L2: Regulations and Standards Regarding Environmental Radiation Monitoring during Decommissioning

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Follow-up Training Course on Environmental Radioactivity Monitoring
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Self-Introduction

ORGANIZATION	• National Research and Innovation Agency (BRIN) • National Nuclear Energy Agency (BATAN) merged into BRIN (since 2022)
DEPARTMENT	• Directorate of Nuclear Facility Management
DIVISION	• Quality Assurance
TRAINING EXPERIENCE	• Nuclear Researcher Exchange Program on Environmental Radioactivity Monitoring, Tsuruga, Japan, 2011 • Instructor Training Course on Environmental Radioactivity Monitoring, Tokai, Japan, 2014 • Advanced Instructor Training Course on Environmental Radioactivity Monitoring, Online, 2021 • Advanced Instructor Training Course on Environmental Radioactivity Monitoring, Tokai, Japan, 2023
EXPERIENCE AS INSTRUCTOR	• Follow-up Training Course on ERM 2014-2024 • Instructor Training Course on ERM 2019 & 2021 (Guest Lecturer)

Background

- Ensuring environmental and public protection on decommissioning
- Regulatory and policy frameworks as the foundation of safety
- Alignment with international standards and best practices
- Supporting safe, efficient, and transparent decommissioning

Objective – Basic Competency

Participants are able to understand and explain the national regulations and international standards governing environmental radiation monitoring during decommissioning, including legal frameworks, policy requirements, and their practical application in ensuring environmental and public safety.

Objective - Success Indicators

- Participants can identify and describe key national laws, regulations, and policies that govern environmental radiation monitoring during decommissioning.
- Participants can explain major IAEA and ICRP standards and their relevance to national implementation.
- Participants can outline how environmental radiation monitoring supports safety, decision-making, and regulatory compliance throughout the decommissioning process.
- Participants can describe the steps and documentation required for environmental licensing, monitoring, and reporting to regulatory authorities during decommissioning.

Outline

Legal and Regulatory Framework

International Standards and Safety Requirements

Role of Environmental Radiation Monitoring in the Decommissioning Process

Environmental Licensing and Reporting Requirements

Legal and Regulatory Framework

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National Regulatory System

A well-structured national regulatory system is essential to ensure that all activities involving radioactive materials, including decommissioning, are conducted safely and in compliance with national laws and international obligations.

The system establishes **authority, accountability, and coordination** among governmental and non-governmental bodies responsible for radiation protection and environmental control.

Legislative Framework

Primary Laws:

- *Nuclear Energy Act* (Act No. 10 Year 1997 in Indonesia) defines fundamental provisions for nuclear safety, security, and safeguards.
- *Environmental Protection Law* (Act No. 32 Year 2009) provides the general basis for environmental management and monitoring.

These laws form the **legal foundation** for issuing subordinate regulations, establishing competent authorities, and enforcing compliance.

Regulatory Authority

A **designated nuclear regulatory body** (**BAPETEN**) is responsible for:

- Establishing and enforcing radiation protection and safety **regulations**.
- **Licensing** and **authorizing** facilities and activities.
- Conducting **inspections, audits**, and enforcement actions.
- Approving **environmental monitoring programs** and evaluating reports.

The authority must be **functionally independent** from organizations that promote or operate nuclear facilities, ensuring impartial oversight.

Supporting Governmental Institutions

Environmental protection agency: oversees non-radiological environmental impacts and coordinates on environmental licensing.

Public health authority: monitors health effects and exposure to the public.

Emergency management agencies: coordinate nuclear/radiological emergency preparedness and response.

These agencies work under a national coordination mechanism to prevent duplication and ensure coherent regulation.

Regulatory Instruments and Guidance

Governmental and ministerial decrees translate legal mandates into operational requirements.

Regulations and safety guides detail technical provisions for:

– Radiation protection standards.
– Environmental monitoring procedures.
– Licensing and reporting requirements for decommissioning activities.

Compliance & Enforcement

- Licensing, inspection, and enforcement processes ensure continuous regulatory control.
- Violations are addressed through sanctions, suspension, or revocation of licenses.
- Regulatory transparency and public communication are promoted to maintain confidence.

Coordination and Interface Mechanisms

Regulatory coordination between the **nuclear regulator** and **environmental authority** is essential during decommissioning.

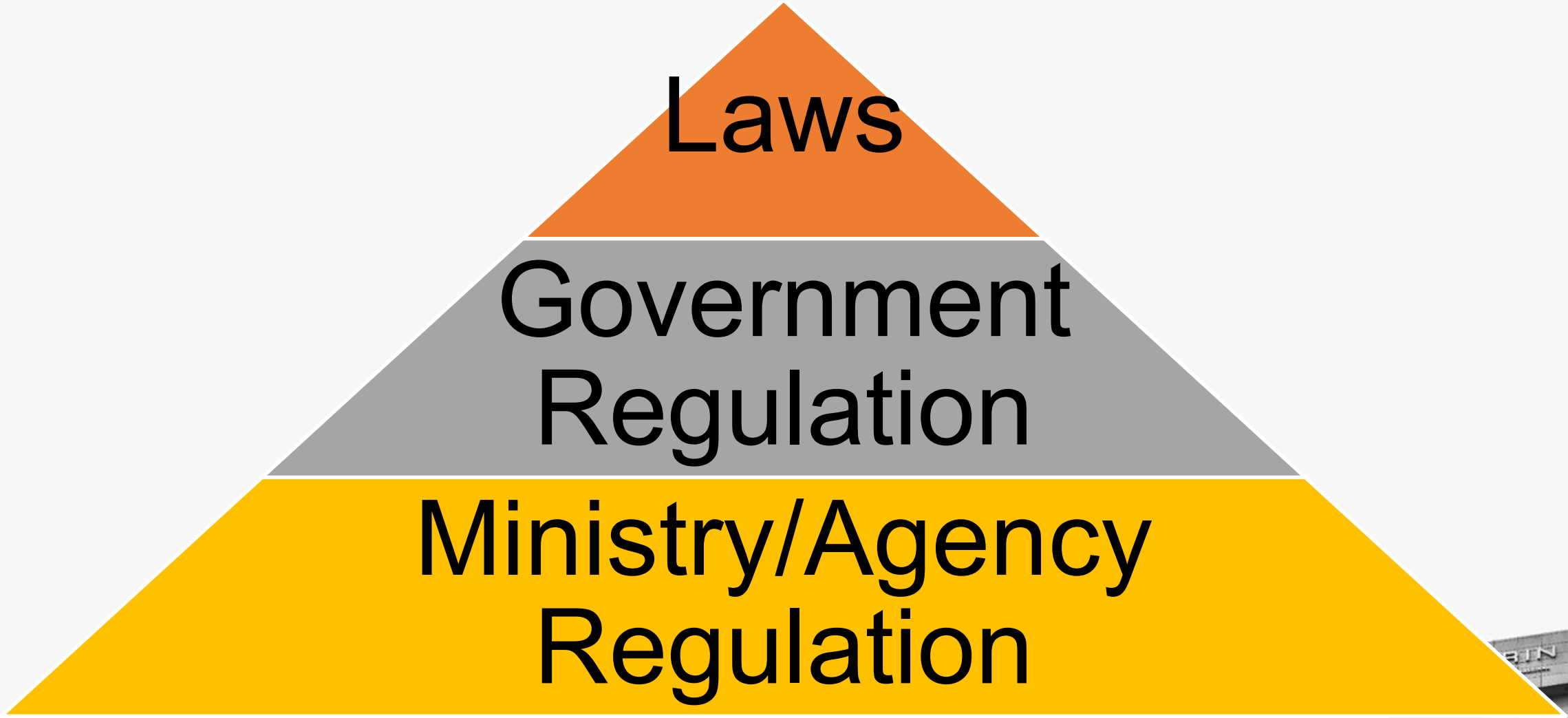
Joint reviews or integrated environmental assessments help align radiation protection with broader environmental objectives.

Interagency agreements (MoUs) often define information sharing, inspection responsibilities, and emergency response roles.

Legal Instruments

- Decommissioning of a nuclear facility is a **highly regulated process**, requiring compliance with both **nuclear safety** and **environmental protection laws**.
- Legal instruments establish the **obligations of licensees**, the **authority of regulatory bodies**, and the **procedures for monitoring, reporting, and environmental control** throughout the decommissioning stages.

Hierarchy of National Legal Framework



Nuclear Energy Law

Provides **the legal foundation for the peaceful use of nuclear energy**, emphasizing safety, security, and safeguards.

Defines the **roles and responsibilities** of the government, regulatory authority, and license holders.

Establishes requirements for **authorization, inspection, enforcement, and public protection**.

Key Provisions Related to Decommissioning and Environmental Monitoring

Licensing: Authorization is required for all stages of a facility's lifecycle, including decommissioning.

Safety Obligations: The licensee is responsible for maintaining radiation protection and safety standards during decommissioning.

Environmental Monitoring: Continuous assessment and control of releases and exposures to the environment are required.

Regulatory Oversight: The nuclear regulatory authority (BAPETEN) is empowered to approve decommissioning plans, monitor compliance, and enforce corrective actions.

Environmental Protection and Management Law

Provides the overarching legal framework for environmental **preservation and pollution control**.

Ensures that all industrial activities, including decommissioning, comply with national environmental quality standards and licensing requirements.

Key Provisions Relevant to Decommissioning

Environmental Impact Assessment (EIA/AMDAL): Decommissioning projects are subject to an environmental assessment to evaluate potential radiological and non-radiological impacts.

