold of concern defined in step 1, and h is the hypotenuse of the triangle computed in step 2.

The detector hotspot threshold now represents the value above which radioactivity exceeding the incident action level may be present for the entire area of interest.

This method assumes:

- Transect spacing is the same between all transect lines; and
- Minimal attenuation (from air and other materials) between the instrument and any radioactive material on the ground.

If either assumption does not hold for the measurements being reviewed, then the data assessor will need to modify the following method.

If the transect spacing is not consistent, then the data assessor should either compute a greatest undetected activity for each transect line or use the greatest transect spacing present.

If the attenuation between the instrument and possible radioactive material on the ground is expected to be significant, then the data assessor should modify the calculations in step 3 to account for this attenuation. Note that as the transect spacing increases to the order of tens of meters, even higher-energy gamma rays (i.e., 1 MeV and greater) will start to experience significant attenuation due to air.

Example: A football field has been surveyed following an RDD detonation nearby. Response leadership would like to know if the football field might contain any hotspots. The survey measurements were conducted by responders walking across the field, creating transects every 5 yards for a total of 25 measurements (two in each end-zone and 21 for the yard lines). Each measurement was reported as the maximum dose rate observed during a transect. Response leadership is concerned about any reading greater than 10 mR/hr.

1. The detector response threshold of concern is 10 mR/hr, equal to the incident action level in this case.
2. The transect spacing is 5 yards, which is 457.2 cm.

   Therefore, x = 0.5*457.2 = 228.6 cm.

$$h = \sqrt{(100\ cm)^2 + x^2} = \sqrt{(100\ cm)^2 + (228.6\ cm)^2} = 249.52\ cm$$

   The hypotenuse is this 249.52 cm.

3. The detector hotspot threshold is computed:

$$D_{hotspot} = D_{response}\frac{(100\ cm)^2}{h^2} = (10\ mR/hr)\frac{(100\ cm)^2}{(249.52\ cm)^2} = 1.6\ mR/hr$$

Data Assessment Conclusion

One or more measurements are greater than the incident action level.

- It is likely that some portion of the surveyed area may encompass an elevated radiation level or hot spot.
- Additional confirmatory measurements should be conducted, including gamma spectroscopy measurements, and surveys for alpha and beta contamination near where the measurements exceeded the incident action level.

One or more measurements are greater than the detector hotspot threshold ($D_{hotspot}$), but no measurements are greater than the incident action level.

- It is possible that a hotspot exists but was not directly in the path of any of the transect lines.
- Conduct additional coarse surveys with finer transect spacing between transects already measured.
- Additional confirmatory measurements may be sought, including gamma spectroscopy measurements, and surveys for alpha and beta contamination.

No measurements are greater than the detector hotspot threshold ($D_{hotspot}$).

- It is unlikely that there are any hotspots greater than the incident action level in the area of concern.
- The entire location can be handled as one unit when considering action levels and release criteria.
- Additional confirmatory measurements may be sought, including gamma spectroscopy measurements, and surveys for alpha and beta contamination.

5.4 Assess Radioactive Contamination Levels in Agricultural Products: Vegetation and Animal Products

Objective: Analyze vegetation samples to monitor if radioactive contamination is present and exceeds incident action levels.

5.4.1 Review Objective

Applicability: Following a release of radioactive material, the impact on agriculture will need to be determined. This includes initial plume modeling, sampling, and decision making regarding the embargo of these agricultural products, such as vegetation and animal milk, based on the determined incident action levels and public protective actions. Based on the isotope, the uptake of the plant matter, the dispersion of the plume, and the level of contamination released, these incident action levels are determined and dictate the amount of intake that is allowable, or whether the crop should be embargoed. Additionally, depending on these findings, restrictions on animal products such as cow's milk or meat may also be enforced to avoid ingestion of contaminated products propagated through the food chain. Commonly the agricultural impacts of a release are more far-reaching than those caused by shelter-in-place orders. The release affects the food supply, the economy, and national and international supply chains. For this scenario, and its possibly large implications, it is crucial to ensure the data presented and used to make the decisions are of high quality, complete, and provide a valid representation of the conditions within the area of concern.

Assumptions: Note that if the assumptions listed here do not hold for the objective being addressed, some conditions of the data assessment flags and conclusions outlined below may need to be changed.

- Sampling has been conducted for a population of interest (e.g., population of items like vegetation or animal products) and the incident response personnel need to determine how likely it is that there is contamination above regulatory limits.

- Possibly contaminated vegetation might be directly ingested by the human population.
  - The human population will be once removed from the contamination when ingesting animal products created from livestock that would have directly ingested contaminated food supplies.
  - Different DRLs and actionable limits will therefore apply for these different ingestion pathways, but the same data assessment methods will apply.
- Field surveying is not adequate for achieving the degree of sensitivity required for this objective.
  - Samples will be sent for laboratory analysis.
- An action level (e.g., a DRL) has been established for comparison with analytical results.
- The sampling method used is effective for the applicable agricultural products and there is a reference to compare to (e.g., unaffected population of similar products).
- The assessor knows the counting efficiency of the detector(s) used as a function of energy (and therefore isotope) information available to them for all instruments used. This is typically reported by the analysis laboratory.
- All measurements have been grouped and separated by date and time collected, and decay correction factors have been applied to all measurements for a predetermined point in time.

5.4.2 Gather Data

All of the listed data elements in Table 21 could be provided in this objective and phase by responders. The successive sections will detail the data assessment process for these possible data types.

Table 21. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	
Samples	✓
Dose rate measurements	
Spectral measurements	✓
Raw count rates	
Background dose rates	
Background spectra	✓

5.4.3 Apply Verification Flags

Using Table 22 as a guide, the data assessor reviews each measurement and applies flags for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing.

Table 22. Verification Data and Flags

Data	Flag if Missing
Background measurement (Should have already been obtained in the Early Phase or from planning/preparation by civil authorities)	Suspicious
Date of collection	Incomplete
Instrument calibration or certification documents[a]	Incomplete
Instrument efficiency (the value of this conversion factor will depend on the instrument and what units the detector reports in and the units needed for assessment)	Incomplete
Instrument make and model, and of associated probes	Incomplete
Instrument serial number	Suspicious
Location	Incomplete
Measurement units	Incomplete
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual	Suspicious
Sample collection procedure	Suspicious
Time of day of collection	Incomplete
Type of material of nearby surfaces relative to the detector	Suspicious
Flags Unique to this Objective	
Date	**Flag if Missing**
Isotope identification confidence (if applicable)	none
Isotopes identified (if applicable)	none
Sample Analysis Method	Incomplete
Sample equipment identification (ID) numbers (e.g., flow meters)	Suspicious
Sample ID number	Incomplete
Sample preservation method prior to analysis (or if N/A)	Suspicious
Sample size (or sample volume)	Incomplete
Sample storage method	Suspicious
Time of day and date of analysis	Incomplete

(a) It is recommended that the calibration records be consistent with at least Tier 1 equipment maintenance records (periodic laboratory calibration) per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies.” (NCRP 2022).

5.4.4 Apply Validation Flags

Using Table 23 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 23. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Precision				For laboratory results, review the instrument information and measurement value and units.	Pre-use quality assessment (QA) has not been completed or not included in report.	Imprecise
Precision				For multichannel analyzer (MCA) results, review full width half maximum (FWHM) for identified peaks.	FWHM is not within expected range.	Imprecise
Accuracy	Review instrument calibration records, if available.	1. Meter is past calibration date. 2. The instrument had an issue with calibration. 3. No calibration information is available. 4. Consistent Response Check performed and passed.	If 1 or 2: Out of Calibration If 3: Incomplete If 4: No Flag	Review counting protocol.	The counting windows (liquid scintillation counting, or LSC) or channel specifications (high-purity germanium, or HPGe) are not appropriate for the analysis.	Invalid

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Accuracy				Review sample chain of custody (COC).	Sample preservation method prior to analysis is not indicated.	COC Missing
Accuracy				Review sample procedure and analysis procedure.	Concentration units were not back-calculated correctly.	Invalid
Representativeness	Review measurement location against a map of the area of interest.	Sample location is well beyond the farthest expected spread of contaminated material and useful background measurements.	Invalid	Review sampled item with relation to product of concern.	Sample obtained from material that cannot be properly compared to product of concern.	Invalid
Completeness	Review the number of “Suspicious” flags applied to the measurement.	Three or more ”Suspicious” flags have been applied.	Suspicious Context	Review sample COC form.	1. COC is incomplete. 2. COC is missing.	If 1, Suspicious Context If 2, Invalid.

