Quality Assurance Project Plan (QAPP)

Radiological Monitoring for TENORM

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Revision Summary Log

Version	Date	Author	Reviewer	Summary of Changes
0	5/1/2026	Gregg West	Sharon Drummond	Initial document

Executive Summary

This Quality Assurance Project Plan (QAPP), developed following U.S. Environmental Protection Agency (EPA) QAPP Guidance revised 02/20/2025, defines the technical, procedural, and quality assurance framework governing radiological monitoring activities performed by Onterris USA, Inc. (Onterris) in support of CNX Resources' operations where Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) may be encountered.

The QAPP establishes requirements for the selection, installation, calibration, operation, and quality control of ambient gamma detectors and truck portal monitoring systems. Procedures are designed to ensure monitoring data is accurate, reproducible, and suitable for operational decision-making and regulatory review, while remaining fully aligned with CNX's Comprehensive Radiation Protection Plan (CRPP) and applicable Pennsylvania and federal radiation protection standards.

This document defines clear roles and responsibilities, instrument control and verification requirements, background radiation determination methodology, alarm setpoints and response actions, data quality assurance processes, and records management expectations. The QAPP is intended to serve as a defensible, auditable foundation for radiological monitoring activities and may be refined as operational experience is gained or as regulatory or client requirements evolve.

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1 Program Overview

1.1 Purpose

This Quality Assurance Project Plan (QAPP) establishes the technical, procedural, and quality assurance requirements governing radiological monitoring activities performed by Onterris USA, Inc. (Onterris) in support of the CNX Resources (CNX) Radical Transparency Program at select active operations where Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) may be encountered. This document is intentionally structured to function not only as a traditional QAPP aligned with U.S. EPA QA/R-5 guidance, but also as the authoritative data management protocol for the program.

The program is designed to be consistent with regulatory frameworks, align with established best practices, and be publicly transparent. Accordingly, all data generated under this QAPP must be scientifically valid, reproducible, and traceable from the point of measurement through final reporting and public communication. The intent is to ensure that any value presented can be fully explained, reconstructed, and defended.

This QAPP governs all aspects of the monitoring program including:

- Deployment and operation of continuous ambient gamma radiation monitoring systems
- Portal-based monitoring of vehicles transporting materials to and from monitored sites
- Establishment and maintenance of background radiation baselines
- Data acquisition, transmission, storage, validation, and reporting
- Quality assurance and quality control (QA/QC) processes
- Investigation protocols and response to elevated readings

The scope of this program spans all relevant operational phases, including pre-development baseline characterization, active drilling and completions, and production/post-production conditions. The program is designed to characterize radiological conditions over time, identify deviations from expected background levels, and provide a basis for evaluating potential exposure pathways.

This QAPP applies to all personnel, equipment, and systems involved in data generation, handling, and reporting. Compliance with this document is mandatory for all project participants. This QAPP does not establish an individual personnel dosimetry program and does not supersede CNX's Comprehensive Radiation Protection Plan (CRPP).

1.2 Regulatory and Guidance Framework

Radiological monitoring activities performed under this QAPP shall comply with applicable federal and Commonwealth of Pennsylvania requirements, including but not limited to:

- U.S. Environmental Protection Agency (EPA) Quality Assurance Project Plan (QAPP) Guidance 02/20/2025
- 25 Pa. Code Article IX – Radioactive Material in Solid Waste Monitoring
- 25 Pa. Code §293.111 – Radiation Protection Action Plan
- Pennsylvania Department of Environmental Protection (PADEP) – Guidance Document on Radioactivity Monitoring at Solid Waste Processing and Disposal Facilities
- ANSI N323A – Calibration and Maintenance of Radiological Survey Instruments
- 10 CFR Part 20 – Standards for Protection Against Radiation

Where conflicts exist, the most conservative applicable requirement shall apply unless otherwise approved by CNX.

1.3 Monitoring Program Framework

The radiological monitoring program is designed to characterize ambient and operational radiation conditions associated with oil and gas development activities, with a focus on identifying and contextualizing potential TENORM-related impacts.

The monitoring strategy is built around three core objectives:

1. Establish background radiation levels
2. Detect and evaluate deviations from background conditions
3. Provide data for internal and external stakeholders

To achieve these objectives, the program incorporates two complementary monitoring components, integrating real-time measurement approaches.

Ambient Gamma Monitoring

Fixed-position ambient gamma detectors are deployed at operational sites. These systems continuously measure radiation levels in units of micro Roentgen per hour (µR/hr) and provide a time-resolved dataset capturing both baseline conditions and operational variability.

