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BEST PRACTICE IN ENVIRONMENTAL MANAGEMENT OF URANIUM MINING

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IAEA NUCLEAR ENERGY SERIES No. NF-T-1.2

BEST PRACTICE IN ENVIRONMENTAL MANAGEMENT OF URANIUM MINING

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FOREWORD

The modern uranium mining industry was born in the middle of the 20th century at a time of rapid industrial and social change and in an atmosphere of concern over the development of nuclear weapons. At many uranium mining operations, the need to produce uranium far outweighed the need to ensure that there were any more than vestigial efforts made in protecting the workers, the public and the environment from the impacts of the mining, both radiological and non-radiological. In the last quarter of the 20th century, the world began to take greater care of the total environment with the introduction of legislation and the development of operating procedures that took environmental protection into account. The uranium mining industry was part of this change, and standards of environmental management began to become of significance in corporate planning strategies. However, by the 1980s, as uranium mining companies began to address the issues of environment protection, the industry began to suffer a cyclical slowdown. By the 1990s, the industry was at a nadir, but the surviving uranium producers continued to develop and implement a series of procedures in environmental management that were regarded as best practices. This, in part, was necessary as a means to demonstrate to the regulators, governments and the public that the mining operations were being run with the intention of minimizing adverse impacts on the workers, people and the environment. This ensured that mining would be allowed to continue.

The decline in uranium mining activity bottomed out in the 1990s, but a resurgence of activity began in the new century that is likely to continue for some time. This has been, in part, due to market conditions and concerns about the shortfall of current production from primary sources (uranium mines) against current reactor fuel demands; the anticipated decrease in future availability of secondary sources such as stockpiles; and the increased interest in nuclear power generation as an integral part of the strategy of many countries to mitigate their impacts on climate change.

The existing uranium mining industry has raised environmental standards through the introduction and development of best practices. One concern is that some of the newer, junior, mining companies and producer nations entering the market in the present expansion phase may not be aware of these best practices and current international standards. Failure to maintain the current high levels of environmental management may see the uranium mining industry's development hampered through the poor performance of a few new, but inexperienced companies, which would result in adverse reactions from the pubic and regulating authorities. This could be especially damaging to the straightforward development of the new resources demanded by the market. As part of a strategy to assist in the maintenance of standards in uranium mining and to assist in the dissemination of information on best practices, the IAEA assisted in the organization of a Technical Meeting on Best Practices in Environmental Management of Uranium Production Facilities, in Saskatoon, Canada, from 22 to 25 June 2004. This report contains the papers presented at that meeting, and the conclusions reached in discussions, together with an overall guide to what is best practice in modern uranium mining.

The IAEA wishes to express its gratitude to all those who participated in the Technical Meeting and the four associated consultants meetings as well as the drafting and review. The IAEA technical officer responsible for this publication was P. Waggitt of the Division of Nuclear Fuel Cycle and Waste Technology.

EDITORIAL NOTE

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1. INTRODUCTION

1.1. BACKGROUND

Unlike many other commodities, many countries consider uranium a strategic commodity and consequently have not always been subject to free market influences. However, this does not negate the applicability of best practice principles to the mining and processing of uranium.

Recognition and adoption of best practice principles are considered fundamental cornerstones of sustainable development for the uranium industry. Best practice in the context of this report covers the social, environmental and economic aspects of an operation; and includes the active search, documentation and implementation of those practices and principles that are most effective in improving the social, environmental and economic performance of an operation. The principles of best practice are universal, but their application is site specific.

Best practice is the development of site/operation specific methodologies that integrate global and local knowledge, which enables planning to produce the best available and most practicable methods to address an operation's site specific requirements and conditions. This enables the operator to achieve production goals and a sustainable operation while minimizing social, environmental and economic impacts. Best practice principles should be applied to every aspect of a mine/mill operation and extend from the exploration and initial development phase through to post-closure stewardship. The successful application requires corporate and regulatory leadership, as well as long term commitment.

Over the last 30 years, there has been a significant and necessary evolution in the level of environmental practices in order to satisfy the public and regulatory agencies' demands for sustainable environmental protection while still providing socioeconomic benefits for all stakeholders. Best practices, by nature, are not static but continuously evolve in response to new technology, increased understanding and awareness of environmental and social impacts, and increasing regulatory requirements and public expectations.

Mining and/or processing operations can have both positive and negative environmental, economic and social impacts on communities. They can provide employment and business opportunities to local communities and may provide the opportunity to remediate legacy sites. However, improperly managed activities can adversely impact the environment, affect the local population, and, in the worst cases, result in severe or catastrophic social and/or environmental impacts as evidenced by many legacy sites still awaiting remediation. Implementation of the best practice principles outlined in this document will minimize the potential for adverse environmental, social and economic impacts.

By minimizing potential adverse impacts, key benefits that result are:

— Improved environmental management;
— Improved socioeconomic outcomes;
— Demonstrated good corporate governance and accountability;
— Improved liability management;
— Improved quality control; and
— Reduced operational costs and increased profitability.

Both the IAEA and the OECD Nuclear Energy Agency (OECD/NEA) have established formal mechanisms to promote the worldwide exchange of information on the environmental consequences of uranium mining and processing and on technologies developed to address those consequences. Publications, documents and reports are available at the IAEA web site (www.iaea.org/Publications/index.html) and the OECD/NEA web site (www.nea.fr/html/pub/welcome.html).

1.2. OBJECTIVE

The objective of this report is to provide both operators and regulators with guidelines and examples of the implementation of the principles of best practice to the uranium mining and processing industry. While the application of best practices within the general mining industry is relatively well established worldwide, there are specific considerations with respect to the extraction and processing of uranium ores.