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Comparability	Note the units of the measurement, and available conversion factors.	The measurement is not reported in either activity per area or activity per volume	Invalid	Note the time of the measurement and compare to any information about the release, if available.	1. The time of the measurement precedes the expected release. 2. If the measurement is indicated as a background measurement and the time coincides with other elevated readings.	If 1, Invalid. If 2, Background
Sensitivity	Compare the reported measurement value to the reported minimum detectable activity (MDA)	The MDA is greater than the Action Level.	Invalid			

5.4.5 Assess Data Quality

Using Table 24 as a guide, the data assessor reviews the data and how they are flagged from both the verification and validation steps. One possible conclusion is presented in Table 24 given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 24 should be used as a starting point. The conclusions from these tables will inform which measurements to include in the final analysis and assessment of the collected data to relay to decision makers.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags can be used to translate CBRN Responder data flags into the "Suspicious" and "Incomplete" data flags used here as well as the additional flags applied during validation. Additionally, laboratory analysis will oftentimes apply its own data quality flags as established in ANSI/ANS-41.5-2012 (ANSI 2012). Appendix B also provides guidance for translating ANSI/ANS-41.5-2012 flags into the flags provided in this guidance.

Table 24. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The "Imprecise" flag has been applied to an individual measurement.	• If a background measurement from the same instrument is available, compare the two measurements. If the response value is greater than the background value by three (e.g., if the background value is 100 cpm and the response value is 300 cpm), then radioactive contamination may be present. • If no background measurement with the same instrument is available, a background measurement should be performed away from any areas suspected of elevated background levels. • If a background measurement with the same instrument cannot be performed, additional confirmatory measurements of samples taken near the same locations should be performed. • If a background measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Out of Calibration" or "none" flag has been applied in regards to instrument calibration information.	• An additional confirmatory measurement of the sample should be performed with a different instrument. • If an additional confirmatory measurement cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Chain of Custody (COC) Missing" flag has been applied to an individual measurement.	• The field team section chief should be contacted to request the COC forms. • The measurement should be considered invalid until the sample preservation method can be verified.

Condition	Possible Conclusions
The “Invalid” flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • It may be necessary to collect a new measurement to replace the invalid one.
The “Background” flag has been applied to an individual measurement.	• It is unlikely that there is a radiation hazard with this sample. • A recount of the sample can be requested from the analysis laboratory. • Additional confirmatory measurements may be sought from the vegetation or animal product population.
The “Incomplete” flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements of the sample, or an additional, similarly located sample, should be performed.
A ”Suspicious Context” flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other nearby samples are available for measurement. • Additional confirmatory measurements of the sample, or an additional, similarly located sample, should be performed.
The number of ”Suspicious” flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements of the sample, or an additional, similarly located sample, should be performed.

Before drawing conclusions, the data assessor should determine whether a sufficient number of samples have been collected and found to be acceptable by the data quality assessment process. The data assessor should use Equations 4 and 5, known as an “compliance sampling test”:

$$C = 100 * \left(1 - \left(1 - \frac{2n}{2N-V+1}\right)^{V}\right), \tag{Eq. 4}$$

$$V = [(1-P) * N], \tag{Eq. 5}$$

where *C* is the percent confidence level (e.g., “95” for the 95% confidence level), *n* is the number of measurements available, *N* is the number of items in the total item population, and *P* is the percentage (expressed as a fraction, e.g., “0.90” for 90%) of the total item population that must be acceptable. The bracket notation indicates that non-integer values should be rounded up to the next highest integer.

Note that, to use this equation, all measurements (n) must be below the incident action level. This equation tests how much of the total item population (N), not all of which will have been measured, is estimated to be below the incident action level.

Put into words, the result of this calculation can be described as follows:

> "Given *n* items measured of *N* total items, we can be *C* percent confident that *P*100* percent of the total number of items are acceptable."

This equation may be used in three ways:

1. Given a predetermined desired confidence level (C), as well as the percentage of the population (P) whose radiation levels must be found to be below the incident action level, this calculation will show the number of samples (n) from the population (N) that must be used in this analysis;
2. Given the known number of samples (n) from the population (N), and the desired confidence level (C), the percentage of the population (P) whose radiation levels can be shown to be below the incident action level may be calculated; and
3. Given the known number of samples (n) from the population (N), and the desired percentage of the population (P) whose radiation levels must be shown to be below the incident action level, the confidence level (C) of that conclusion may be calculated.

As shown in Figure 5 the fraction of the total number of items that need to be measured and found acceptable increases for increasing confidence level desired. Additionally, the number of acceptable samples increases dramatically as the desired percent of the population (P) whose radiation or contamination levels are shown to be below the desired incident action level of concern. This must be considered by data assessors and decision makers together to ensure the desired statistics can be supported by available resources.

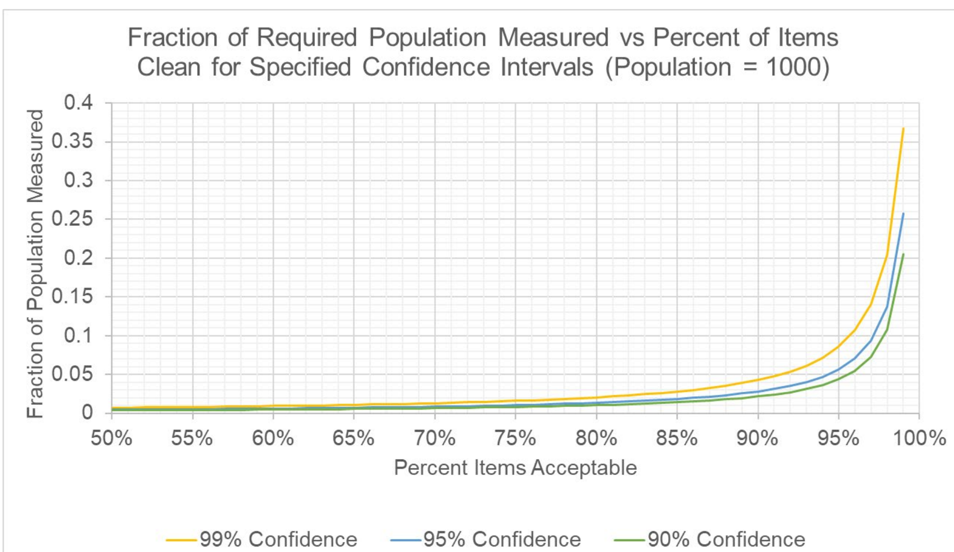

Figure 5 An example of the percentage of the population that needs to be sampled and shown to have radiation levels below the incident action level of concern for the given confidence levels for a total population of 1000 (N = 1000).

Example

The state Department of Agriculture wants to end an embargo on spinach for Thompson County. This embargo was put in place during the Early Phase of the response following an RDD detonation. The alpha contamination was suspected to have spread over a large range of area encompassing 60 spinach farms. These farms supply food throughout a metropolitan area of approximately 500,000 people. Plant samples have been collected throughout the county, and all collected samples have been analyzed by affiliated laboratories. Crop samples from 39 farms were collected, and these were averaged into a single concentration value for each farm. In order to lift the embargo on this section of the crop, decision makers have determined that at least 56 farms (92.5% of the total number of farms) must be below 45 pCi/kg to lift the embargo. The Department of Agriculture has asked if sufficient samples were collected to provide defensible conclusions about the total spinach crop.