Ambient monitoring is designed to:

- Establish site-specific background radiation profiles
- Detect sustained or transient increases above background
- Provide continuous data for trend analysis and public transparency

These systems form the primary real-time monitoring system of the program and enable identification of changing conditions.

Portal Monitoring

Portal monitoring systems are deployed to evaluate vehicles transporting materials to and from monitored locations, including produced water, drill cuttings, and associated waste.

Each portal system utilizes dual detectors positioned to measure radiation levels as vehicles pass through the monitoring zone. The maximum value from the left and right detectors is used as the evaluation metric to ensure a conservative assessment.

Portal monitoring is designed to:

- Screen materials for radiological conditions above background
- Provide a consistent and repeatable evaluation methodology
- Generate event-based data directly linked to operational activities

These systems provide a controlled, point-in-time screening mechanism for outgoing wastes that complements continuous ambient monitoring.

1.4 Monitoring Philosophy

The monitoring program is intentionally designed to prioritize:

- **Consistency over complexity** – Simple, repeatable methods that can be consistently applied
- **Transparency over optimization** – Data that can be clearly explained to non-technical stakeholders
- **Quality and quantity –** With multiple radiological detection systems, large volumes of quality data can be collected and analyzed.

By integrating continuous monitoring (ambient) and event-based screening (portal), the program provides a multi-layered characterization of radiological conditions.

This approach ensures that results are not only technically valid, but also interpretable, verifiable, and credible.

2 ROLES AND RESPONSIBILITIES

Clear delineation of roles and responsibilities is essential to maintaining data integrity, ensuring independent verification, and supporting audit readiness. Responsibilities are assigned to maintain separation between data generation and data validation functions wherever practicable.

2.1 Project Manager

The Project Manager is responsible for overall program execution, including coordination with the client, allocation of resources, and ensuring compliance with this QAPP. The Project Manager maintains accountability for schedule, deliverables, and overall program performance.

- Overall responsibility for execution of radiological monitoring services
- Ensures compliance with this QAPP
- Primary point of contact with CNX

2.2 Field Lead

The Field Lead is responsible for installation, operation, and maintenance of monitoring equipment. This includes:

- Deployment of ambient and portal monitoring systems
- Execution of routine checks and source response checks
- Documentation of field activities and observations
- Assurance that all field activities are conducted in accordance with this QAPP.

2.3 Field Staff

- Perform instrument checks, background measurements, and monitoring activities
- Complete required documentation accurately and contemporaneously
- Immediately report abnormal readings or equipment issues to the Field Lead and Project Manager

2.4 Data Manager

The Data Manager is responsible for the integrity and performance of the data management system. Responsibilities include:

- Oversight of data acquisition and transmission systems
- Management of data storage, backup, and access controls
- Implementation of data validation and flagging processes
- Maintenance of data traceability from raw input to reported output

2.5 Quality Assurance (QA) Lead

The QA Lead provides independent oversight of data quality and program compliance. The QA Lead is not involved in routine data collection activities and is responsible for:

- Independent review of datasets
- Verification of validation processes and flagging
- Identification and documentation of nonconformances
- Oversight of corrective action processes

2.6 Radiation Safety Officer (RSO)

- Establishes action levels per the CNX CRPP
- Coordinates regulatory notifications if required
- Determines required follow-up actions
- Ensures alignment with applicable radiation protection standards

3 INSTRUMENTATION AND MEASUREMENT SYSTEMS Overview

3.1 Monitoring Systems

Ambient Gamma Radiation Detectors

Ambient monitoring systems consist of fixed gamma radiation detectors capable of continuous measurement and data logging. Ludlum Model 375-10 instrumentation, or equivalent, shall be used for ambient monitoring program. Instruments shall:

- Provide measurements in µR/hr
- Be capable of continuous or near-continuous operation
- Be positioned strategically near operations or activity with potential waste
- Integrate with data logging and communication systems
- Maintain performance under expected environmental conditions

Truck Portal Monitoring Systems

Trucks containing waste shall be monitored for gamma radiation using Ludlum Model 375P-1000 instrumentation, or equivalent. Truck portal monitoring systems shall:

- Integrate with data logging and communication systems
- Provide audible and visual alarms when gamma radiation of 10 µR/hr or greater above background is detected
- Allow alarm setpoints to be automatically adjusted relative to background, based on a 10 minute average of instantaneous background readings prior to a truck being scanned

3.2 Calibration and Instrument Control

3.2.1 Calibration Standards

All radiation detection instruments shall undergo annual calibration using NIST-traceable radioactive sources performed by the manufacturer or an accredited calibration laboratory in accordance with ANSI N323A.