Environmental License (Izin Lingkungan): Required before decommissioning activities begin; linked with the decommissioning license issued by the nuclear regulator.

Monitoring and Reporting: Licensees must conduct and report periodic environmental monitoring, including radiation parameters, to both the nuclear regulator and environmental authority.

Waste Management and Pollution Control: Requires safe management of radioactive and conventional waste to prevent contamination.

Regulations and Technical Guides: Government and Ministerial Regulations

Translate the provisions of national laws into operational and technical requirements.

Define the procedures for licensing, radiation protection, and environmental monitoring.Ensure consistency with IAEA Safety Standards.

Examples:

- Government Regulation No. 45/2023 – Safety of Ionizing Radiation and the Security of Radioactive Sources
- Government Regulation No. 43/2006 – Nuclear Reactor Licensing
- Government Regulation No. 22/2021 – Implementation of Environmental Protection and Management

BAPETEN Regulations

BAPETEN Regulation No. 4/2013 – Radiation Protection and Safety (implementation of IAEA GSR Part 3).

BAPETEN Regulation No. 7/2013 & 7/2017 – Environmental Radioactivity Limit (sets requirements for monitoring programs, sampling, and reporting).

BAPETEN Regulation No. 4/2009 – Decommissioning of Nuclear Reactor (specifies safety and licensing requirements for decommissioning, including monitoring obligations).

BAPETEN Regulation No. 6/2011 – Decommissioning of Nuclear Installations Nonreactor

BAPETEN Regulation No. 16/2012 - Clearance Levels

BAPETEN Regulation No. 3 of 2014 - Arrangement of Environmental Impact Assessment (AMDAL) Documents in the Field of Nuclear Energy

Environmental Ministry Regulations

Ministerial Regulation No. 4/2021 – Implementation of AMDAL

Ministerial Regulation No. 16/2012 - Guidelines for the Preparation of Environmental Documents

Ministerial Regulation No. 18/2021 - Certification of Competence for AMDAL Preparers and Environmental Feasibility Assessment

Integration and Harmonization

Cross-sectoral consistency between nuclear and environmental regulations is crucial.

Joint reviews and shared data between BAPETEN and environmental authorities reduce duplication and enhance transparency.

National regulations are aligned with IAEA Safety Standards to **meet international obligations** and best practices.

National Laws & Regulations Summary

Regulatory Level	Number & Year	Title of Regulation
Law	Law No. 10 of 1997	Nuclear Energy
	Law No. 32 of 2009 (in conjunction with Law No. 11 of 2020 – Job Creation Act)	Environmental Protection and Management
Government Regulation (GR)	GR No. 45 of 2023	Safety of Ionizing Radiation and Security of Radioactive Sources
	GR No. 43 of 2006	Licensing of Nuclear Reactors
	GR No. 22 of 2021	Implementation of Environmental Protection and Management
BAPETEN Regulation	BAPETEN Regulation No. 6 of 2011	Decommissioning of Non-Reactor Nuclear Installations
	BAPETEN Regulation No. 4 of 2009	Decommissioning of Nuclear Reactors
	BAPETEN Regulation No. 16 of 2012	Clearance Levels
	BAPETEN Regulation No. 3 of 2014	Arrangement of Environmental Impact Assessment (AMDAL) Documents in the Field of Nuclear Energy
	BAPETEN Regulation No. 7 of 2013 and No. 7 of 2017	Environmental Radioactivity Limit Values
	BAPETEN Regulation No. 4 of 2013	Radiation Protection and Safety
Ministerial Regulation of Environment / MoEF (KLHK)	MoEF Regulation No. 4 of 2021	List of Business and/or Activities Requiring AMDAL, UKL-UPL, or SPPL
	MoEF Regulation No. 16 of 2012	Guidelines for the Preparation of Environmental Documents
	MoEF Regulation No. 18 of 2021	Certification of Competence for AMDAL Preparers and Environmental Feasibility Assessment

International Standards and Safety Requirements

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IAEA Safety Standards System

- The **International Atomic Energy Agency (IAEA)** develops and maintains a comprehensive system of **Safety Standards** that establish the fundamental principles, requirements, and guidance to ensure the protection of people and the environment from harmful effects of ionizing radiation.
- These standards form the **global reference framework** for national regulatory systems, including those governing **environmental radiation monitoring during decommissioning**.
- The IAEA Safety Standards are **non-binding internationally**, but they:
  - Reflect **international consensus and best practices**.
  - Serve as a **benchmark for national legislation and regulations**.
  - Provide a **basis for international peer review and cooperation**.

Purpose IAEA Standards

Protect **people and the environment** from radiation risks arising from all nuclear and radiation-related activities.

Provide a **coherent and harmonized framework** that supports Member States in developing and implementing national safety infrastructures.

Cover **the entire lifecycle** of facilities and activities — from site selection, design, construction, operation, and **decommissioning**, to waste management and environmental protection.

Ensure **continuous improvement** in safety through learning, research, and feedback from experience.

Structure and Hierarchy of the Safety Standards

Safety Fundamentals

- Represent the **top tier** of the hierarchy.
- Establish the **basic safety objective** and **ten safety principles** that underpin all safety standards.
- Provide the ethical and conceptual foundation for radiation protection and nuclear safety.

Safety Requirements

- Represent the **second tier** of the hierarchy.
- Specify **what must be done** to meet the objectives and principles defined in the Safety Fundamentals.
- Contain **"shall" statements** that define binding requirements for regulatory implementation.
- **General Safety Requirements (GSR)** — applicable to all facilities and activities.
- **Specific Safety Requirements (SSR)** — applicable to particular facility types (e.g., reactors, waste facilities).

Safety Guides

- Represent the **third tier** and provide **practical recommendations** on how to meet the Safety Requirements.
- Use "should" statements, describing good practices and methods for implementation.
- Are designed for **regulators, operators, and technical experts**.

Relevant IAEA Safety Standards

Safety Fundamental-1 *Fundamental Safety Principles*.

- Principle 1: Responsibility for safety rests with the person or organization responsible for facilities and activities.
- Principle 7: Protection of present and future generations.
- Principle 10: Protective actions must be justified and optimized.

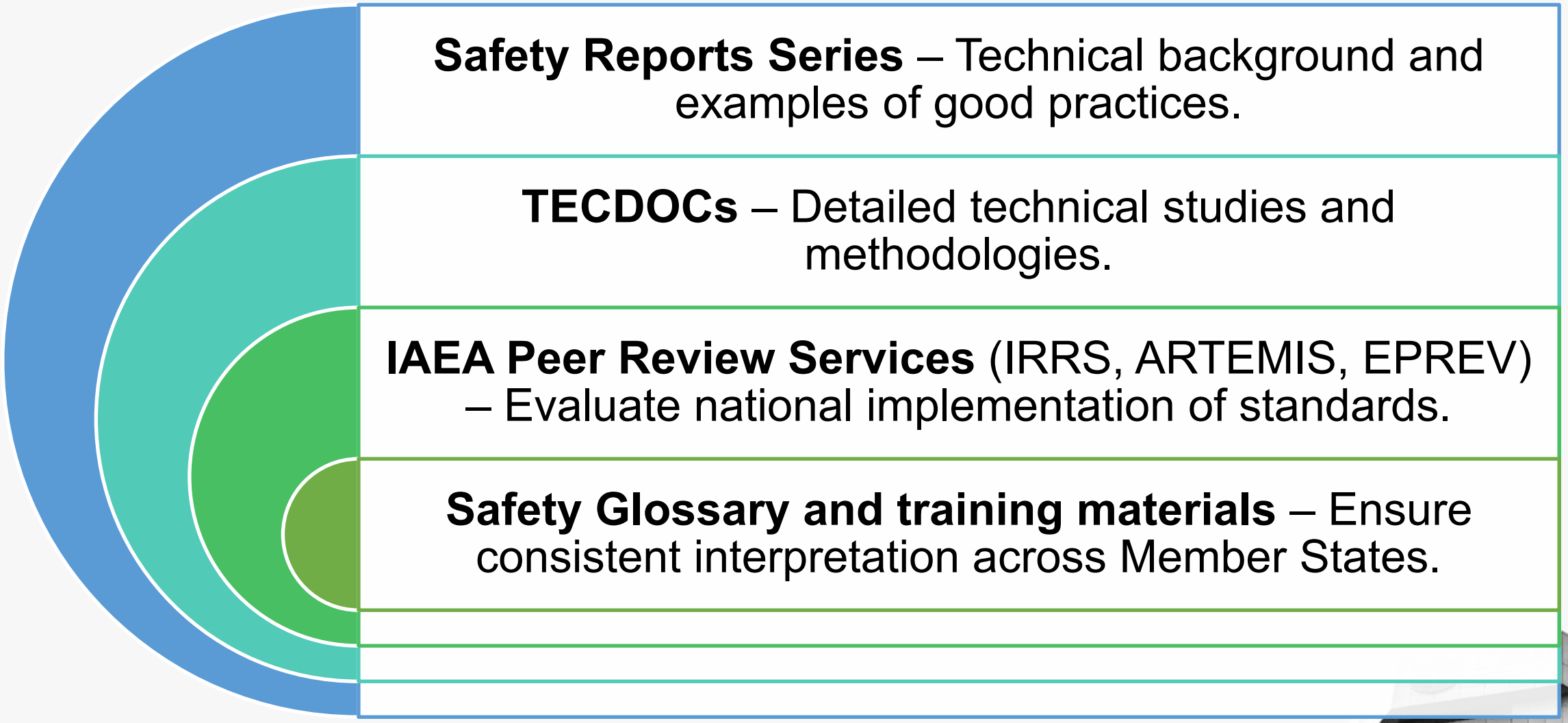
Safety Requirements

- **GSR Part 3**– *Radiation Protection and Safety of Radiation Sources (BSS)*
  → Sets out fundamental requirements for radiation protection of workers, the public, and the environment.
- **GSR Part 6** – *Decommissioning of Facilities*
  → Defines the safety requirements for planning, implementing, and verifying decommissioning, including environmental monitoring provisions.
- **GSR Part 1** – *Governmental, Legal and Regulatory Framework for Safety*
  → Establishes requirements for regulatory systems and oversight responsibilities.