All samples were measured to be below 45 pCi/kg. Therefore, the data assessor knows they can use Equation 1. Due to limited time, it is not possible to collect any additional data. Therefore, they want to know with what level of confidence this can be stated given the existing parameters.

n =39; N=60; P=0.925

$$V = [(1 - P) * N] = [(1 - 0.925) * 60] = 4.5$$

$$C = 100 * \left(1 - \left(1 - \frac{2n}{2N - V + 1}\right)^{V}\right) = 100 * \left(1 - \left(1 - \frac{2 * 39}{2 * 60 - 4.5 + 1}\right)^{4.5}\right)$$

$$C = \mathbf{99.31}\%$$

The result means that there is a 99% chance that at least 92.5% of the spinach crop in Thompson County is likely to be below 45 pCi/kg. This means that if the total population were sampled repeatedly, the results would match the measurements from the actual population 99 percent of the time. Therefore, the conclusion drawn regarding these data has a high confidence of properly representing the conditions of the true population.

The decision maker is responsible for deciding what action to take following this finding, however the data defensibly support the conclusion that the embargo of this population can be lifted given the current conditions.

Data Assessment Conclusion

One or more measurements are greater than the incident action level of concern.

- It is likely that some percentage of the population exceeds the current incident action level.
- Additional measurements may be requested to confirm specific locations or item sub-populations from the sample which exceeds the incident action level.
- Locations or discrete item Sub-populations from which no Certain sub-populations (items from specific locations or other delineators) from which no sampled items exceed the incident action level may be considered as separate collections. These collections may be re-tested individually using the same method in this objective. For example, if all samples that result in values that exceed the action limit come from one location, that location could be considered separately. The remaining population (all of which are below the action limit) could then be re-tested. Care should be taken to ensure that sub-populations are representative of some reasonable grouping (e.g., crop products from one farm that were distributed across the whole farm property).

No measurements are greater than the incident action level.

- Perform a compliance sampling test.
- When possible, a percent confidence or percentage of the area of concern should be specified and provided to the data assessor.
- Once the data assessor has completed the calculation, they should state their answer as "Given *n* measurements, we can be *C* percent confident that *P*100* percent of the area is below the action level."

5.5 Assess Radioactive Contamination in Water

Objective: Analyze water samples over time to monitor for water contamination.

5.5.1 Review Objective

Applicability: This objective applies to decisions about trends in drinking water contamination levels monitored over time. This section addresses water collection from surface water, open air water storage locations, or water intake locations that may be directly subject to contamination or downstream from contamination to provide guidance to assessors to help address whether those bodies of water are contaminated for consumption. Other water sources, such as groundwater and water already in sealed storage are not considered here.

Collection of water samples may result in counting performed in the field as well as in a laboratory with advanced methods. Note, the following sections will not provide an in-depth analysis of laboratory verification and validation for sample analysis; for in-depth detail for these processes the assessor is directed towards EPA or ANSI documents (EPA 2000; EPA 2002, ANSI/HPS 2013). The verification and validation tables presented here contain all the basic checks necessary for both field and lab sample data, and the findings should be compared to lab analysis reports.

Assumptions: Note that if the assumptions listed here do not hold for the objective being addressed, some conditions of the data assessment flags and conclusions outlined below may need to be changed.

- Sampling has been conducted at multiple points in time and the incident response personnel need to determine how likely it is that the water source is becoming contaminated above an incident action level.
- This assessment focuses primarily on potential sources of drinking water because a PAG exists for such water use. No radiological protective action guidance exists for other water uses, such as recreational and industrial. Therefore, assessing data for such water use is not covered here.
- Sampling is assumed to be performed at a single representative point at the origin of the drinking water supply, such as a water treatment plant, rather than sampling the output of the population's faucets or at the originating body of water.
- All measurements will include collecting gamma spectra of the samples.
- Sampling water wells is not considered here. This would require obtaining samples from multiple wells to determine average concentration levels of this drinking supply for a limited population compared to the general public receiving water from a treatment plant.

- An incident action level has been established to which sample analyses may be compared.
- Relevant efficiency as a function of energy (and therefore isotope) information is available for all instruments used.
- Any radionuclides of interest being monitored have long decay times compared to the time between samples (e.g., monitoring for cesium-137 with samples being taken every week for a month). If this is not the case, other methods must be used to account for autocorrelation between samples.
- At least 11 water measurements are available to begin this process.
- The sampling method used is effective for the applicable water source and a background water reference is available for comparison (e.g., uncontaminated tap water).

5.5.2 Gather Data

All of the listed data elements in Table 25 could be provided in this objective and phase by responders. The successive sections will detail the data assessment process for these possible data types.

Table 25. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	
Samples	✓
Dose rate measurements	
Spectral measurements	✓
Raw count rates	
Background dose rates	
Background spectra	✓

5.5.3 Apply Verification Flags

The data assessor should gather the details listed in Table 26 for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing.

Table 26. Verification Data and Flags

Data	Flag if Missing
Background measurement (Should have already been obtained in the Early Phase or from planning/preparation by civil authorities)	Incomplete
Date of collection	Incomplete
Instrument calibration or certification documents[(a)]	Incomplete
Instrument efficiency (the value of this conversion factor will depend on the instrument and what units the detector reports in and the units needed for assessment)	Incomplete
Instrument make and model, and of associated probes	Incomplete
Instrument number	Suspicious

Data	Flag if Missing
Location serial	Incomplete
Measurement units	Incomplete
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual	Suspicious
Sample collection procedure	Suspicious
Time of day of collection	Incomplete
Type of material of nearby surfaces relative to the detector	Suspicious

Flags Unique to this Objective

Date	Flag if Missing
Batch identification (ID) number	Suspicious
For collected samples, shipping manifest (if applicable)	None
If used, flow/volume meter ID number	Incomplete
If used, sample equipment ID numbers	Suspicious
Isotope identification confidence (if applicable)	None
Isotopes identified (if applicable)	None
Sample analysis method	Incomplete
Sample ID number	Incomplete
Sample preservation method (or if N/A)	Suspicious
Sample size (or sample volume)	Incomplete
Sample storage method	Suspicious
Sampling position (e.g., intake, main tank, outflow)	Suspicious
Sample depth (e.g., surface, bottom, specific depth with measurement)	Suspicious
Time of day and date of analysis	Incomplete

(a) It is recommended that the calibration records be consistent with at least Tier 1 equipment maintenance records (periodic laboratory calibration) per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies”. (NCRP 2022).

5.5.4 Apply Validation Flags

Using Table 27 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 27. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Precision	Review the instrument information and measurement value and units.	Pre-use quality assurance (QA) has not been completed or not included in report.	Imprecise	For multichannel analyzer (MCA) results, review full width half maximum (FWHM) for identified peaks.	FWHM is above expected value for detector.	Imprecise
Accuracy	Review instrument calibration records, if available.	1. Meter is past calibration date. 2. The instrument had an issue with calibration. 3. No calibration information is available. 4. Consistent response check performed and passed.	If 1 or 2: Out of calibration If 3: Incomplete If 4: No Flag	Review counting protocol.	The counting windows (liquid scintillation counting, or LSC) or channel specifications (MCA) are not appropriate for the analysis.	Invalid
Accuracy				Review sample collection procedure	Sample preservation method prior to analysis not indicated	Suspicious context
Accuracy				Review sample procedure and analysis procedure	Concentration units were not back-calculated correctly	Invalid

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Representativeness	Review measurement location against a map of the area of interest.	Sample location is well beyond the farthest expected spread of contaminated material and useful background measurements.	Invalid	Review sampled item with relation to product of concern.	Sample taken from non-representative depth.	Invalid
Completeness	Review the number of “Suspicious” flags applied to the measurement.	Three or more ”Suspicious” flags have been applied.	Suspicious context	Review sample chain of custody (COC) form.	1. COC is incomplete 2. COC is missing.	If 1, Suspicious Context If 2, COC Missing.
Comparability	Note the units of the measurement, and available conversion factors.	The measurement is not reported in either activity per area or activity per volume.	Invalid	Note the time of the measurement and compare to any information about the release, if available.	1. The time of the measurement precedes the expected release. 2. If the measurement is indicated as a background measurement and the time coincides with other elevated readings.	If 1, Invalid. If 2, Background
Sensitivity	Compare the reported measurement value to the reported minimum detectable activity (MDA).	The MDA is greater than the Action Level.	Invalid			

5.5.5 Assess Data Quality

Using Table 28 as a guide, the data assessor reviews the data and how they are flagged from both the verification and validation steps. One possible conclusion is presented in Table 28 given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 28 should be used as a starting point. The conclusions from these tables will inform which measurements to include in the final analysis and assessment of the collected data to relay to decision makers.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, can be used to translate CBRN Responder data flags into the “Suspicious” and “Incomplete” data flags used here as well as the additional flags applied during validation. Additionally, laboratory analysis will oftentimes apply its own data quality flags as established in ANSI/ANS-41.5-2012 (ANSI 2012). Appendix B also provides guidance for translating ANSI/ANS-41.5-2012 flags into the flags provided in this guidance.