3.2.2 Calibration Acceptance

Calibration certificates shall document:

- Instrument model and serial number
- Calibration date
- Radiation sources and energies used
- Calibration factors or response curves, as necessary

3.3 Installation and Commissioning

Onterris shall install monitoring equipment on site at locations representative of site conditions and operational activity where the presence of TENORM is most likely to occur.

Prior to use, each instrument shall undergo commissioning that includes:

- Confirmation of a valid annual calibration
- Verification of power and functionality
- Complete comprehensive set-up and pre-usage source response check (SRC) to determine equipment operability within defined parameters
- Confirmation of alarm functionality (where applicable)
- Establishment of initial background radiation levels
- Successful transmission of data from the monitoring device to Onterris servers.

3.3.1 Operational Source Response Check (SRC) – Purpose

SRCs verify instrument response to a known radiation source and confirms basic functionality. SRCs do not replace formal calibration. SRC results are documented and explicitly flagged within the dataset

SRC – Ambient Monitoring Units

- Frequency: Weekly
- Acceptance criteria: Instrument response within ±20% of expected response

SRC – Portal Monitoring Units

- Frequency: Per operational shift
- Verification includes detector response and alarm activation
- Acceptance criteria: Instrument response within ±20% of expected response

SRC – Other Handheld Radiation Detectors (as necessary)

- Frequency: Daily or Prior to Usage
- Verification includes detector response and alarm activation

3.3.2 Out-of-Tolerance Response

Instruments failing SRC acceptance criteria shall prompt the following actions:

- Confirm that:
  - Detector power supply or batteries are satisfactory
  - Cables are intact, connected sufficiently, and not damaged
  - The source is held to the probe in the same manner as the measurements used for SRC setup
- Reperform the SRC
- After second failure:
  - Remove detector from service immediately
  - Be tagged as out-of-service
  - Be evaluated for recalibration or repair

4 AMBIENT GAMMA MONITORING SYSTEMS: Purpose and alarms

Ambient gamma monitoring systems provide continuous or periodic assessment of gamma radiation conditions at active operational sites. In order to support identification of abnormal gamma radiation conditions, ambient monitors should be deployed at locations that best represent the ambient radiation readings at the site and near areas where potential TENORM-containing materials are potentially stored.

Ambient monitor alarm thresholds shall be set at 0.020 mR/hr, consistent with the Investigation Threshold defined in Section 14.

Notifications of alarms for ambient units are immediately communicated via text and email to Onterris employees.

Responses to elevated ambient monitor readings shall follow the Action Levels and Decision Flow defined in Section 14.

5 Portal Monitoring System and Decision Logic

Portal monitoring represents a critical control point for evaluating material movement and potential TENORM transport. The system is designed to provide consistent, repeatable, and defensible screening of vehicles and materials entering or exiting the site.

5.1 Measurement Approach

Each portal system utilizes two detectors positioned to capture radiation levels from the vehicle as it passes through the monitoring zone.

For each vehicle:

- Left detector reading is recorded
- Right detector reading is recorded
- The maximum value of the two detectors is used as the evaluation value

This approach ensures a conservative and defensible assessment, accounting for potential asymmetry in material distribution.

5.2 Portal Monitor Action Level

Portal monitor measurements from vehicles are compared against the defined Action Level:

Action Level = Background + 10 μR/hr

- Background level is based on a 10 minute average of instantaneous background readings prior to each truck being scanned
- If evaluation value ≤ Action Level → Pass
- If evaluation value > Action Level → Alarm triggered

5.3 Re-Scan Protocol

All initial alarm conditions at Portal monitoring locations shall be subject to a mandatory re-scan to confirm reproducibility and reduce false positives. Upon an initial alarm:

1. The vehicle shall be repositioned and re-scanned
2. A second evaluation value shall be calculated
3. If alarm condition persists the vehicle will be moved to a designated location per CNX's CRPP and the CNX RSO will be notified.

Outcome determination:

- Second scan ≤ Action Level→
  - Event recorded as cleared on re-scan
  - No further action required
- Second scan > Action Level →
  - Event classified as INVESTIGATION
  - Follow-up actions initiated

5.4 Event Data Requirements

Each portal event shall include:

- Date and time
- Vehicle identifier (if available)
- Left and right detector readings
- Evaluation value (max of left/right)
- Alarm status
- Re-scan result
- Final disposition (pass, cleared on re-scan, investigation)

5.5 Data Treatment

- All portal events are retained in the dataset
- Events are flagged according to outcome
- Portal data are integrated into the broader data management system with full traceability

6 BACKGROUND RADIATION DETERMINATION

6.1 Purpose

Background radiation measurements establish baseline conditions used to set alarm thresholds and interpret continuous monitoring data collected by the ambient monitoring stations.