Safety Guides

- **GSG-9** – *Regulatory Control of Radioactive Discharges to the Environment*.
- **RS-G-1.8** – *Environmental and Source Monitoring for Purposes of Radiation Protection*.
- **SSG-47** – *Decommissioning of Nuclear Power Plants, Research Reactors and Other Facilities*.
- **GSG-7** – *Occupational Radiation Protection*.
- **GSG-3** – *The Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste*.

Supporting Documents



GSR Part 3
Radiation Protection and Safety of Radiation Sources

GSR Part 3	• establishes **the fundamental requirements** for radiation protection and safety applicable to all exposure situations — planned, existing, and emergency — including **those arising during decommissioning**.
Protection of the Public and Environment (Requirement 31–34):	• Licensees must ensure that discharges of radioactive material are controlled and kept **as low as reasonably achievable (ALARA)**, taking social and economic factors into account. • The environment must be protected from harmful radiation effects through the application of **limits, constraints, and monitoring programs**.
Monitoring and Assessment (Requirement 35):	• Environmental and source monitoring programs must be implemented to verify compliance with authorized limits. • Monitoring should cover air, water, soil, and biota to assess **exposure pathways** and potential impacts.
Regulatory Framework:	• The regulatory body must set **dose limits**, establish **monitoring and reporting obligations**, and ensure that operators maintain adequate records of discharges and environmental data.
Application to Decommissioning:	• During decommissioning, radiological surveys and environmental monitoring form part of the **end-state assessment** to demonstrate that the site meets **clearance or release criteria**.

GSR Part 6
Decommissioning of Facilities

GSR Part 6

- sets out the **safety requirements** for the **planning, conduct, and completion** of decommissioning activities for all types of facilities that use radioactive materials.

Key Elements Relevant to Environmental Monitoring and Protection:

1.Integration of Environmental Protection (Requirement 3 & 4):
- Decommissioning planning must identify **potential environmental impacts** and define **monitoring strategies** to mitigate them.
- The safety case should address protection of both people and the environment throughout the decommissioning phases.

2.Monitoring and Surveillance (Requirement 16):
- Continuous monitoring of radiation levels, airborne activity, liquid discharges, and contamination is required to confirm that **control measures remain effective**.
- Environmental monitoring results are part of the **regulatory reporting and verification process**.

3.Final Survey and Site Release (Requirement 18):
- A comprehensive **final radiological survey** and environmental monitoring are conducted to demonstrate that residual radioactivity meets **clearance levels**.
- Data from environmental monitoring support the **final status report** submitted for regulatory approval.

4.Waste Management and Records (Requirement 19–20):
- Environmental monitoring contributes to **characterization of wastes**, control of releases, and **long-term record-keeping** for site history and compliance documentation.

RS-G-1.8 Environmental and Source Monitoring for Purposes of Radiation Protection

RS-G-1.8

- provides **practical guidance** on the design, implementation, and operation of **environmental and source monitoring programs** in support of radiation protection and regulatory compliance.

Key Guidance Points:

1.Objectives of Monitoring Programs:
- To assess exposure of the public through environmental pathways.
- To verify the effectiveness of control measures for radioactive releases.
- To confirm compliance with regulatory limits and constraints.

2.Design and Implementation:
- Monitoring programs should be based on **site-specific assessments**, including source term, dispersion, and critical group identification.
- Sampling locations and frequencies must be selected based on **potential exposure pathways** (air, water, food chain, etc.).

3.Quality Assurance and Data Management:
- Monitoring systems must follow **QA/QC procedures**, calibration standards, and documentation requirements.
- Data should be traceable, validated, and maintained for long-term evaluation.

4.Application to Decommissioning:
- Monitoring supports **baseline establishment**, **transition monitoring**, and **post-decommissioning surveillance**.
- RS-G-1.8 complements GSR Part 6 by providing **technical detail** on monitoring methodologies and evaluation criteria.

SSG-47 Decommissioning of Medical, Industrial and Research Facilities

SSG-47

- offers **specific guidance** on how to apply the safety requirements of **GSR Part 6** to **small-scale facilities**, such as hospitals, laboratories, and research installations, which are often **heterogeneous and widely distributed**.

Key Guidance Elements:

1.Decommissioning Strategy and Planning:

- Must integrate environmental monitoring as part of the **radiological characterization and safety assessment process**.
- Requires early identification of monitoring needs for potential contamination of air, water, and soil.

2.Environmental Monitoring during Decommissioning:

- Recommends **routine sampling and measurement** of environmental media near facilities to detect any unplanned releases.
- Emphasizes the need for **reference (baseline) data** to evaluate the effectiveness of cleanup activities.

3.Verification and Final Survey:

- Details procedures for **final status survey** and **environmental verification** before site release.
- Monitoring data must confirm that **residual activity is below regulatory criteria** for unrestricted or restricted use.

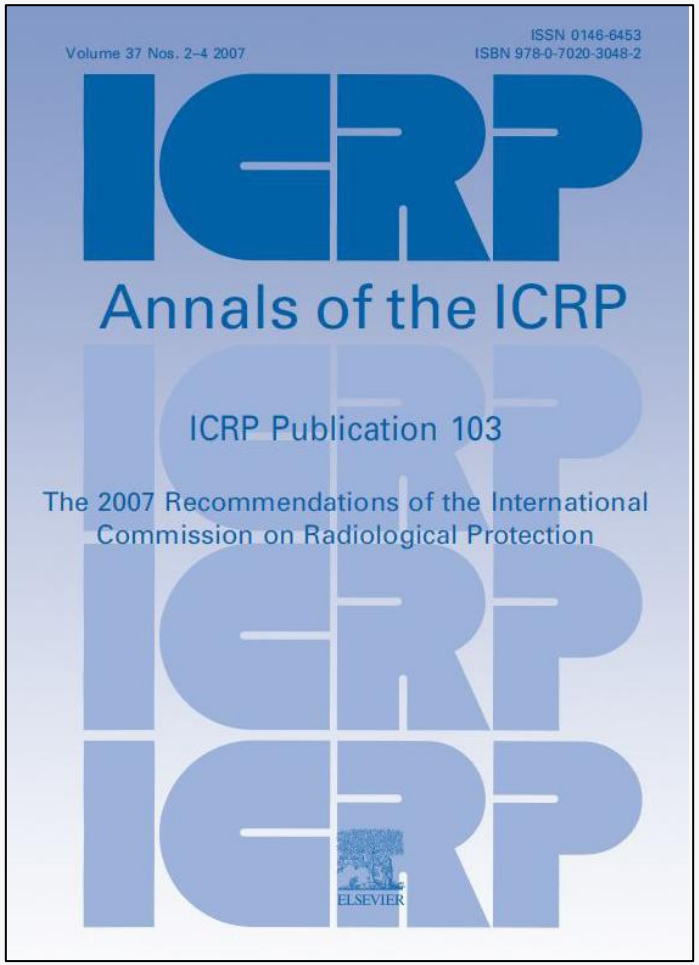
4.Stakeholder and Regulatory Interface:

- Encourages **transparent communication** of monitoring results with regulatory authorities and affected communities.
- Recommends **record retention and public accessibility** of environmental monitoring data to ensure accountability.

ICRP Recommendations

- The **International Commission on Radiological Protection (ICRP)** provides the **scientific and ethical foundation** for the system of radiological protection used worldwide, including in IAEA Safety Standards and national regulations.
- Its recommendations form the **conceptual framework** for:
  - Setting dose limits and constraints,
  - Designing monitoring programs,
  - Assessing environmental and public exposures, and
  - Implementing radiation protection measures during **operation and decommissioning** of nuclear facilities.

ICRP Publication 103: The 2007 Recommendations of the ICRP



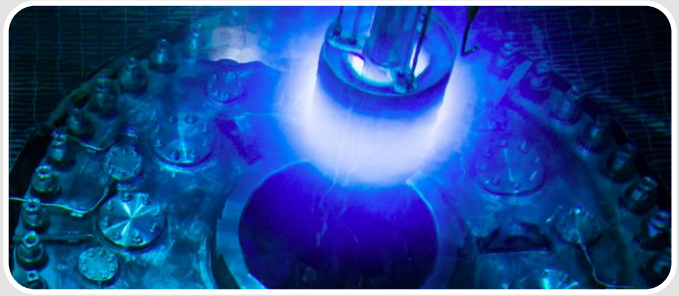
Publication 103 revises and consolidates the ICRP system of radiological protection to reflect scientific advances and evolving ethical and societal expectations.

It establishes **three fundamental principles** and a **systematic framework** for protecting people and the environment from ionizing radiation.

Fundamental Principles of Radiological Protection

Principle	Description	Application to Decommissioning and Environmental Monitoring
Justification	Any decision that alters exposure situations should do more good than harm.	Decommissioning actions, monitoring plans, or remediation strategies must provide net benefit (e.g., reducing long-term risk).
Optimization (ALARA)	Exposures must be kept As Low As Reasonably Achievable, taking into account economic and societal factors.	Monitoring data should be used to optimize cleanup levels, work procedures, and discharge control.
Dose Limitation	Individual dose limits should not be exceeded for planned exposure situations.	Regulatory limits (e.g., 1 mSv/year for public) are used to set discharge constraints and monitoring thresholds.