Table 28. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The “Imprecise” flag has been applied to an individual measurement.	• If a background measurement from the same instrument is available, compare the two measurements. If the response spectra contain gamma peaks at energies and quantities not associated with background or naturally occurring radioactive material (NORM, isotopes such as potassium-40, radium-226, thorium-232), then radioactive contamination may be present. • If no background measurement with the same instrument is available, a background measurement should be performed away from any areas suspected of elevated background levels. • If a background measurement with the same instrument cannot be performed, additional confirmatory measurements of samples taken near the same locations should be performed. • If a background measurement with the same instrument cannot be performed, an additional “Suspicious” flag may be applied to this measurement.
The “Out of Calibration” flag has been applied in regard to instrument calibration information.	• An additional confirmatory measurement of the sample should be performed with a different instrument. • If an additional confirmatory measurement cannot be performed, an additional “Suspicious” flag may be applied to this measurement.
The “COC Missing” flag has been applied to an individual measurement.	• The field team section chief should be contacted to request the chain of custody (COC) forms. • The measurement should be considered Invalid until the sample preservation method can be verified.

Condition	Possible Conclusions
The "Invalid" flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • It may be necessary to collect a new measurement to replace the invalid one.
The "Background" flag has been applied to an individual measurement.	• It is unlikely that there is a radiation hazard with this sample. • A recount of the sample can be requested from the analysis laboratory. • Additional confirmatory measurements may be sought from the vegetation or animal product population.
The "Incomplete" flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements of the sample, or an additional, similarly located sample, should be performed.
A "Suspicious Context" flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other nearby samples are available for measurement. • Additional confirmatory measurements of the sample, or an additional, similarly located sample, should be performed.
The number of "Suspicious" flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements of the sample, or an additional, similarly located sample, should be performed.

Before drawing conclusions, the data assessor should perform a Mann-Kendall test. This test is used to check for trends over time in a dataset. It is recommended the data assessor use a spreadsheet or other numerical computation software to aid in performing this test. To perform a Mann-Kendall test, the data assessor should follow these steps:

1. List all measurements in the order they were collected. These measurements are then referred to as $x_1, x_2, \ldots$ to x_n, where n is the total number of measurements.
2. Compute the differences between a given sample result and each previous result. For example, if there are 11 total measurements, start by calculating $(x_{11} - x_{10})$, $(x_{11} - x_9)$, $(x_{11} - x_8)$, *and* $(x_{11} - x_7)\ldots$ and recording each resulting difference. Then move on to x_{10}, x_9, and x_8, and so forth in turn. Since x_1 is the first measurement, no further differences are computed once this measurement is reached.
3. Assign each difference result a value as follows:
   a. If the difference is positive, the value is 1;
   b. if the difference is negative, the value is -1; and
   c. if the difference is zero (i.e., the numbers are exactly the same), the value is 0.

4. Sum all of the values computed in step 3. This sum will be referred to as *S*.
5. Make a note of each value that appears more than once in the set of measurements, and the total number of values that appear more than once in the set of measurements. The total number of values that appear more than once is the number of "tied groups".
   a. For example, if values are [23, 24, 29, 6, 27, 24, 24, 28, 23, 25, 13], then the values 23 and 24 appear multiple times. Therefore, the number of tied groups is 2.
6. For each value that appears more than once in the set of measurements, note how many times that value appears in the set of measurements. The number of times the value appears will be called the value's "repetition".
   a. For example, for the same values from step 5, the repetition of the value 23 would be 2 (because it appears twice), and the repetition of the value 24 would be 3 (because it appears three times).
7. Compute the variance of *S* (the sum from step 4) using Equation 4:

$$Var(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p-1}^{g} t_p\left(t_p - 1\right)\left(2t_p + 5\right)\right] \quad \text{(Eq. 4)}$$

   where *Var(S)* is the variance of *S*, *n* is the total number of measurements, *g* is the number of tied groups (from step 5), and t_p is the repetition of the p^{th} value (from step 6).
8. Compute the Mann-Kendall test statistic, Z_{MK}, using Equations 5a-5c, as appropriate:
   a. If *S* > 0, $Z_{MK} = \frac{S-1}{\sqrt{Var(S)}}$ (Eq. 5a)
   b. If S < 0, $Z_{MK} = \frac{S+1}{\sqrt{Var(S)}}$ (Eq. 5b)
   c. If S = 0, $Z_{MK} = 0$ (Eq. 5c)
9. Note the desired percent confidence (*C*) of the test. If no desired percent confidence is provided, 95% confidence can be used as a default. Next, compute alpha, *α*, which is 1 – C/100. E.g., if 95% confidence is used, then *α* = 0.05.
10. To test whether a monotonic trend is present in the data, compare Z_{MK} computed in step 8 to $Z_{1-\alpha}$, and $Z_{1-\alpha/2}$, the z-score of the $(1-\alpha)^{th}$ and $(1-\alpha/2)^{th}$ percentiles of the standard normal distribution. The percentiles for the normal distribution can be found in many statistics textbooks and software packages (e.g., *Statistical Methods for Environmental Pollution Monitoring* by Gilbert (Gilbert 1987)).

Data Assessment Conclusion

One or more measurements are greater than the incident action level.

- Perform a Mann-Kendall test.
  a. If Z_{MK} is greater than or equal to $Z_{1-\alpha}$ in step 10, then a monotonically upward trend exists in the data, indicating that the level of contamination in the water is increasing with 100*(1-α) percent confidence. Additional confirmatory measurements may be requested and the time interval between samples may be increased.
  b. If Z_{MK} is less than or equal to $Z_{1-\alpha}$ in step 10, then a monotonically downward trend exists in the data, indicating that the level of contamination in the water is decreasing with 100*(1-α) percent confidence. The water should continue to be monitored.
  c. If the absolute value of Z_{MK} is greater than or equal to $Z_{1-\alpha/2}$ in step 10, then a monotonic trend exists in the data, indicating that the level of contamination in the water is changing with 100*(1-α) percent confidence. See options a and b, above.
  d. If the absolute value of Z_{MK} is less than or equal to $Z_{1-\alpha/2}$ in step 10, a monotonic trend cannot be said to exist in the data with 100*(1-α) percent confidence, indicating that contamination levels may be fluctuating up and down or that they are not changing. Additional confirmatory measurements may be requested and the time interval between samples may be increased.
- Potential impacts and timelines may be requested. Developing these is outside the scope of this guidance.

All measurements are less than the incident action level.

- Perform a Mann-Kendall test.
  – If Z_{MK} is greater than or equal to $Z_{1-\alpha}$ in step 10, then a monotonically upward trend exists in the data, indicating that the level of contamination in the water is increasing with 100*(1-α) percent confidence. Additional confirmatory measurements may be requested and the time interval between samples may be increased. Additionally, the amount before the contamination level in the water is expected to reach the incident action level may be estimated based on the current trend, e.g., using a linear regression.
  – If Z_{MK} is less than or equal to $Z_{1-\alpha}$ in step 10, then a monotonically downward trend exists in the data, indicating that the level of contamination in the water is decreasing with 100*(1-α) percent confidence. The water may continue to be monitored, or the time interval between samples may be increased.
  – If the absolute value of Z_{MK} is greater than or equal to $Z_{1-\alpha/2}$ in step 10, then a monotonic trend exists in the data, indicating that the level of contamination in the water is changing with 100*(1-α) percent confidence. See options a and b, above.
  – If the absolute value of Z_{MK} is less than or equal to $Z_{1-\alpha/2}$ in step 10, a monotonic trend cannot be said to exist in the data with 100*(1-α) percent confidence, indicating that contamination levels may be fluctuating up and down or that they are not changing. The time interval between samples may be maintained or increased. Alternatively, the time interval between samples may be decreased if greater detail on fluctuations is desired.
- Any recommendation to increase the sampling interval should be accompanied by the expectation that the contamination levels will continue to decrease or remain steady based on the current state of stabilization at the incident release site.