6.2 Initial Background Establishment

Background radiation levels shall be established to define the baseline reference conditions for each monitoring location and to support all subsequent evaluations:

- Following installation and commissioning of radiation monitoring equipment

- During routine SRCs and system verification activities
- As part of any investigation of equipment performance issues or data anomalies

Background measurements shall be collected under conditions that are:

- Representative of normal site conditions
- Free from known radiological sources or operational influences

The background value shall exclude:

- Spikes or short-duration anomalies
- Data associated with active operations (e.g., material movement, drilling, completions)
- Data flagged as INVALID, INVESTIGATION, BUMP_TEST, or MAINTENANCE
- Retained for audit and comparison with future verification activities

6.3 Routine Verification

Background conditions are continuously monitored through automated validation processes via alarms and periodically verified through structured review to ensure ongoing representativeness of site conditions.

Automated monitoring includes:

- Comparison of incoming ambient data to established baseline ranges
- Identification of sustained deviations from expected variability
- Flagging data exceeding defined background thresholds

Sustained or unexplained deviations identified through either automated processes or formal review shall trigger investigation flagging and potential background re-evaluation.

7 ACTION LEVELS AND RESPONSE

Action levels define standardized operational responses when measured gamma radiation levels exceed established thresholds relative to site-specific background. Action levels are aligned with CNX operational expectations and the CNX Comprehensive Radiation Protection Plan (CRPP).

7.1 Investigation Threshold

Ambient Monitors

A measured gamma radiation level exceeding 0.020 milliroentgen per hour (mR/hr) constitutes an Investigation Threshold.

Truck Portal Monitors

A measured gamma radiation level exceeding 0.010 milliroentgen per hour (mR/hr) above established background constitutes an Investigation Threshold.

7.2 Required Immediate Actions

When the Investigation Threshold is exceeded, the following actions shall be taken immediately:

- Pause affected activities in the immediate area, as appropriate
- Verify instrument calibration and SRC status
- Re-measure at the same location to confirm the reading
- Document readings, location, time, and site conditions
- Notify the Onterris Field Lead
- Notify CNX site personnel and the CNX Radiation Safety Officer (RSO)

CNX and RSO Evaluation

Following notification, CNX leadership and the RSO shall evaluate the condition and determine any additional actions, including expanded monitoring, access controls, or other controls consistent with the CRPP.

7.3 Resolution and Documentation

All Investigation Threshold exceedances and resulting actions shall be documented. Resolution shall be confirmed prior to resuming normal operations.

7.4 Action Level Decision Flow

Decision Flow:

1. Reading ≤ Investigation Threshold → Continue operations, document routine monitoring.
2. Reading > Investigation Threshold → Initiate Investigation Threshold actions.
3. Elevated reading confirmed → Notify CNX and RSO.
4. CNX/RSO determines controls → Implement directed actions.

Condition resolved → Document resolution and resume normal operations.

7.5 External Influence Investigation Protocol

When data are is suspected to be affected by an external influence, Onterris and CNX will review available information to t determine whether the data is reasonably attributable to CNX operations, instrument/equipment performance, or external/non-CNX sources or conditions,.

Onterris will review and document applicable monitoring system information, including:

- Instrument power status, communication status, and data continuity;
- Operational status of the monitoring equipment during the affected period;
- Instrument alarm history, fault codes, data gaps, spikes, or abnormal signal behavior;
- Recent calibration status and any maintenance, relocation, repair, or configuration changes;
- Results of applicable source checks, bump tests, and background checks;
- Whether the instrument was operating within expected parameters before, during, and after the affected period;
- Comparison to nearby or related monitoring locations, if available;
- Weather conditions, precipitation, lightning, or other environmental factors that could affect readings or instrument performance;
- Field observations, site notes, photographs, or technician comments, if available.

CNX will review and document relevant operational information for the affected period, including:

- Active CNX operations occurring at or near the monitored location;
- Any changes in site operations, process conditions, equipment status, or work activities;
- Movement, handling, storage, transfer, or removal of produced water, drill cuttings, sludge, scale, filter socks, pipe, tanks, containers, or other potentially TENORM-impacted materials;
- Truck traffic, loading/unloading activity, waste transport, or temporary staging of materials ;
- Maintenance, pigging, tank cleaning, filter changes, equipment removal, or other work that could disturb or displace potentially radioactive material;
- Whether any radiography, sealed sources, tracers, isotopes, or other radiation-producing activities were authorized, planned, or conducted by CNX or its contractors;

- Any known abnormal events, spills, releases, weather-related disruptions, or emergency response activities.