Exposure Situations



Planned Exposure Situations – Activities involving deliberate introduction and control of radiation sources (e.g., operation and decommissioning of nuclear facilities).

Emergency Exposure Situations – Unexpected events requiring urgent protective actions.

Existing Exposure Situations –

Pre-existing contamination or natural background radiation requiring management.

Decommissioning falls primarily under **planned exposure situations**, but may temporarily involve **existing exposure situations** during site remediation or legacy contamination control.

Categories of Exposure

Occupational Exposure – Workers involved in decommissioning and monitoring.

Public Exposure – Members of the public who may be affected by releases or residual contamination.

Medical Exposure – Patients (not directly relevant to decommissioning).

Protection of the Environment

ICRP 103 explicitly extends its framework to include **environmental protection**, emphasizing that:

- Humans are protected as part of their environment.
- Specific consideration should also be given to **non-human biota** (e.g., plants and animals) to maintain ecosystem integrity.

ICRP introduced the concept of **Reference Animals and Plants (RAPs)** to represent key components of ecosystems for evaluating potential radiological effects in environmental assessments → ICRP 108.

Quantities and Dose Constraints

Effective Dose (E): Used to assess stochastic risk (cancer/hereditary effects).

Absorbed Dose (D): Relevant for deterministic effects and environmental organisms.

Dose Constraints: Used prospectively to limit exposure in planned situations, typically:

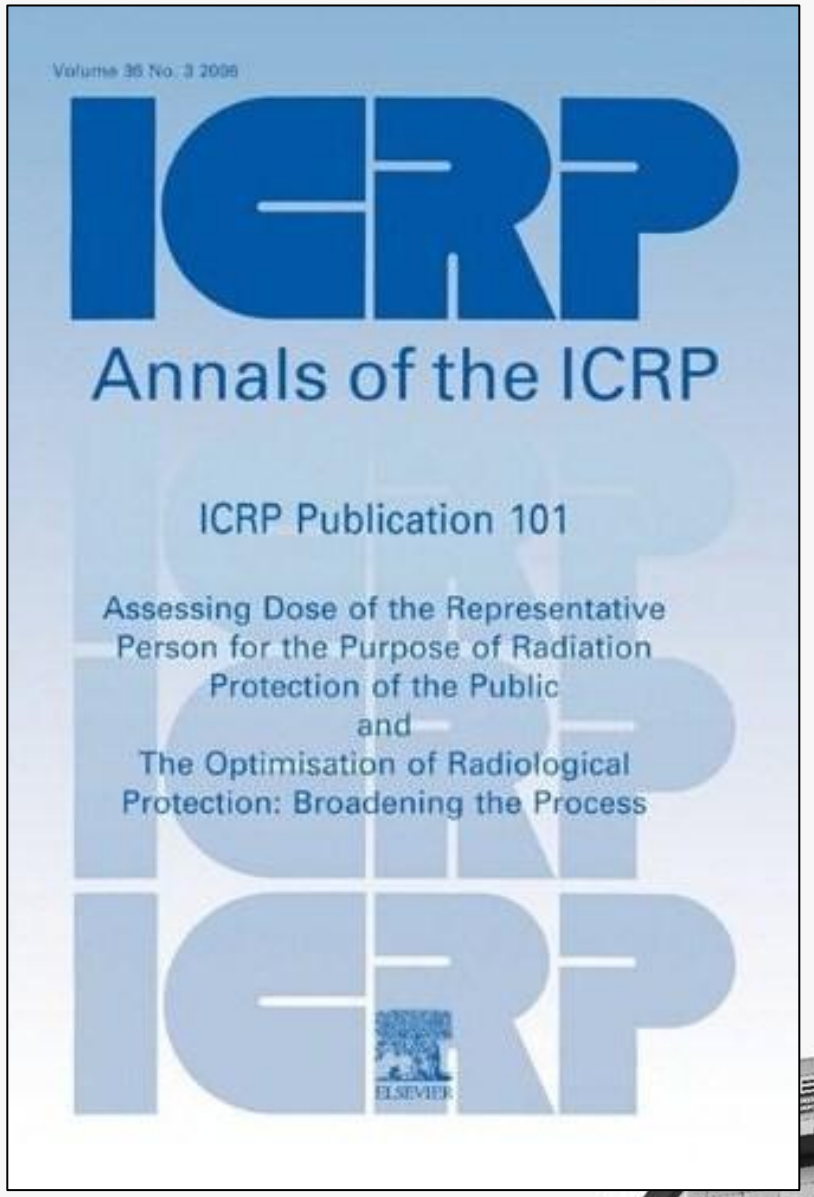
- **1 mSv/year** for members of the public.
- **20 mSv/year** averaged over 5 years for occupational exposure.

Application in Decommissioning

In the context of environmental radiation monitoring:

- Monitoring programs must demonstrate compliance with **dose constraints**.
- Data support **optimization decisions** on cleanup, waste management, and site release.
- Environmental assessment integrates both **human and ecological protection goals** consistent with ICRP 103.

ICRP Publication 101 (2006): Assessing Dose of the Representative Person for the Purpose of the Radiation Protection of the Public & Optimization of Radiological Protection – Broadening the Process



Aspects of Optimization

Optimization as a Continuous Process	• Must be applied at all stages of facility lifecycle, including **planning, operation, and decommissioning**. • Requires continuous evaluation of protection options and monitoring data.
Use of Reference Levels and Constraints	• Optimization involves setting **reference levels** for different exposure situations, guiding protective actions and monitoring criteria.
Stakeholder Involvement	• Optimization should involve **interested parties**, including workers, regulators, and the public, especially during decommissioning projects affecting local communities.
Use of Cost–Benefit and Multicriteria Analysis	• Balances radiation protection benefits against costs, practicality, and social considerations. • Encourages transparent justification for chosen protection levels or cleanup endpoints.

Application in Environmental Radiation Monitoring

Aspect	Application to Decommissioning
Optimization of Monitoring Programs	Monitoring frequency, sampling points, and detection sensitivity should be optimized to achieve adequate protection with efficient resource use.
Decision on Remediation Levels	Monitoring data guide decisions on when remediation can stop or when a site can be released from regulatory control.
Feedback Mechanism	Monitoring results provide feedback for improving radiological protection practices (learning-based approach).
Public Engagement	Transparency and communication of monitoring results enhance stakeholder confidence in decommissioning outcomes.

UNSCEAR and OECD/NEA

- While the **ICRP** provides the *conceptual and ethical foundation* for radiological protection, several international organizations contribute to the **scientific, technical, and policy support system** that underpins global radiation safety and environmental protection.
- Among these, the **United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)** and the **Nuclear Energy Agency (NEA)** of the **Organisation for Economic Co-operation and Development (OECD)** play **complementary roles** in providing:
  - Authoritative scientific assessments (UNSCEAR), and
  - Policy coordination, best practices, and harmonization (OECD/NEA).
- Their outputs form the **scientific and policy backbone** of international standards such as the **IAEA Safety Standards** and **ICRP recommendations**

Application in Environmental Radiation Monitoring

- The IAEA Safety Standards (e.g., **GSR Part 3**) are **directly derived** from ICRP's conceptual system.
- ICRP provides the **scientific and ethical basis**, IAEA translates it into **legal and regulatory requirements**.

ICRP Concept	Reflected in IAEA Document	Operational Implication
Justification	SF-1, GSR Part 3	Regulatory approval for decommissioning must be justified.
Optimization (ALARA)	GSR Part 3, GSR Part 6	Environmental monitoring programs designed to minimize doses and discharges.
Dose Limits & Constraints	GSR Part 3	Regulatory bodies set public and occupational dose limits.
Environmental Protection	GSR Part 3, GSG-9, SSG-64	Incorporation of biota and ecosystem monitoring into environmental assessments.

The Role of UNSCEAR

Area	Description	Relevance to Decommissioning and Environmental Monitoring
Assessment of Radiation Sources and Exposures	Compilation of data on natural, medical, occupational, and public exposure.	Provides baseline data for comparison with decommissioning site monitoring results.
Health Effects of Ionizing Radiation	Evaluation of epidemiological studies and biological effects (e.g., cancer risk).	Supports justification and optimization of protection measures.
Environmental Effects of Radiation	Study of radiation impacts on non-human biota and ecosystems.	Informs environmental dose assessment and biota monitoring.
Global Trends and Data Harmonization	Collection of data from Member States to establish global averages and trends.	Enables benchmarking of national monitoring results against global norms.

UNSCEAR Publications

UNSCEAR 2000 Report: Comprehensive global assessment of radiation exposure from all sources.

UNSCEAR 2008, 2010, 2020/2021 Reports: Updated findings on medical, occupational, and public exposure; and effects of radiation on the environment.

UNSCEAR 2016 White Paper: Framework for assessing effects of radiation on biota.

These reports provide **quantitative data and analytical methodologies** for:

- Estimating dose from routine and residual releases,
- Evaluating the significance of environmental contamination,
- Supporting decision-making on remediation and site release criteria.