5.6 Estimate Gross Radiation Type Activities

Objective: Estimate the activity of each radiation type present (e.g., alpha, beta, gamma) .

5.6.1 Review Objective

Applicability: During emergencies, data will be collected using various survey and sampling methods. Handheld survey meters will be used to collect dose or count rate data for alpha, beta, or gamma radiation in the field. Samples from the ground or air will also be collected and undergo laboratory analysis to determine the presence of various isotopes. The data generated during the early and Intermediate Phases can be used to estimate the activity of radionuclides recorded in this manner, informing protective actions and model refinement. This section can be used once measurements have been recorded, converting those values into standard reference forms that may be necessary for various follow-on actions. Data for alpha, beta, and gamma radiation may exist depending on the incident and can each be used to determine the activity per specified area of that radiation type. It is crucial to characterize these activities to help decision makers proceed.

Assumptions: Note that if these assumptions do not hold for the objective being addressed, some conditions of the data assessment flags and conclusions outlined below may need to be changed.

- This section applies to personnel that will produce an estimated mean activity, or activity per unit area or volume (also called an "activity concentration"), given both survey and sampling data.
- The assessor has measurements from a meter with a known active area (meter face surface area) to convert to a reference size (100 cm^2) or from a sample that has a known collection area.
- A survey and sampling plan was designed for a specific area of interest and completed as intended.
- The true distribution of values may or may not be normally distributed, and an adequate number of data points have been collected to perform this analysis and draw conclusions with the desired level of confidence. Since this objective relates more to characterization, there is no set number of measurements required. However, 11 measurements is a starting point that assumes a normally distributed population that can be used to initiate characterization. Additional measurements may be necessary if starting assumptions do not hold true.
- It is assumed that the data assessor has guidance to reference for how to perform proper energy linearity, energy resolution, so efficiency, and background corrections and calculations for each relevant instrument. Therefore, this section focuses on taking these formalized data and analyzing them to determine activities of each radiation type.
- The radiation type(s) (alpha, beta, or gamma) released during the incident are known at this time and the relevant guidance for each type may be referenced in this section.
- The data assessor is aware of which instrument was used for each radiation type, and they have relevant efficiency information available to them for all instruments used to collect the data.

5.6.2 Gather Data

All of the listed data elements in Table 29 could be provided in this objective and phase by responders. The successive sections will detail the data assessment process for these possible data types.

Table 29. Available Data Types for Response Objective

Data Type Collected for Objective	Expected to be Present for Objective
Surveys	✓
Samples	✓
Dose rate measurements	
Spectral measurements	✓
Raw count rates	✓
Background dose rates	
Background spectra	✓

5.6.3 Apply Verification Flags

The data assessor should gather the details listed in Table 30 for each measurement in all reports, as applicable. The table summarizes useful data fields for each measurement and the appropriate flag to be applied if that information is missing.

Table 30. Verification Data and Flags

Data	Flag if Missing
Background measurement	Incomplete
Date of the collection	Incomplete
Distance of instrument to surface being measured	Suspicious
Instrument range selection	Incomplete
Instrument calibration or certification records[(a)]	Incomplete
Instrument dose conversion factor (dose per count) (if dose rate instrument)	Incomplete
Instrument make and model, and of associated probes	Incomplete
Instrument serial number	Suspicious
Location	Incomplete
Measurement unit	Incomplete
Measurement value	Incomplete
Name of the individual	Suspicious
Organization of the individual (if applicable)	Suspicious
Orientation of instrument to nearby surfaces	Suspicious
Survey method – stationary or scanning (an instrument in a moving vehicle is considered a scan)	Incomplete
Type of material of nearby surfaces relative to the detector	Suspicious

Flags Unique to this Objective

Date	Flag if Missing
Conversion factor from counts per minute (cpm) to disintegrations per minute (dpm) for the instrument (if count rate instrument)	Incomplete
Instrument active area (if a contamination instrument)	Incomplete
If a moving survey method was used: the approximate speed of the meter or vehicle the meter was in	Incomplete
Number of measurements required	Incomplete

(a) It is recommended that the calibration records be consistent with at least Tier 1 equipment maintenance records (periodic laboratory calibration) per National Council on Radiation Protection and Measurements (NCRP) Statement No. 14, “Instrument Response Verification and Calibration for use in Radiation Emergencies”. (NCRP 2022).

5.6.4 Apply Validation Flags

Using Table 31 as a guide, the data assessor reviews each action and applies the condition to the data. This series of actions and their corresponding conditions will determine how to flag the data. If the data do not meet the condition for the corresponding action, then the data are not flagged.

Table 31. Validation Actions, Conditions, and Flags

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Precision	Review the instrument information and measurement value and units.	The instrument does not provide a dose readout, but the value is representative of a dose range instead.	Imprecise			
Accuracy	Review instrument calibration records, if available.	1. Meter is past calibration date. 2. The instrument had an issue with calibration. 3. No calibration information is available. 4. Consistent response check performed and passed.	If 1 or 2: Out of calibration If 3: Incomplete If 4: No Flag			
Representativeness	Review measurement location against a map of the area of interest.	Measurement location is well beyond the farthest expected spread of contaminated material and useful background measurements.	Invalid			
Completeness	Review the number of “Suspicious” flags applied to the measurement.	Three or more ”Suspicious” flags have been applied.	Suspicious Context			

PARCCS Parameter	Action	Conditions	Flag if Condition is True	Additional Actions for this Objective	Conditions	Flag if Condition is True
Comparability	Note the units of the measurement, and available conversion factors (including area or volume correction factor).	The measurement is not reported in units of activity per area or volume.	Invalid	Note the time of the measurement and compare to any information about the release, if available.	1. The time of the measurement precedes the expected release. 2. If the measurement is indicated as a background measurement and the time coincides with other elevated readings.	If 1 or 2: Invalid
Sensitivity	Compare the instrument range selection to the measured value.	The measured value is lower than, or at the lower limit of, the instrument's sensitivity range.	Invalid			

5.6.5 Assess Data Quality

Using Table 32 as a guide, the data assessor reviews the data and how they are flagged from both the verification and validation steps. One possible conclusion is presented in the Table 32 given that the stated condition is true. There will be unique aspects to every incident; because of this, the specific circumstances of two different incidents might lead the data assessor to draw different conclusions from the same measurement(s) and from the table presented here. Table 32 should be used as a starting point. The conclusions from these tables will inform which measurements to include in the final analysis and assessment of the collected data to relay to decision makers.

If data have been collected in CBRN Responder, note that some flags may already have been automatically applied to the measurements. Appendix B, Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags, can be used to translate CBRN Responder data flags into the "Suspicious" and "Incomplete" data flags used here as well as the additional flags applied during validation. Additionally, laboratory analysis will oftentimes apply its own data quality flags as established in ANSI/ANS-41.5-2012 (ANSI 2012). Appendix B also provides guidance for translating ANSI/ANS-41.5-2012 flags into the flags provided in this guidance.

Table 32. Quality Assessment Conditions and Possible Conclusions

Condition	Possible Conclusions
The "Imprecise" flag has been applied to an individual measurement.	• The individual measurement should not be used for this action. It can be used as supporting information or disregarded. • It may be necessary to collect a new measurement to replace the imprecise one as quantitative values reported as counts or count rate are needed for assessment.
The "Out of Calibration" flag has been applied.	• An additional confirmatory measurement should be performed with a different instrument in the same location or of the sample. • If an additional confirmatory measurement with the same instrument cannot be performed, an additional "Suspicious" flag may be applied to this measurement.
The "Invalid" flag has been applied to an individual measurement.	• The individual measurement should be disregarded for this analysis. • It may be necessary to collect a new measurement to replace the invalid one. • If the measurement is reporting counts per time (cps or cpm), an efficiency conversion must be applied.
The "Incomplete" flag has been applied to an individual measurement.	• The missing information should be sought from the individual who collected the measurement. • The measurement should not be considered usable until the missing information has been obtained. • Additional confirmatory measurements in the same locations, or an additional, similarly located sample, should be performed.