Following the review, Onterris will summarize the available evidence and recommend whether the affected data should be flagged as **External Influence**. CNX will review the recommendation and provide operational concurrence or additional information as needed.

The **External Influence** flag may be applied when the available evidence indicates the data were not reasonably attributable to CNX operations and were more likely influenced by off-site, third-party, environmental, unidentified, or otherwise non-CNX sources or conditions. Application of the flag does not invalidate the data; it identifies the data as affected by conditions outside CNX operational control based on the available investigation record.

8 DATA MANAGEMENT AND QUALITY ASSURANCE

8.1 Data Recording

All radiological monitoring data generated under this QAPP shall be recorded in a timely, accurate, and legible manner using approved field logs, electronic records, or data capture systems.

Data records shall include, as applicable:

- Date and time of measurement
- Location and monitoring point identification
- Instrument identification (model and serial number)
- Measured values and units
- Background reference values
- Technician name or initials

8.2 Data Review and Verification

Onterris shall conduct routine and as-needed data review to verify:

- All readings above the Investigation Threshold have been investigated and resolved (steps need defined)
- Completeness of records
- Compliance with procedural requirements
- Consistency with expected background and operational conditions

Data review shall be performed by qualified Onterris personnel independent of the individual who collected the data where practicable.

8.3 Quality Assurance Checks

Quality assurance checks include:

- Verification of calibration and SRC status
- Review of alarm events and responses
- Evaluation of anomalous or unexpected readings

Any discrepancies identified during QA review shall be documented and evaluated.

8.4 Nonconformance Identification

Nonconformances may include, but are not limited to:

- Instrument use outside calibration or SRC requirements
- Incomplete or missing documentation
- Failure to follow established procedures

8.5 Corrective Action

When a nonconformance is identified:

- The issue shall be documented
- Immediate corrective actions shall be implemented as appropriate
- Root cause shall be evaluated if required
- Preventive actions shall be identified to prevent recurrence

Corrective actions shall be tracked to closure.

9 Data Architecture and System Design

The data architecture is a foundational component of this program and is designed to ensure full traceability, auditability, and defensibility of all data generated. The system is structured to maintain data integrity from acquisition through reporting, while supporting both internal analysis and external transparency.

9.1 Data Flow Architecture

All data generated under this program follow a defined, controlled pathway:

Instrument → Data Logger → Secure Transmission → Central Database → Processing Layer → Reporting Systems

Each stage in this process is governed by defined controls to ensure:

- No loss of data during acquisition or transmission
- Preservation of original (raw) data in its original form
- Traceability of all transformations and calculations
- Time synchronization across all systems and components

This structured flow, detailed in the flow chart below, ensures a consistent and auditable chain of custody for all data.