The Role of OECD/NEA

NEA Body	Role and Function	Relevance to Decommissioning and Environmental Monitoring
Committee on Radiological Protection and Public Health (CRPPH)	Develops radiological protection policy guidance and coordinates with ICRP and IAEA.	Provides best practices for environmental monitoring and stakeholder engagement.
Committee on Decommissioning of Nuclear Installations and Legacy Management (CDLM)	Focuses on decommissioning strategies, waste management, and legacy site remediation.	Shares lessons learned and technical guidance for monitoring during decommissioning.
Radioactive Waste Management Committee (RWMC)	Addresses long-term waste disposal and safety cases.	Relevant for monitoring of waste repositories post-decommissioning.
Expert Group on Radiological Protection Science (EGRPS)	Identifies research needs to improve protection systems.	Supports development of new monitoring techniques and dose modeling methods.

OECD/NEA Contributions

The NEA provides:

- **Consensus Documents and Reports** – Policy recommendations on radiological protection and environmental management;
- **Workshops and Collaborative Projects** – Platforms for sharing experience in site remediation, monitoring, and stakeholder involvement;
- **Benchmarking and Data Sharing** – Comparative analyses of national decommissioning and monitoring practices;
- **Support to International Standards Development** – Close collaboration with IAEA, ICRP, and EC in updating protection frameworks.

Examples include:

- *NEA (2016): Radiological Protection Science and Application*
- *NEA (2015): Stakeholder Involvement in Decision Making*
- *NEA (2021): Ensuring the Adequacy of Funding Arrangements for Decommissioning and Radioactive Waste Management*

International vs National

Aspect	International Guidance	Typical National Implementation (example: Indonesia / BAPETEN)
Legal status	Non-binding normative documents (requirements + guidance); used as global benchmark.	Binding when transposed into national laws/regulations (Acts, Government Regs, Regulator rules). Example: BSS → implemented via BAPETEN regs.
Level of prescription	Requirements (GSR) set “what shall” be done; Safety Guides (SSG/RS-G) provide “how” but are broadly framed.	National regulations and technical rules must translate “shall/should” into specific permit conditions, monitoring frequencies, sampling methods.
Scope and universality	Global, designed to be broadly applicable across facility types and Member States.	Adapted to local context: facility types, environment, institutional capacity, existing laws (narrower, contextualized).
Flexibility / adaptability	Encourages risk-informed, graded approaches (proportionate to hazard).	Graded approach adopted variably depending on regulatory practice and risk tolerance; may be conservative or permissive.
Enforcement & compliance	Guidance recommends regulatory mechanisms (licensing, inspection, enforcement) but does not enforce.	National regulator enforces through licenses, inspections, sanctions (e.g., BAPETEN license conditions, inspection regime).
Technical detail	Safety Guides and ISO standards provide technical methods, QA/QC, dosimetry, sampling standards.	Technical detail implemented via regulatory guides, national standards, or referenced international ISO methods; practical uptake depends on lab capacity and accreditation.
Monitoring design & protocols	Emphasizes site-specific design, baseline, pathways, QA, data management.	National practice typically prescribes baseline + operational + post-closure monitoring, but specifics (species, radionuclides, frequency) are tailored per license.
Dose criteria and derived limits	Provides principles (dose limits, constraints, derived concentration guidance), not always single numeric values.	National dose limits often mirror ICRP/IAEA values (e.g., 1 mSv/yr public); derived concentrations and clearance levels implemented in regs or technical guides.
Reporting & transparency	Recommends public reporting, peer review, data archiving; encourages stakeholder engagement.	National practice varies — some countries publish monitoring results and reports; others limit public access. Regulations may require reporting to regulator and sometimes public disclosure.
Capacity & resources	Assumes Member States will build capacity; offers IAEA assistance and peer review.	Implementation constrained by national resources: manpower, accredited labs, monitoring equipment, funding for long-term surveillance.
Peer review & continuous improvement	IAEA peer reviews (IRRS, ARTEMIS), NEA exchanges, scientific updates (UNSCEAR) support improvement.	Countries may request/undergo peer reviews; frequency and follow-up depend on national policy and resources.

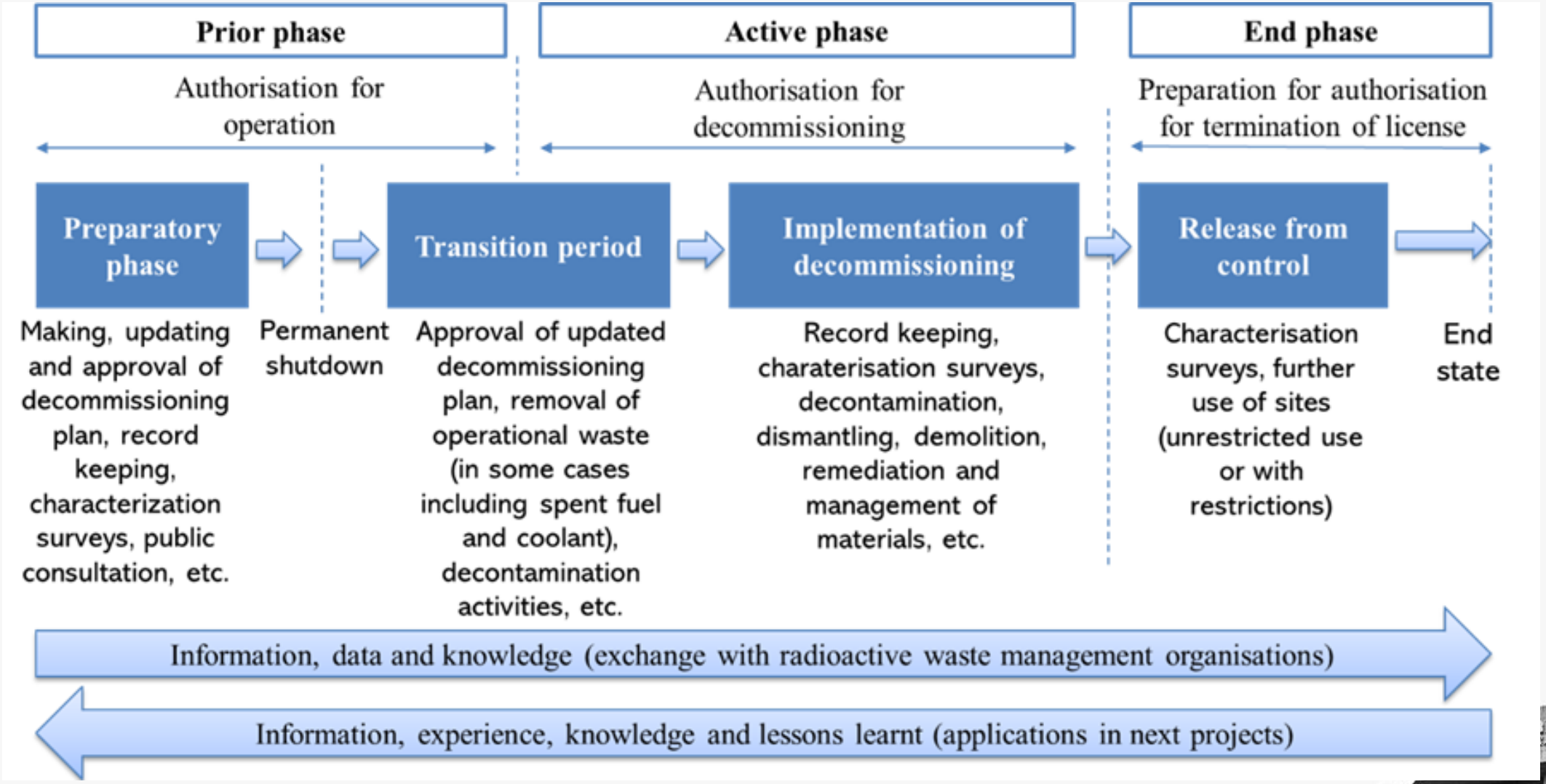
Gaps and Challenges

Regulatory Transposition Gap	• *Issue:* IAEA "requirements" need legal/regulatory transposition; delay or partial transposition creates ambiguity. • *Consequence:* Inconsistent license conditions, uncertainty for licensees.
Technical Capacity Shortfall	• *Issue:* Limited laboratory accreditation (ISO/IEC 17025), insufficient field monitoring equipment, or trained personnel. • *Consequence:* Incomplete QA/QC, longer turnaround times, less reliable data.
Resource and Funding Constraints	• *Issue:* Long-term monitoring requires sustained budgets; decommissioning phases can span years. • *Consequence:* Monitoring programs may be scaled down or interrupted.
Data Management & Integration	• *Issue:* Lack of standardized data formats and national databases for environmental radiological data. • *Consequence:* Difficulty in trend analysis, peer comparisons, public disclosure.
Stakeholder Engagement & Transparency	• *Issue:* International guidance emphasizes public involvement; national practice may lack robust consultation mechanisms. • *Consequence:* Public distrust, delays due to social opposition.
Harmonization Across Sectors	• *Issue:* Nuclear regulator and environmental agency mandates can overlap or be inconsistent. • *Consequence:* Conflicting permit conditions and duplicated monitoring.
Application of Optimization (ALARA)	• *Issue:* Practical, documented application of ALARA in monitoring design and remediation endpoints may be weak. • *Consequence:* Overly conservative or insufficient remediation decisions.

Role of Environmental Radiation Monitoring in the Decommissioning Process

Session-3

Decommissioning Phases



Objectives of ERM during Decommissioning

- To describe the **specific goals and functions** of environmental radiation monitoring throughout the decommissioning process, **ensuring protection** of workers, the public, and the environment in **compliance** with regulatory and international safety requirements.