Condition	Possible Conclusions
A "Suspicious Context" flag is present for a measurement.	• Any missing information should be sought from the individual who collected the measurement. • Avoid using this measurement if other nearby measurements are available. • Additional confirmatory measurements in near same location as the original measurement, or of a similarly located sample, should be performed.
The number of "Suspicious" flags for a set of measurements is equal to or greater than three times the number of measurements.	• Any missing information should be sought from the individuals who collected the measurements. • Additional confirmatory measurements in the same area should be performed.
All measurements have been grouped by radiation type and separated by date and time collected, and decay correction factors have been applied to all measurements for a predetermined point in time.	• The count rate or dose rate should be calculated for each of these groups of measurements. • The greatest time difference between individual measurements in each group should be less than the half-life of the shortest-lived isotope, if known. • If the time stamp of a measurement appears to exceed the reported isotope's half-life, disregard. Additional confirmatory measurements in near same location as the original measurement, or a similarly located sample, should be performed.

Once these data have been deemed to be acceptable for use in analysis, the mean of the radionuclide concentration for the measured locations must be calculated. This can be done for alpha, beta, or gamma measurements, but only measurements of each type should be used together for analysis. It is recommended the data assessor use a spreadsheet or other numerical computation software to aid in performing this test. The data assessor should follow these steps:

1. If the dataset is reasonably large (number of samples is greater than 30) and normally distributed go to step 2, otherwise go to step 4.
    a. If the dataset does not follow a normal distribution but is not large (number of samples is less than 30), then the t-distribution and usual confidence interval calculation may be used. This approach is fairly robust to non-normality. For more details, consult a statistics textbook (e.g., *Statistical Methods for Environmental Pollution Monitoring* by Gilbert (Gilbert 1987)).
2. Determining the mean ($\bar{x}$) and standard deviation (SD) for the number of samples.

$$mean = \bar{x} = \frac{(n_1 + n_2 + n_2 + \cdots + n_N)}{N}$$

$$SD = \sqrt{\frac{((n_1 - \bar{x})^2 + (n_2 - \bar{x})^2 + \cdots + (n_N - \bar{x})^2)}{N}}$$

3. Construct the 95% confidence interval using the determined mean and standard deviation. This will give a two-sided confidence interval that indicates the 2.5% and 97.5% bounds surrounding the mean.

$$CI(95\%) = \bar{x} \pm 1.96 * SD$$

The final values would be reported as $(\bar{x} - 1.96 * SD, \bar{x}, \bar{x} + 1.96 * SD)$ or as the value and confidence interval above.

4. If the dataset is non-normal but is not large (number of samples less than 30) determine the median of the determined values.
5. Find the median by ordering the values from lowest to highest and determining the central (middle) value. This is the median.
6. Next find the quantiles associated with the two-sided 95% confidence level. These will be the upper and lower confidence bounds (e.g., for 95% confidence interval: find the 2.5 percentile and 97.5 percentile, these are the lower and upper bounds of the confidence interval, respectively). To calculate the 95% confidence interval on the median, consult statistical calculation software or a statistics textbook (e.g., *Sampling: Design and Analysis* by Sharon L. Lohr. (Lohr 2010)).

Data Assessment Conclusion

Calculate the mean radionuclide concentration for each location for each radiation type.

- The value at each location should be reported with a 95% confidence interval. E.g., “57 dpm ± 5 dpm alpha”.
- If the confidence interval is very wide, e.g., more than 20% of the value itself, then collecting additional measurements should be considered. For example, collecting additional measurements should be considered if the value is 57 dpm, and the confidence interval is greater than 11.4 dpm.

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Appendix A – Glossary

Accuracy – "How close is each measurement to the true value?" This data parameter describes the comparison of a result to a consensus value, generally expressed in terms of an error, either as an absolute value or percentage, where the measurement is compared to a mean or known true value.

Action Level – A quantitative value that is compared to measured values to determine whether a specific set of actions is warranted. For example, an action level of 1 rem for evacuating a local population may be established based on the 2017 EPA Protective Action Guidance manual[1].

Assessment Phase – The third phase of the data life cycle, which occurs after data and information have been collected. The assessment phase includes the verification, validation, and data quality assessment processes. The output of the assessment phase is a set of conclusions about the data.

Comparability – "Can two measurements or sets of measurements be compared?" This data parameter describes whether measurements can be compared based on the instrument used, the type of measurement, the units used, and the question being answered. This is generally a qualitative parameter.

Completeness – "Did we collect all the data we planned for?" This data parameter describes how many measurements were collected compared to the number of planned measurements, generally expressed as a percentage of the actual to the planned numbers of measurements. It can also describe the completeness of the information collected for each individual measurement.

Data – The term for collections of both quantitative and qualitative facts and observations. For example, "9 mR/hr" and "Jane Smith" and "the corner of Cherry and 9th Ave." are data. Data require context to be actionable, at which point the data are transformed into information.

Data Life Cycle – The term for the data quality process composed of the planning, implementation, and assessment phases. The goal of the data life cycle is to support traceable and defensible conclusions based on data and information collected to address a question or meet an objective. The data life cycle addresses decision and estimation objectives, where the output is a conclusion about a specific parameter of the data, such as whether the mean of the data is above or below a certain threshold, or an estimation of a statistical parameter with known accuracy and precision, such as 1.9 ± 0.2 mR/hr.

Data Quality – A collection of qualitative and quantitative information about a measurement or set of measurements that indicates whether or not the data can be used to address a specific question or objective or meet specified requirements for estimating a parameter of the data, such as the mean.

Data Quality Assessment (DQA) – The process of evaluating verified and validated data against the established data quality objectives for its suitability in addressing a decision or

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[1] U.S. Environmental Protection Agency. 2017. *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents*. EPA-400/R-17/001. https://www.epa.gov/sites/default/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf

estimation objective. This process may involve performing statistical tests on groups of measurements, and results in a data assessor drawing conclusions about the data relative to the specific decision or estimation objective.

Data Quality Objectives (DQOs) – Qualitative and quantitative requirements on data and information necessary to support a specific decision or estimation objective. DQOs are established in the planning phase.

Implementation Phase – The second phase of the data life cycle, which occurs as data and information are being collected. The implementation phase includes quality assurance and quality control practices and processes. The output of the implementation phase is data and information that meet the data quality objectives established in the planning phase of the data life cycle.

Information – The term for collections of data that have been organized into a meaningful and useful context. For example, the data, "9 mR/hr" and "Jane Smith" and "the corner of Cherry and 9th Ave." can be transformed into information by tying them together: "Jane Smith measured 9 mR/hr at the corner of Cherry and 9th Ave."

Measurement – As a verb, to measure denotes the act of detecting or quantifying physical phenomena. In this guidance, the term measurement is most often used as a noun, and specifically refers to the data generated by the act of detecting or quantifying radiological emissions.

Measurement Quality Objectives (MQOs) – Qualitative and quantitative performance requirements for measurement data and information characteristics, such as precision and accuracy, based on established data quality objectives.

Minimum Detectable Activity (MDA) – MDA is the minimum detectable quantifiable activity above background to successfully determine elevated activity is present. This is instrument-specific and takes into account sample and background count time, background count rate, and detector efficiency.

Planning Phase – The first phase of the data life cycle, which occurs before data and information are collected. The planning phase includes the data quality objectives process and generation of measurement quality objectives. The output of the planning phase is a set of data quality objectives and measurement quality objectives.

Precision – "How much variation is there between measurements?" This data parameter describes the reliability by which an investigator can reproduce the sample results. It measures the amount of dispersion among series of measurements and is often provided as a standard deviation.

Quality Assurance – Encompasses all of the actions necessary to provide confidence that the data and information collected during a measurement are of sufficient quality to be used to support a specific decision or estimation objective. This includes recording information about the circumstances of a measurement, such as the instrument calibration. Quality assurance is mainly conducted in the implementation phase.