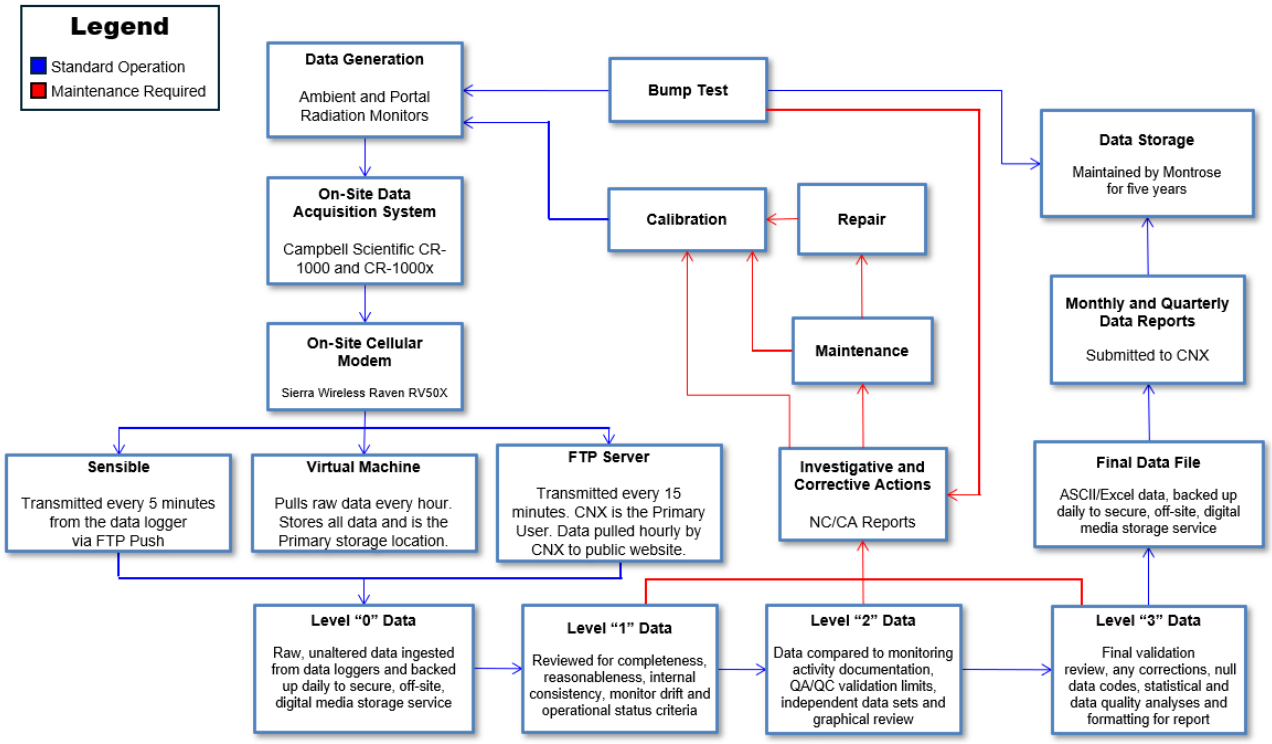

Figure 10-1 – Radiation Monitoring Program Data Flow Chart

9.2 Data Integrity and Traceability

Raw data are preserved in their original form and are never overwritten. All processed, validated, or aggregated data maintain a direct linkage to the originating raw dataset.

Each data point can be traced through:

- Instrument of origin (including serial number or unique identifier)
- Timestamp of collection
- Transmission and storage history
- Validation status, flags, reason codes and applied rules
- Inclusion in aggregated datasets, summaries or reported outputs

This traceability ensures that any reported value can be reconstructed, verified, and defended.

9.3 Data Transmission and Storage

Data are transmitted from field systems via secure communication protocols (e.g., cellular data transmission) to a centralized data repository. Systems are designed to:

- Buffer data locally in the event of communication loss
- Automatically transmit backlogged data upon reconnection
- Prevent duplication/redundant records or loss of records
- End-to-end transmission verification to confirm data receipt

Primary data storage systems are supported by routine backups to ensure long-term data preservation and disaster recovery capability.

9.4 Data Processing

Data processing is performed within a controlled environmental and includes:

- Application of validation rules (Automated and Manual)
- Assignment of data quality flags
- Aggregation to defined reporting intervals (e.g., rolling averages, time-weighted averages, maximum concentrations)

All processing steps are controlled and documented. No transformation is performed without defined logic with transparent and reviewable methodology.

10 Data Acquisition and Measurement Requirements

All data generated under this program shall meet minimum structural, temporal, and quality requirements to ensure traceability, consistency, and usability across all stages of the data lifecycle. These requirements establish a standardized data foundation to support validation, analysis, reporting, and defensibility.

10.1 Required Data Elements

Each individual data record shall include, at minimum:

- Timestamp (synchronized across all systems)
- Location identifier (site and specific monitor location)
- Instrument identifier (unique ID tied to calibration and maintenance records)
- Measurement value (e.g., µR/hr; CPS where applicable)
- Applicable background reference value, corresponding to the active baseline condition
- Data quality flag (as defined in Section 11)
- System status indicator (normal operation, maintenance, offline, etc.)

For portal monitoring events, additional required elements include:

- Left detector reading (µR/hr)
- Right detector reading (µR/hr)
- Calculated evaluation value (maximum of left/right detectors)
- Alarm status (triggered/not triggered)
- Re-scan indicator (yes/no)
- Final disposition (pass, cleared on re-scan, investigation initiated)

10.2 Time Synchronization

All monitoring systems, including ambient monitors, portal systems, and data logging infrastructure, shall maintain synchronized time stamps to within ±1 minute of the system reference time.

Time synchronization is required to support:

- Correlating events across systems including alignment of ambient and portal data
- Reconstructing sequences of operational activities
- Supporting defensible investigation of anomalies, alarms or exceedances

System architecture shall include mechanisms for routine time verification and correction to prevent drift and ensure ongoing alignment.

10.3 Data Frequency and Resolution

- Ambient monitoring systems shall collect data at a minimum resolution of 2-second intervals
- Portal monitoring systems shall capture data at sufficient resolution to characterize the full vehicle pass-through event

Where supported by instrumentation, higher-frequency data may be collected; however:

- Raw high-resolution data shall be retained without loss
- Data shall be normalized to defined reporting intervals for analysis and reporting, as described in Section 12
- Aggregation methods shall preserve event integrity and peak response characteristics

These requirements ensure that data resolution is adequate for both real-time decision-making and post-event reconstruction, without compromising data manageability.