Key Points

Verification of Radiological Safety and Compliance	To confirm that discharges, residual radioactivity, and radiation levels remain within authorized limits established by the regulatory body.
	To demonstrate compliance with national regulations, license conditions, and applicable international standards (e.g., IAEA GSR Part 3 and Part 6).
	To provide documented evidence supporting regulatory oversight and decision-making for decommissioning milestones.
Assessment of Environmental Impact	To evaluate the influence of decommissioning activities (such as dismantling, waste handling, or soil remediation) on the surrounding environment.
	To detect and quantify any radiological changes in air, water, soil, and biota compared with baseline conditions.
	To ensure that releases to the environment are as low as reasonably achievable (ALARA principle).
Protection of the Public and Ecosystems	To ensure that the collective and individual doses to members of the public remain below the dose limits and within optimization principles.
	To identify potential exposure pathways (e.g., inhalation, ingestion, external radiation) and implement appropriate control measures.
	To provide assurance that natural resources, such as groundwater and agricultural areas, are not adversely affected.

Key Points

Support for Site Release and Clearance Decisions	To provide quantitative data for demonstrating that residual contamination meets **clearance and site release criteria** (as per IAEA Safety Reports No. 72).
	To verify that radiological conditions are safe for future land use after decommissioning is completed.
	To support the regulator's final decision on license termination and public communication.
Early Detection and Corrective Response	To enable early identification of unexpected releases or contamination spread during dismantling or waste transfer operations.
	To trigger timely corrective actions to prevent further contamination or exposure.
	To minimize potential regulatory non-compliance and enhance operational safety.
Data for Transparency and Stakeholder Communication	To provide objective, verifiable data to regulators, stakeholders, and the public, promoting trust and transparency in the decommissioning process.
	To contribute to long-term environmental records that support historical accountability and institutional memory.

Overview of Monitoring Phases

Environmental radiation monitoring during decommissioning is typically divided into three main phases, each with distinct objectives and technical requirements:

Baseline Monitoring (Pre-Decommissioning Phase)

Operational Monitoring (During Decommissioning Activities)

Post-Decommissioning Monitoring (After Site Release or Closure)

These phases form a continuous process for establishing environmental conditions, controlling radiological impact, and verifying safe site restoration.

Baseline Monitoring (Pre-Decommissioning Phase)

Objective:
To determine the natural background radiation levels and existing environmental radioactivity before dismantling or decontamination begins.

Key Aspects:

- Establishes a **reference dataset** against which any future radiological changes can be compared.
- Helps identify **pre-existing contamination** from historical operations.
- Provides input for the **Environmental Impact Assessment (EIA)** and supports the development of monitoring plans and site characterization.

Typical Activities:

- Sampling and analysis of environmental media: air, soil, surface water, groundwater, sediments, and biota.
- Determination of radionuclide inventories and spatial distribution.
- Meteorological and hydrological data collection for dispersion modeling.

Expected Outcomes:

- A validated database of baseline radiological conditions.
- Definition of monitoring locations, frequencies, and analytical methods for subsequent phases.

Operational Monitoring (During Decommissioning Phase)

Objective:
To monitor and control radiological conditions and discharges while decommissioning activities are in progress, ensuring compliance with regulatory limits and safety standards.

Key Aspects:

- Detects any **changes in environmental radiation levels** due to dismantling, waste handling, or contamination removal.
- Provides **early warning** of abnormal releases or migration of contaminants.
- Verifies the effectiveness of **engineering controls and containment measures**.

Typical Activities:

- Routine measurement of ambient gamma dose rates around the facility perimeter.
- Sampling of air, effluent, and surface or groundwater near operational areas.
- Radiochemical analysis for radionuclides of concern (e.g., Cs-137, Co-60, Sr-90, H-3).
- Continuous or periodic data reporting to the regulatory body.

Expected Outcomes:

- Assurance that discharges remain within authorized limits.
- Immediate corrective actions in case of deviations.
- Records supporting safety performance and regulatory compliance.

Post-Decommissioning Monitoring (After Site Release or Closure)

Objective:
To confirm that the site and surrounding environment remain radiologically safe after decommissioning activities have been completed and the facility has been released from regulatory control.

Key Aspects:

- Ensures that residual radioactivity levels meet **clearance and site release criteria** (as per IAEA Safety Reports No. 72).
- Provides **long-term surveillance** where residual contamination could potentially migrate or re-emerge.
- Maintains public and stakeholder confidence through transparent reporting.

Typical Activities:

- Verification sampling and measurements of residual soils, groundwater, and vegetation.
- Periodic reassessment of environmental dose to the public.
- Comparison of post-closure data with baseline and regulatory clearance levels.
- Documentation for regulatory approval of license termination.

Expected Outcomes:

- Demonstration that the site poses **no undue radiological risk** to the public or environment.
- Regulatory confirmation of site release and termination of license.
- Establishment of long-term institutional controls, if required.

Integration Across Phases

The three phases are **interconnected**: baseline data form the foundation for operational monitoring, and both inform post-decommissioning verification.

Consistency in sampling methods, quality assurance, and data management across all phases ensures **comparability and regulatory reliability**.

Monitoring Design

- To provide guidance on the design of an **effective and representative** environmental radiation monitoring program during decommissioning — covering how to select sampling locations, determine appropriate sampling frequencies, and define the parameters and radionuclides to be analyzed.

Principles of Monitoring Design

Site-Specific Conditions — including facility history, types of radionuclides used, and local environmental features.

Potential Exposure Pathways — such as air dispersion, surface runoff, groundwater migration, and food-chain transfer.

Regulatory and Safety Requirements — compliance with national and international standards (IAEA, ICRP, BAPETEN, etc.).

Data Quality Objectives (DQOs) — ensuring that collected data are representative, accurate, and suitable for decision-making.

Optimization (ALARA Principle) — monitoring should balance the need for adequate information and reasonable resource use.

Sampling Locations

Sampling locations must represent both **potential impact zones** and **background/reference areas**, ensuring comprehensive coverage of the environment around the decommissioning site.

Criteria for Location Selection:

Proximity to known or potential **release points** (e.g., stacks, drainage outlets, waste storage).	Consideration of **prevailing meteorological and hydrological conditions** (e.g., wind direction, groundwater flow).	Representation of **various environmental media** (air, soil, water, sediment, vegetation).	Accessibility, security, and consistency with historical monitoring points.

Typical Monitoring Zones

Zone Type	Purpose	Examples of Locations
On-site (Controlled Area)	Detect direct impacts from decommissioning work	Inside facility boundary, near dismantling zones, waste storage areas
Perimeter (Site Boundary)	Monitor potential releases to the environment	Fence line, drainage outlets, effluent discharge points
Off-site (Surrounding Environment)	Assess public exposure and environmental transport	Nearby residential areas, water bodies, agricultural fields
Background/Reference Area	Establish baseline levels for comparison	Locations upwind or upstream, unaffected by facility operations

Sampling Frequency

- Sampling frequency depends on the **phase of decommissioning**, **type of medium**, and **expected variability** in environmental conditions.

Phase	Frequency Range	Remarks
Baseline (Pre-Decommissioning)	Quarterly to semi-annual	Establish initial background and seasonal variation
Operational (During Decommissioning)	Weekly to monthly	Higher frequency due to potential fluctuations in activities
Post-Decommissioning (After Site Release)	Annual or semi-annual	Long-term verification and trend analysis

Factors Influencing Frequency

- Type and mobility of radionuclides involved (e.g., tritium vs. cesium).
- Volume and duration of dismantling activities.
- Sensitivity of surrounding environments (e.g., groundwater near communities).
- Regulatory or license conditions.

Monitoring Parameters and Media

Environmental Medium	Typical Parameters	Key Radionuclides of Concern
Air (Particulate & Gaseous)	Ambient gamma dose rate, airborne particulate concentration	Cs-137, Co-60, Sr-90, H-3, I-131, noble gases
Surface Water	Gross alpha/beta, radionuclide concentration, pH, conductivity	H-3, Sr-90, Cs-137, Co-60
Groundwater	Activity concentration, flow direction, conductivity, turbidity	H-3, Sr-90, Cs-137, Ra-226, U-238
Soil and Sediment	Activity concentration, density, moisture	Cs-137, Co-60, Am-241, Pu isotopes
Biota (Plants, Fish, Crops)	Radionuclide uptake and concentration ratio	Cs-137, Sr-90, K-40, H-3
External Radiation	Ambient gamma dose rate	Direct radiation field measurement with dosimeters

Quality Assurance and Data Validation

An effective monitoring design must include a **robust QA/QC system** to ensure data reliability and traceability.

Use of **standardized sampling and analytical procedures** (ISO/IAEA guidelines).

Calibration of instruments and laboratories with traceable standards.

Duplicate and blank samples for precision and contamination control.

Data verification and review before reporting or interpretation.

Environmental Impact Assessment and Decision-Making

Monitoring design should align with EIA findings, focusing on **critical exposure pathways** identified during site assessment.

Data obtained from each phase should be used for **model validation** (e.g., RESRAD, ERICA) and **radiological dose estimation**.