Quality Control – Encompasses all of the actions that control and measure the circumstances of a measurement. For example, recording the height of a measurement above the ground is a quality control action. Quality control is mainly conducted in the implementation phase.

Representativeness – “Do the samples come from the same area?” This data parameter describes how well a sample characterizes or describes a specific population and is generally reported as a qualitative basis. This can be evaluated, for example, by checking whether measurements were taken on the same kind of terrain, or within a certain distance from each other.

Sensitivity – “Are the instruments used sensitive enough to detect what we are looking for?” This data parameter describes at what threshold value an instrument can detect radiation. Instruments may have several different sensitivity thresholds for different radiation types and for different specific radionuclides.

Validation – The act of comparing measurement information collected against a list of measurement quality objectives and noting whether the measurement quality objectives have been met. Data validation asks the question, “Were the measurement quality objectives achieved for each measurement and as a whole?” The purpose of data validation is to determine if the measurement parameter requirements for the parameters have been achieved by the measurements being considered.

Verification – The act of comparing measurement information collected against a list of measurement information required and noting whether the information collection requirements have been fulfilled. Verification asks the question, “Did all of the requested information get collected?” The purpose of data verification is to ensure that the records associated with a specific set of radiological measurements reflect all of the processes and procedures used to generate that dataset.

Appendix B – Crosswalk between DQA Toolkit Guidance Flags and Additional External Assessment Flags

B.1 CBRN Responder Assessment Flags

CBRN Responder automatically applies specific flags to a measurement when uploaded to the database. Flags can be applied to survey, sample, and spectroscopic data uploaded in the “Data“ tab by field teams or laboratory analysis teams. Based on where the data originated, different flags may be applied, as outlined in Table B.1, Table B.2, and Table B.3. The “Analytical Results” tab does not have any flags that can be applied.

These automatic flags can be manually added or removed during assessment. Additionally, flags may be added retroactively. The applied flags within CBRN Responder can be viewed by selecting “Flags” within the “Choose Visible Columns” menu option on the data pages. Many of these flags have been included following requests from users since the inception of the flag capability in 2017. The meaning of each of these flags are explained in this appendix. The full list and description of assessment flags implemented within CBRN Responder can also be found by navigating to the details of any survey and expanding the “Assessment Details” section.

The flags in CBRN Response combine all three steps of the data assessment process into one and do not distinguish between verification, validation, or data assessment. However, these flags are useful indicators of facets of the measurement that should be addressed during the previously outlined verification, validation, and data assessment steps found in the main body of this report.

To translate these automatic flags into relevant flags used throughout this guidance, these flags are regrouped in this appendix into verification or validation tables based on their relevance. Additionally, the relevant flags are specified for both the early and Intermediate Phases to reconcile with the flags this guidance has outlined for various objectives in these phases.

Table B.1. Assessment Flags Implemented in CBRN Responder for Survey Data

Flag	Description
Edited after full assessment	The data point has been edited after it has been assessed at the "Data is Approved on Passed Review?" step (the step where the data point is considered either approved or rejected). This flag will be removed once it is reassessed at the "Data are Approved on Passed Review?" step.
Equipment in need of maintenance	The selected equipment has a maintenance schedule defined, and it is currently in need of maintenance.
Equipment with no assigned radiation units	The selected equipment was not assigned any radiation units so we cannot determine if the radiation type and unit used on the reading is appropriate for the equipment.
Failed standardization	The calculation to standardize the reading failed.
Incomplete Assessment Data	The selected equipment is missing required assessment data (surface area and efficiency).
Inverted coordinates	The latitude and longitude for the reading are likely inverted.

Flag	Description
Needs follow-up reading	Use this flag to mark a data point as needing a follow-up reading to validate the data. This flag can only be manually added, and it is not based on any calculation or automatic rules.
No equipment selected	The reading does not have equipment metadata.
Suspicious equipment	Equipment was chosen that is not assigned to the collector's field team.
Suspicious location	The location is outside of the event radius.
Suspicious probe	A probe was chosen that is not assigned to the meter or no meter was selected.
Suspicious radiation type	A radiation type was chosen that is not valid for the equipment selected.
Suspicious reading	A reading of "0" was input.
Suspicious unit	A unit was chosen that is not valid for the equipment selected.
Suspiciously high reading	Reading is above average for region.
Suspiciously low reading	Reading is below expected background.

Table B.2. Assessment Flags Implemented in CBRN Responder for Spectroscopic Data

Flag	Description
Edited after full assessment	The data point has been edited after it has been assessed at the “Data is Approved on Passed Review?” step (the step where the data point is considered either approved or rejected). This flag will be removed once it is reassessed at the “Data is Approved on Passed Review?” step.
Equipment in need of maintenance	The selected equipment has a maintenance schedule defined, and it is currently in need of maintenance.
Incomplete assessment data	The selected equipment is missing required assessment data (surface area and efficiency).
Inverted coordinates	The latitude and longitude for the reading are likely inverted.
Needs follow-up reading	Use this flag to mark a data point as needing a follow-up reading to validate the data. This flag can only be manually added, and it is not based on any calculation or automatic rules.
Suspicious coordinates	The coordinates for this record are not along the expected path based on previous and subsequent records.
Suspicious equipment	Equipment was chosen that is not assigned to the collector's field team.
Suspicious location	The location is outside of the event radius.
Suspicious unit	A unit was chosen that is not valid for the equipment selected.
Other	This flag can only be added to a data point through manual intervention by a user. It is not automatically added to any data points.

Table B.3. Lab Analysis Flags for Sample and Spectroscopic Data

Flag	Description
Concentration invalid for volume	There is no concentration definition defined for a sample of this volume.
Edited after full assessment	The data point has been edited after it has been assessed at the "Data is Approved on Passed Review?" step (the step where the data point is considered either approved or rejected). This flag will be removed once it is reassessed at the "Data are Approved on Passed Review?" step.
Inverted coordinates	The latitude and longitude for the reading are likely inverted.
Needs follow-up reading	Use this flag to mark a data point as needing a follow-up reading to validate the data. This flag can only be manually added, and it is not based on any calculation or automatic rules.
Suspicious coordinates	The coordinates for this record are not along the expected path based on previous and subsequent records.
Suspicious location	The location is outside of the event radius.
Suspicious unit	A unit was chosen that is not valid for the equipment selected.
Other	This flag can only be added to a data point through manual intervention by a user. It is not automatically added to any data points.

In the Early Phase of a response, it is more likely that data will be uploaded that do not meet all verification checks, nor all precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) requirements. These data may be automatically flagged by CBRN Responder based on what data are missing or what the measurement value appears to convey (e.g., severity level), but it is still crucial that a data assessor perform his or her own assessment on these data using the guidance outlined in this guidance. Table B.4 and Table B.5 translate all available CBRN Responder flags to what this guidance describes.

Table B.4. CBRN Responder Assessment Flags to Verification Flag Comparison

Flag in CBRN Responder	Equivalent Verification Flag in this Guidance
Equipment with no assigned radiation units (survey)	Incomplete if the instrument make and model are unknown; none otherwise
Incomplete assessment data (survey, spectroscopic)	Incomplete
No equipment selected (survey)	Incomplete
Other (survey, spectroscopic, lab analysis)	Suspicious

Table B.5. CBRN Responder Assessment Flags to Validation Flag Comparison

Flag in CBRN Responder	Equivalent Validation Flag from this Guidance
Concentration invalid for volume (laboratory analysis)	Invalid
Edited after full assessment (survey, spectroscopic, lab analysis)	Suspicious Context
Equipment in need of maintenance (survey, spectroscopic)	Out of Calibration
Failed standardization (survey)	Invalid
Inverted coordinates (survey, spectroscopic, lab analysis)	Suspicious Context
Needs follow-up reading (survey, spectroscopic, laboratory analysis)	Suspicious Context
Suspicious coordinates (spectroscopic, laboratory analysis)	Suspicious Context
Suspicious equipment (survey, spectroscopic)	Suspicious Context
Suspicious location (survey, spectroscopic, laboratory analysis)	Suspicious Context
Suspicious probe (survey)	Suspicious Context
Suspicious radiation type (survey)	Suspicious Context
Suspicious reading (survey)	Suspicious Context
Suspicious unit (survey, spectroscopic, lab analysis)	Suspicious Context
Suspiciously high reading (survey)	Suspicious Context
Suspiciously low reading (survey)	Suspicious Context
Other (survey, spectroscopic, lab analysis)	Suspicious Context

B.2 ANSI/ANS-41.5-2012 Laboratory Analysis Assessment Flags

Additional to flags applied within CBRN Responder, some laboratory analysis may instead apply the ANSI/ANS-41.5-2012 flags to their data. These include three flags, as outlined, and mapped to validation flags used in this guidance in Table B.6.