11 Data Validation and Quality Control

All data are subject to structured, repeatable, and auditable validation procedures designed to identify errors, anomalies, and conditions requiring further evaluation. Validation is performed through a combination of automated logic and independent QA review.

11.1 Validation Philosophy

Validation is intentionally tight and proactive, with the goal of:

- Early identification of data quality issues
- Preventing invalid data propagation to downstream systems
- Ensuring that all reported values are technically defensible
- Differentiation between environmental signals, maintenance, calibration and other operational influences

Validation also serves to identify meaningful events requiring investigation, documentation, and potential response.

11.1.1 Data Classification Philosophy (INVALID vs. INVESTIGATION)

For the purposes of validation, anomalous data shall be classified into one of two primary categories:

1. INVALID

Data that are known to be erroneous, non-physical, or not representative of actual environmental conditions.

Criteria for classification as INVALID include:

- Physically impossible values (e.g., < 0 µR/hr)
- Confirmed instrument malfunction or failure

- Missing critical data elements required for interpretation
- Data collected during known non-operational states (if not otherwise categorized as QA activity)

INVALID data shall:

- Be excluded from all analytical and reporting datasets
- Be retained in the system with full traceability
- Require documentation of the cause where determinable

2. INVESTIGATION

Data that are potentially valid but exhibit anomalous behavior requiring further review to determine origin and significance.

Criteria for classification as INVESTIGATION include:

- Exceedance of defined thresholds (e.g., background + trigger level)
- Rapid or atypical rate-of-change relative to expected variability
- Patterns inconsistent with established background conditions
- Indicators of potential instrument instability not yet confirmed

INVESTIGATION data shall:

- Be retained and flagged pending QA review
- Be evaluated for potential environmental, operational, or instrument-related causes
- Be reclassified as VALID or INVALID upon completion of QA review, where appropriate
- Be included in reporting with appropriate context and documentation

11.2 Validation Workflow

Validation is applied sequentially using the following ruleset where each step assigns or updates a data quality flag in accordance with Section 11:

Step 1 – Range Validation

- Any measurement < 0 µR/hr is physically invalid and shall be flagged as INVALID
- Zero values shall be evaluated for instrument status and flagged if associated with system malfunction

Step 2 – Data Completeness Check

- Missing required fields (timestamp, instrument ID, measurement value) result in INVALID flag

- Partial records are retained for auditability but excluded from analysis and reporting

Step 3 – Rate-of-Change (Spike) Detection

- Rapid changes exceeding predefined thresholds (e.g., abrupt increases inconsistent with environmental variability) are flagged as INVESTIGATION
- Thresholds are established based on baseline variability observed during background characterization

Step 4 – Background Deviation Evaluation

Any value exceeding background + 10 μR/hr is flagged as INVESTIGATION

Sustained elevations (multiple consecutive intervals) are prioritized for review and evaluated for potential operational or environmental cause

Step 5 – Instrument Performance Check

- Patterns indicative of drift, instability, or sensor malfunction trigger INVESTIGATION or INVALID flags depending on severity
- Instrument performance checks will incorporate:
  - Historical trending
  - Cross-comparison with nearby monitors (where applicable)
  - QA/QC activity records

Step 6 – QA Activity Identification

- All SRC, calibration, and maintenance periods are flagged as BUMP_TEST or MAINTENANCE
- These data are retained and contextualized but excluded from operational analysis

11.3 Automated vs Manual Validation

Validation is implemented through a **dual-layer approach**:

- Automated validation is applied at the data processing stage and is:
  - Applied systematically during data ingestion and processing
  - Based on predefined, documented rules
  - Ensures consistency, repeatability, and real-time flagging
- Manual validation is:
  - Conducted by QA personnel
  - Confirms or refines automated validation
  - Flags conditions and ensure appropriate classification or escalation

12 Data Flagging and Classification System

A standardized data flagging system is implemented to ensure that all data are transparently classified and traceable throughout the data lifecycle.