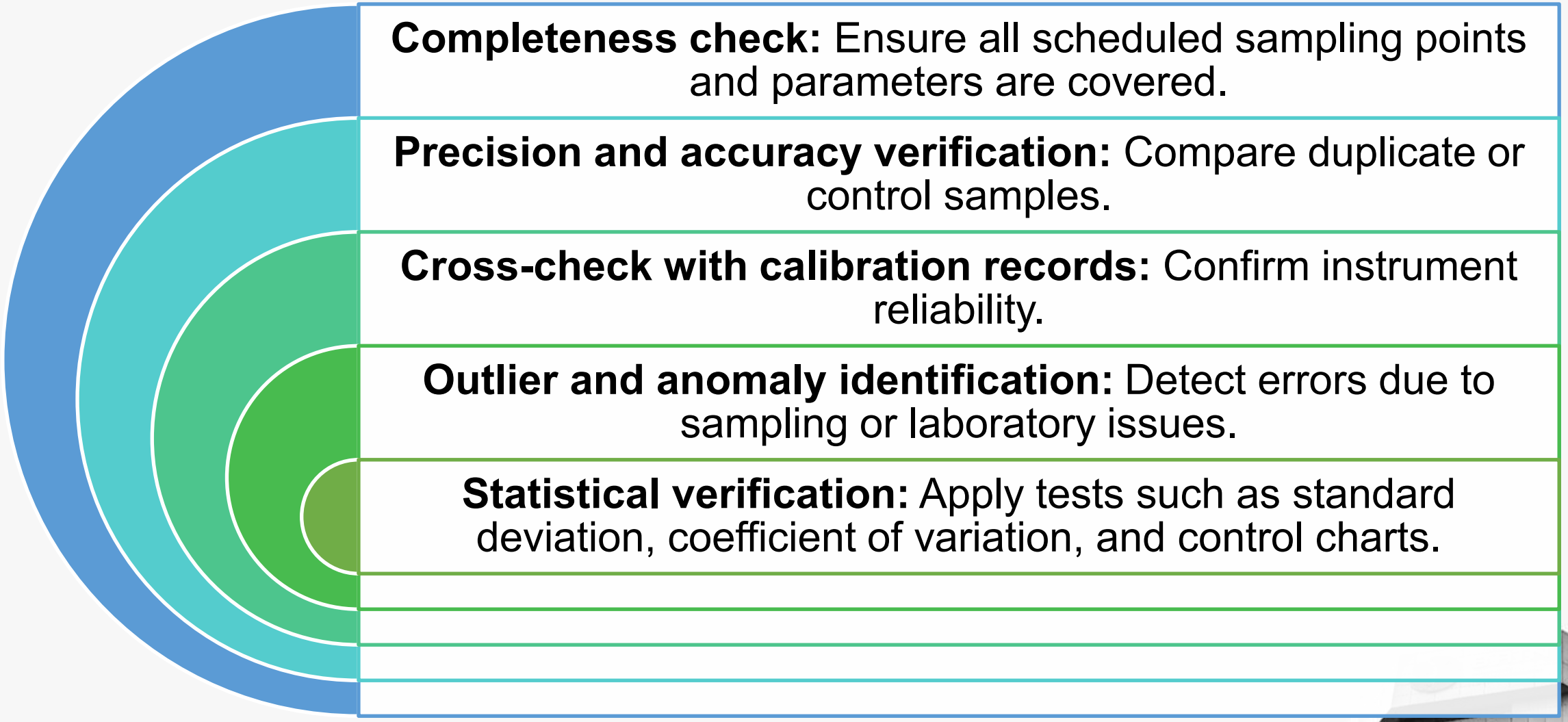
Results guide **corrective actions**, **decommissioning strategy adjustments**, and **regulatory reporting**.

Data Analysis & Interpretation

The main objectives of analyzing and interpreting environmental monitoring data during decommissioning are to:

- **Verify compliance** with national dose and release limits.
- **Identify abnormal conditions or trends** indicating potential contamination or release.
- **Assess effectiveness** of decontamination and remediation measures.
- **Support decisions** on site clearance, waste management, and post-decommissioning surveillance.
- **Provide transparent information** for regulatory reporting and stakeholder communication.

Data Validation



Completeness check: Ensure all scheduled sampling points and parameters are covered.

Precision and accuracy verification: Compare duplicate or control samples.

Cross-check with calibration records: Confirm instrument reliability.

Outlier and anomaly identification: Detect errors due to sampling or laboratory issues.

Statistical verification: Apply tests such as standard deviation, coefficient of variation, and control charts.

Data Management

Use of **electronic databases or environmental monitoring systems (EMS)** for data storage and retrieval.

Ensure **traceability** (sample ID, date, location, analyst, instrument).

Maintain **chain of custody documentation** for regulatory defensibility.

Methods of Data Analysis

Descriptive Statistics	• Mean, median, maximum, minimum, standard deviation. • Frequency distribution and percentile ranking. • Ratio comparisons between on-site and off-site or background levels.
Comparative Analysis	• Compare measured activity concentrations against **regulatory limits or derived concentration guides (DCGs)**. • Evaluate differences between **baseline and operational/post-decommissioning** periods. • Assess ratios of radionuclide concentrations across environmental media (e.g., water-to-soil transfer).
Spatial Analysis	• Mapping activity concentrations using **GIS tools** to visualize contamination distribution. • Identify **hotspots** or areas with higher-than-expected readings. • Support remediation planning or focused monitoring.
Temporal Analysis	• Plot results over time to assess **temporal trends** (increasing, decreasing, stable). • Identify seasonal variations or correlations with specific decommissioning activities. • Detect long-term residual contamination or recovery after cleanup.

Trend Evaluation

Trend Detection Techniques

- **Graphical methods:** Time-series plots, moving averages.
- **Statistical tests:** Mann–Kendall trend test, linear regression, control charts.
- **Anomaly identification:** Compare against control limits or expected variability range.

Interpretation of Trends

- **Increasing trend:** May indicate releases, contamination migration, or monitoring bias → requires investigation.
- **Stable trend:** Suggests effective control and containment of residual radioactivity.
- **Decreasing trend:** Indicates successful decontamination, natural decay, or environmental recovery.

Data Interpretation of Dose Assessment

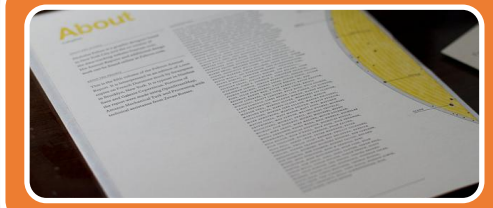
Convert activity concentrations into **dose estimates** using appropriate conversion factors (ICRP or national standards).

Assess doses to **critical groups** or **representative persons** via relevant exposure pathways (inhalation, ingestion, external).

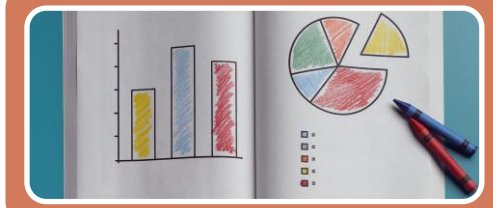
Compare with **public dose limits** (e.g., 1 mSv/year) and **optimization principles (ALARA)**.

Use dose modeling tools (e.g., **RESRAD**, **ERICA**, **IMBA, MONDAL**) to project potential future exposure scenarios.

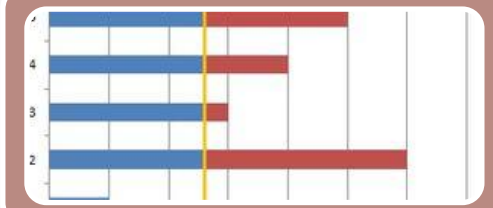
Reporting of Results



Regular reporting to regulatory bodies according to license conditions.



Include **summary tables, charts, and interpretations**, not just raw data.



Clearly state whether results are **within compliance limits** and whether trends suggest any corrective action.

Use **transparent and accessible communication formats** for public or stakeholder updates.

Decision-Making Based on Data Interpretation

Decision Area	Data Use
Site characterization	Establish contamination extent
Decontamination planning	Identify priority zones
Waste classification	Determine clearance or disposal category
Site release	Demonstrate compliance with clearance criteria
Post-closure monitoring	Verify long-term safety and stability

Role of Monitoring in Waste Management

Characterization:
Monitoring results help identify contamination levels in dismantled materials, structures, soil, and water.

Segregation and Classification:
Environmental and radiological measurements guide waste categorization (e.g., exempt waste, very low-level, low-level, or intermediate-level waste).

Optimization:
Supports the ALARA principle by minimizing unnecessary waste volumes through accurate contamination assessment.

Verification:
Confirms the effectiveness of decontamination activities before materials are reused, recycled, or disposed of.

Waste Classification and Clearance

Waste Category	Monitoring Objective
Exempt Waste	Demonstrate activity below exemption levels
Clearable Material	Show compliance with clearance limits for release or reuse
Conditioned Waste	Confirm integrity and radiological content before storage/disposal

Monitoring for Site Release

Provide evidence that residual radioactivity in soil, groundwater, and structures is **below clearance levels**.

Confirm that future occupants or land users will not be exposed to doses exceeding **1 mSv/year** (public dose limit).

Support the **final safety assessment** and **license termination application**.