Table B.6. ANSI Lab Analysis Flags Mapped to DQA Guidance Validation Flags

Flag in ANSI/ANS-41.5-2012	Equivalent Validation Flag from Guidance
U (undetected)	None
J (estimated)	Suspicious Context
R (rejected)	Invalid

Appendix C – Comparison of Data Collected for Each Response Objective

Table C.1 summarizes the tables found in main report subsection 2 Gather Data for each response objective. This table can be used for a quick comparison of needed data types between response objectives.

Table C.1. Data Collected for each Response Objective

Data Type Collected for Objective	Assess Reports	Compare to Incident Action Level	Screen Items	Release Areas	Scan for Hotspots	Contaminated Items	Contamination in Water	Estimate Activity
Surveys		✓	✓	✓	✓			✓
Samples				✓		✓	✓	✓
Dose rate measurements	✓	✓	✓		✓			
Spectral measurements		✓		✓		✓	✓	✓
Raw count rates	✓	✓	✓		✓			✓
Background dose rates	✓	✓	✓		✓			
Background spectra		✓		✓		✓	✓	✓

Appendix D – Early Phase Objectives Job Aids

Assess Reports of Elevated Radiation Levels

Early Phase Measurements Collected

☐ Dose Rate ☐ Raw Counts ☐ Background Dose Rates

Verification Flags

"Incomplete" if measurements missing: ☐ Location ☐ Time ☐ Date

☐ Detector type/model ☐ Measurement Value ☐ Units

"Suspicious" if measurements missing: ☐ Collector Name ☐ Collector Org

☐ Detector Orientation ☐ Survey Method ☐ Distance from Target

☐ Mode (Stationary/Scan) ☐ Speed

Validation Flags

"Imprecise" if: ☐ Instrument outputs dose range instead of value

"Out of Calibration" if: ☐ Meter is past due for calibration ☐ Problems with calibration

"None" if: ☐ No calibration info available

"Invalid" if measurement taken: ☐ Outside area of interest ☐ Before release date/time

☐ Not in mR/hr or cpm ☐ Is background collected with other elevated readings

"Suspicious Context" if: ☐ 5+ "Suspicious" flags have been applied

Data Quality Assessment Conditions

"Imprecise" flag present: If background measurement is available, compare against response value. If response value >3x background value, then contamination may be present. Otherwise if no background measurement is available, perform measurement to establish background using same instrument away from suspected elevated areas. If unable to take background measurement with same instrument, take confirmatory measurements in nearby locations and apply "Suspicious" flag.

"Out of Calibration" flag present: Take confirmatory measurement with different instrument in same location. If unable to perform, apply "Suspicious" flag.

"Invalid" flag present: Disregard the measurement for this analysis. It may be necessary to collect new measurements to replace invalid measurements.

“Incomplete” flag present: Measurement should not be considered usable until the missing information can be obtained from the individual who collected the measurement. Collect additional confirmatory measurements.

“Suspicious Context” flag present: Missing information should be collected from individual who collected the measurement. If other nearby measurements without this flag exist, avoid using this measurement. Collect additional nearby confirmatory measurements.

Number of “Suspicious” flags for a measurement set ≥ 3× the number of measurements: Missing information should be collected from the individual who collected the measurement. Collect additional nearby confirmatory measurements.

Insufficiently spaced measurements (no two measurements at least 15 m or 50 ft apart outdoors; at least 3 m or 10 ft apart indoors): Collect additional measurements with appropriate spacing. Disregarded or “not usable” measurements do not count for spacing purposes.

One instrument used for all valid measurements: Collect additional nearby confirmatory measurements with a different instrument.

Data Quality Assessment Conclusions

If: ☐ Background is elevated, and: ☐ Identified isotopes consistent with NORM

OR: ☐ Measurement < 3× typical background

Then: ☐ Radiation hazard presence UNLIKELY ☐ Confirmatory measurements may be sought

If the above conditions are not true:

☐ Radiation hazard presence is LIKELY ☐ Compare measurements to incident action level

Compare to an Incident Action Level

Early Phase Measurements Collected

☐ Surveys ☐ Dose Rate ☐ Spectra ☐ Raw Counts

☐ Background Dose Rates ☐ Background Spectra

Verification Flags

"Incomplete" if measurements missing: ☐ Location ☐ Time ☐ Date

☐ Detector type/model ☐ Measurement Value ☐ Units ☐ Pre-deployment verification check ☐ Instrument/probe make/model

"Suspicious" if measurements missing: ☐ Background Measurement

☐ Collector Name ☐ Collector Org ☐ Detector Orientation

☐ Survey Method ☐ Distance from Target ☐ Mode (Stationary/Scan)

☐ Speed ☐ Serial Number ☐ Range Selection

☐ Surface material of measurements

Validation Flags

"Imprecise" if: ☐ Instrument outputs dose range instead of value

"Out of Calibration" if: ☐ Meter is past due for calibration ☐ Problems with calibration

"None" if: ☐ No calibration info available

"Invalid" if measurement taken: ☐ Outside area of interest ☐ Before release date/time

☐ Not in mR/hr or cpm ☐ Is background collected with other elevated readings
☐ Instrument not suitable for dose rate zone ☐ Time of measurement precedes release
☐ Measured value is outside instrument's sensitivity range

"Suspicious Context" if: ☐ 5+ "Suspicious" flags have been applied ☐ No calibration information available

Data Quality Assessment Conditions

"Imprecise" flag present: If background measurement available, compare against response value. If response value >3x background value, then contamination may be present. Otherwise if no background measurement available, perform measurement to establish background using same instrument away from suspected elevated areas. If you are not able to take background

measurement with same instrument, take confirmatory measurements in nearby locations and apply “Suspicious” flag.

“Out of Calibration” flag present: Take confirmatory measurement with different instrument in same location. If you are unable to perform the measurement, apply a “Suspicious” flag.

“Invalid” flag present: Disregard the measurement for this analysis. It may be necessary to collect new measurements to replace invalid measurements.

“Incomplete” flag present: Measurement should not be considered usable until the missing information can be obtained from the individual who collected the measurement. Collect additional confirmatory measurements.

“Suspicious Context” flag present: Missing information should be collected from the individual who collected the measurement. If other nearby measurements without this flag exist, avoid using this measurement. Collect additional nearby confirmatory measurements.

Number of “Suspicious” flags for a measurement set ≥ 3x the number of measurements: Missing information should be collected from the individual who collected the measurement. Collect additional nearby confirmatory measurements.

Measurement < 3x typical background OR consistent with elevated background and identified isotopes consistent with naturally occurring radioactive material (NORM): Unlikely that radiation hazard is present. Additional confirmatory measurements may be sought, including nuclide identification (ID) using a radioisotope identification device (RIID) or alpha/beta survey.

Number of measurements is less than minimum requested number: Request additional measurements.

Correction factors applied for predetermined time: Calculate average count or dose rate for each time-grouped set of measurements. If the maximum time difference within group exceeds isotope half-life, disregard and perform additional confirmatory measurements.

Data Quality Assessment Conclusions

If: ☐ 1 or more measurements greater than incident action level

Then: ☐ Radiation hazard presence LIKELY☐ Confirmatory measurements may be sought

☐ Consult predictive models for isotopic composition/duration

If the above condition is not true:

Then: ☐ Any radiation hazard presence above incident action level UNLIKELY

☐ Confirmatory measurements may be sought

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