12.1 Data Flag Definitions

Table 13-1 – Data Flag Definitions

Flag	Definition
VALID	Data meeting all validation criteria during normal operating conditions
BUMP_TEST	Data generated during SRC activities
MAINTENANCE	Data collected during maintenance, calibration, or system downtime
POWR_LOSS	Periods of data interruption or transmission failure due to power failure
COMM_LOSS	Periods of data interruption or transmission failure due to communication failure
INVESTIGATION	Data exceeding defined thresholds or exhibiting behavior triggering a review
INVALID	Data failing validation criteria or confirmed to be erroneous

12.2 Flagging Requirements

- Every data record shall include a flag designation
- Flags are assigned during validation and retained permanently through the data lifecycle
- Flags shall not be overwritten or deleted without updating the audit history
- Any modification or refinement of a flag shall:
  a. Be logged with timestamp and user/system ID
  b. Maintain full audit history of prior classifications

12.3 Use of Flags in Analysis and Reporting

- All data is included in standard operational reporting
- INVESTIGATION data is included with appropriate context, documentation, and Quality Assurance documentation
- BUMP_TEST, MAINTENANCE, and INVALID data are included with appropriate context and retained for auditability, traceability, and QA review

This approach ensures transparency while maintaining analytical integrity.

13 Data Aggregation, Analysis, and Reporting

Data are processed and presented at multiple levels to support operational decision-making, regulatory compliance, and public transparency.

13.1 Data Aggregation Levels

- Raw Data:
  - Collected at 1-minute intervals
  - Retained in full resolution
- Operational Data:
  - Ambient data is aggregated to hourly averages
  - Portal data reports the maximum reading for each truck
  - Used for internal analysis, QA, and public reporting

14 Data Review, QA/QC, and Corrective Action

14.1 Independent QA Review

All data undergo independent review by qualified personnel not directly involved in initial data collection.

Review includes:

- Verification of validation logic
- Confirmation of flag assignments
- Evaluation of investigation events
- Assessment of completeness and consistency
- Nonconformance Identification

Nonconformance includes:

- Failure to follow procedures
- Data inconsistencies or errors
- Instrument performance issues

All nonconformances are documented and tracked.

14.2 Corrective Action Process

For each nonconformance:

1. Issue is documented
2. Root cause is identified
3. Corrective action is implemented

4. Effectiveness is verified

All actions are tracked to closure and retained for audit.

14.3 Audit Readiness

The program is designed to support audit and review at any time. All data, documentation, and decisions must be:

- Traceable
- Documented
- Reproducible

15 TRAINING AND QUALIFICATIONS

15.1 Training Requirements

Personnel performing radiological monitoring activities under this QAPP shall receive training appropriate to their assigned responsibilities.

Training shall address:

- Basic radiation safety principles
- Instrument operation and limitations
- Calibration and SRC requirements
- Background measurement procedures
- Alarm recognition and response
- Documentation requirements

15.2 Qualification Verification

Onterris shall ensure that personnel assigned to radiological monitoring tasks:

- Have completed required training
- Are competent to perform assigned duties
- Are familiar with this QAPP, SOPs and applicable CNX procedures

15.3 Refresher Training

Refresher training shall be provided periodically and when:

- Procedures are revised
- New equipment is introduced

Performance issues or nonconformances indicate a need for retraining.

16 HEALTH, SAFETY, SECURITY, AND ENVIRONMENT

16.1 General Safety

All work performed under this QAPP shall comply with:

- Applicable Onterris health and safety requirements
- CNX site safety rules
- Site-specific Health and Safety Plans

16.2 Radiation Safety

Radiological monitoring activities shall be conducted in a manner that:

- Minimizes exposure consistent with “As Low As Reasonably Achievable” (ALARA) principles
- Avoids unnecessary contact with potential TENORM sources
- Defers radiological control decisions to the CNX RSO where required

16.3 Stop Work Authority

All Onterris personnel retain stop work authority and shall immediately stop work if conditions are observed that pose an imminent risk to personnel, the environment, or equipment.

16.4 Security

Monitoring equipment and records shall be protected from unauthorized access, damage, or tampering.

17 RECORDS MANAGEMENT

17.1 Record Types

Records generated under this QAPP include, but are not limited to:

- Calibration certificates
- SRC and functional check logs

- Background radiation determination records
- Portal monitoring verification and alarm logs
- Data review and corrective action records

17.2 Record Retention

All records shall be retained by Onterris for a minimum of five (5) years, unless a longer retention period is required by CNX or regulatory authorities.

17.3 Record Accessibility

Records shall be maintained in a manner that allows timely retrieval for:

- Internal review
- Client review
- Regulatory inspection or audit

18 REVISION HISTORY AND DOCUMENT CONTROL

18.1 Document Control

This QAPP is a controlled document. Changes shall be made only through the document revision process.

18.2 Revisions

Revisions shall be documented and shall include:

- Revision number
- Description of changes
- Date of revision
- Approval authority

18.3 Distribution

Current versions of this QAPP shall be distributed to:

- Onterris project personnel
- CNX representatives as appropriate

Obsolete versions shall be removed from use.