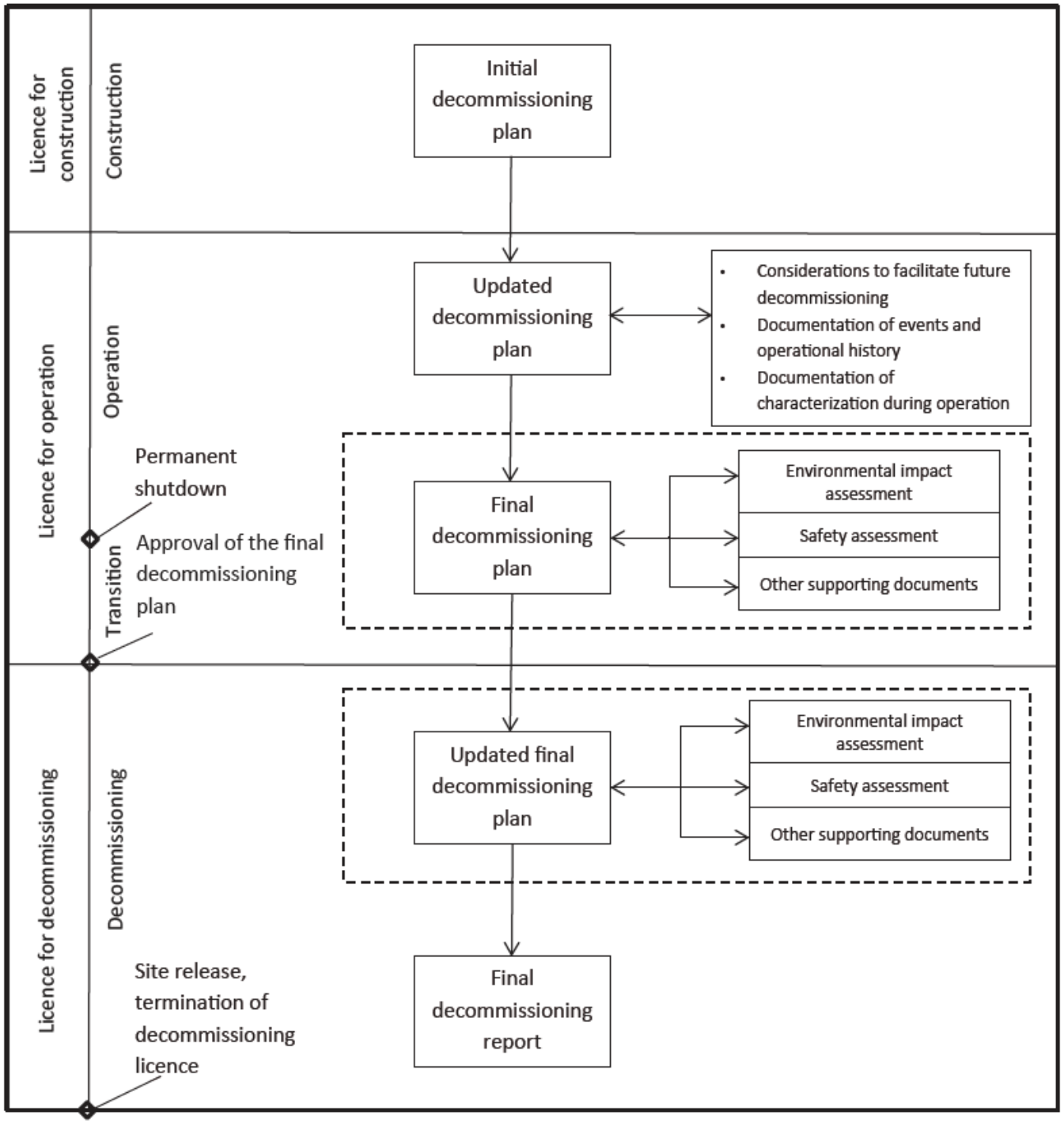
Types of Site Release

Type of Release	Monitoring Requirements	Regulatory Outcome
Unrestricted Release	Demonstrate compliance with public dose limits; no institutional control required	Site can be reused freely
Restricted Release	Show compliance under specific land-use or control conditions	Requires continued monitoring or land-use restriction
Conditional Release	Site may be used for controlled industrial or research purposes	Regulatory oversight maintained for a limited period

Environmental Licensing and Reporting Requirements

Session-4

Evolution of the Decommissioning Plan



Environmental Licensing Stages

Environmental licensing is a formal regulatory process designed to ensure that all decommissioning activities are conducted in a manner that protects human health and the environment from radiological and non-radiological impacts.

It establishes the **legal framework** for environmental protection obligations and defines the sequence of **application, assessment, and approval** before decommissioning operations can commence.

Application Stage

The licensee (facility operator) must submit an **Environmental License Application** as part of the **Decommissioning License Package** to the regulatory bodies — typically the **nuclear regulatory authority (e.g., BAPETEN)** and the **environmental authority (e.g., Ministry of Environment)**.

The application must include:

- **Decommissioning Plan**, including scope and schedule of dismantling activities.
- **Environmental Impact Assessment (EIA)** or equivalent study.
- **Environmental Radiation Monitoring Plan (ERMP)** covering baseline, operational, and post-decommissioning phases.
- **Waste management and discharge control strategies.**

Assessment Stage

Regulatory authorities conduct a **technical and environmental review** to evaluate:

Adequacy of radiological and environmental protection measures.	Completeness and accuracy of the baseline environmental data.	Potential impacts of dismantling and remediation activities.	Alignment with national laws and international standards (IAEA, ICRP, UNSCEAR).

The review may involve:

Public consultation and disclosure of key findings.	**Independent expert review** or **peer assessment** for complex facilities.	Request for **additional information or revisions** from the applicant.

Approval Stage

Upon satisfactory review, the regulatory bodies issue the following:

- **Environmental Permit or License**, specifying conditions and monitoring requirements.
- **Approval of the Environmental Monitoring Plan (ERMP)**, which becomes a binding part of the decommissioning license.

Approval typically includes:

- Authorized **monitoring scope, frequency, and parameters**.
- **Reporting obligations** and submission schedule.
- **Corrective actions** required in case of exceedance or abnormal findings.

The license is valid for a defined period and may be **renewed or amended** as decommissioning progresses.

Regulatory Requirements for Environmental Monitoring Plans

- Environmental Radiation Monitoring Plans (ERMPs) are required to ensure that monitoring during decommissioning is systematic, scientifically justified, and compliant with both **national regulations** and **international safety standards**.
- The ERMP serves as an operational and regulatory tool to demonstrate that **discharges and environmental exposures remain within authorized limits**.

General Regulatory Requirements

The ERMP must be prepared **before the start of any dismantling or remediation work**.

It should be **submitted to the regulatory authorities** (nuclear and environmental) as part of the decommissioning license documentation.

The plan must describe the **rationale, scope, and methodology** of environmental monitoring, including justification of sampling points and parameters.

Required Contents of the ERMP

Purpose and Scope	• Objectives of monitoring and its integration with the overall decommissioning strategy. • Spatial boundaries: on-site, site perimeter, and off-site monitoring zones.
Monitoring Design	• Sampling locations and frequency. • Monitored media: air, water, soil, sediment, vegetation, and biota. • Measured parameters: dose rates, radionuclide concentrations, and relevant chemical indicators.
Methodology and Procedures	• Sampling and laboratory analysis methods. • Calibration and quality assurance/quality control (QA/QC) measures. • Equipment specifications and maintenance procedures.
Evaluation Criteria and Reference Levels	• Derived concentration and dose limits in accordance with national standards. • Application of ICRP *reference levels* for radiological protection.
Reporting and Documentation	• Format and schedule of reporting to the regulatory body. • Data management system and record-keeping procedures. • Protocol for abnormal results or exceedance events.

Documents to Be Prepared

- **Environmental Radiation Monitoring Plan (ERMP).**
- **Standard Operating Procedures (SOPs)** for sampling and analysis.
- **Quality Assurance/Quality Control (QA/QC) Manual.**
- **Baseline Monitoring Report.**
- **Periodic Monitoring Reports.**
- **Final Environmental Monitoring Report** for site release evaluation.

Reporting to the Regulatory Body

Reporting environmental radiation monitoring results is an essential component of regulatory oversight during decommissioning.

Its purposes are to:

- Provide **documented evidence of compliance** with radiological and environmental protection requirements.
- Ensure that **environmental conditions remain within acceptable limits** throughout decommissioning.
- Support **regulatory decision-making**, including safety assessments, corrective actions, and site release authorization.
- Maintain **transparency and public confidence** in the decommissioning process.

Types of Reports

Type of Report	Content Overview	Purpose
Baseline Monitoring Report	Pre-decommissioning environmental data, including background dose rates and radionuclide concentrations.	Establish reference conditions for comparison.
Routine / Periodic Monitoring Report	Regular measurements of environmental parameters (air, water, soil, vegetation) and trend analysis.	Demonstrate compliance and detect deviations.
Abnormal or Event Report	Notification and detailed description of incidents exceeding reference levels or unexpected trends.	Ensure immediate corrective actions and regulatory notification.
Final Environmental Monitoring Report	Summary of all monitoring data after completion of decommissioning.	Support final safety assessment and site release decision.

Reporting Frequency

- Reporting frequency is determined by the **risk level**, **decommissioning phase**, and **regulatory conditions** attached to the environmental and decommissioning licenses.

Decommissioning Phase	Typical Reporting Frequency	Remarks
Pre-decommissioning (Baseline)	One-time submission prior to license approval.	Establishes baseline data.
Active Decommissioning (Dismantling, Waste Handling)	Quarterly (every 3 months) or Semi-annually (every 6 months).	May be increased for higher-risk activities.
Site Restoration / Stabilization	Every 6 months until conditions are stabilized.	Frequency may be reduced as activities wind down.
Post-Decommissioning / Site Release Verification	Final report plus annual follow-up (if required).	Supports final clearance.
Abnormal or Emergency Events	Immediate notification (within 24 hours), followed by a detailed report within 7 working days.	Required for regulatory response and corrective action.

Summary

Environmental radiation monitoring is mandated under national nuclear and environmental laws to ensure protection of people and the environment throughout all decommissioning phases.

IAEA Safety Standards (GSR Part 3, GSR Part 6, RS-G-1.8) and ICRP principles form the global basis, then national implementation should reflect local legal and institutional contexts.

Licensing, monitoring, inspection, and enforcement form a continuous control cycle.

Transparency, documentation, and stakeholder communication enhance public trust.

Thank You for Your Attention

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