1.3. STRUCTURE

This report briefly discusses all the aspects of best practices in the sustainable development of an operation at a high level and does not try to be prescriptive. It is divided into the following main sections: Section 2, Guiding Principles; Section 3, Best Practice Application.

2. GUIDING PRINCIPLES

The development of modern uranium production facilities requires extensive planning so that they are socially, environmentally and economically sustainable and are accepted by society. This will only occur if basic guiding principles of sustainable development are practiced. There are a number of such principles that should be used to assist the development of uranium facilities:

— Sustainable development principles;
— As low as reasonably achievable (ALARA) principles;
— Precautionary principle.

2.1. SUSTAINABLE DEVELOPMENT

Our Common Future — the Brundtland Report — states that “humanity has the ability to make development sustainable — to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs” [1].

The original Brundtland definition can be broken down into four conditions for sustainable development:

— Material and other needs for a better quality of life have to be fulfilled for people of this generation;
— The process should be as equitable as possible;
— Respecting ecosystem limits; and
— Building the basis on which future generations can meet their own needs.

Expanding on the Brundtland warning, not only should this generation not totally deplete resources that will be vital to future generations, the environment must not be adversely impacted so as to leave the Earth, or significant portions of it, with severe constraints on future human use. This imposes constraints on the manner in which uranium resources are exploited.

Sustainable development in the context of this report balances four main aspects:

— Environment;
— Social issues;
— Economics;
— Governance.

Implementing sustainable development principles will often require a change in technology, economic factors, and/or ideas, attitudes and behaviors. A sustainable industry is one that balances the environmental, social and economic requirements within a regime of good governance. Concentration on only one aspect is certain to conflict with the others. For example, focusing exclusively on environmental protection can make an operation unprofitable, and a failing business will lose shareholders and be unable to develop and meet its social obligations. However, the balance of the emphasis on each particular aspect will vary with the specific operation and the local physical and social environment in which it operates. Good corporate and regulatory governance will have structures in place to permit the appropriate balance to be achieved.

Ultimately, it is the economic success that supports the social and environmental commitments. It is important that any development can provide stable, long term economic benefits that continue even after the operations have ceased. Society does not value economic viability to the exclusion of social and environmental sustainability. Full accounting and provisioning of future costs therefore need to be incorporated into the economics of a project to achieve sustainability over the long term.

2.2. AS LOW AS REASONABLY ACHIEVABLE

The ALARA principle for worker radiation protection requires that exposure to risks arising from radiation needs to be kept as low as reasonably achievable, with social and economic factors being taken into account. In addition, there is an absolute limit to the allowable exposure of any one individual, regardless of the benefit to society as a whole. Often, the ALARA principle is wrongly viewed as mandating that concentrations of a constituent in the discharge shall be as low as achievable.

2.3. PRECAUTIONARY PRINCIPLE

This concept requires that effective environmental management must anticipate, prevent and correct the causes of environmental degradation. Further, the lack of full scientific certainty should not be used to postpone preventative measures.

Applying best practice guiding principles to a project will require that each of the four cornerstones of sustainable development are put into practice with the following as key objectives.

Environmental aspects:

— Promote responsible stewardship of natural resources and the environment, including remediation of past damage;
— Minimize waste and environmental damage throughout the whole supply chain;
— Exercise prudence where impacts are unknown or uncertain;
— Operate within ecological limits and protect critical natural capital.

Social aspects:

— Ensure a fair distribution of the costs and benefits of development for all those alive today;
— Respect and reinforce the fundamental rights of human beings, including civil and political liberties, cultural autonomy, social and economic freedoms, and personal security;
— Seek to sustain improvements over time by ensuring that depletion of natural resources will not deprive future generations through replacement with other forms of capital;
— Optimize utilization of human resources.

Economic aspects:

— Maximize human well-being;
— Ensure efficient use of all resources, natural and otherwise, by maximizing returns;
— Seek to identify and internalize environmental and social costs;
— Maintain and enhance the conditions for viable enterprise.

Governance aspects:

— Ensure transparency by providing all stakeholders with access to relevant and accurate information;
— Ensure accountability for decisions and actions;
— Encourage cooperation in order to build trust and shared goals and values;
— Ensure that decisions are made at the appropriate level as close as possible to and with the people and communities most directly affected.

3. BEST PRACTICE APPLICATION

The application of best practice principles for a project begins at the conceptual phase and continues throughout all of the stages of a project. The prinicples typically are:

— Conceptual design and/or exploration;
— Feasibility studies;
— Construction;
— Operation;
— Remediation;
— Closure and post-closure stewardship.

In effect, best practice principles are continually developed and improved upon for any project as it moves through the stages of the cycle and as more information is collected and a better understanding gained. Generally, this commences with baseline data collection.

3.1. BASELINE DATA COLLECTION

The value of collecting good quality baseline data prior to project development cannot be overstated. Baseline information is required to characterize both the physical and social environment prior to project development. Typically, baseline studies are conducted to accomplish the following:

— Collect data about pre-development conditions;
— Document information on pre-development conditions;
— Integrate information into project supporting documents (e.g. monitoring and remediation plans).

Baseline information is used for making impact predictions and for assessing project alternatives and mitigation measures. It may also be used in other programmes, such as remediation and monitoring plans, as a comparison against future change(s).

Collection of baseline information may include field studies, literature reviews of existing documentation, database searches and conducting interviews within communities adjacent to the proposed project area. When planning the collection of baseline information, it is important to consider the following aspects:

— Timing;
— Amount and reason that specific information is required;
— Local and traditional knowledge;
— Incorporation of both qualitative and quantitative data.

The scope of a baseline data collection programme must clearly define the baseline parameters required. Examples of baseline data include but are not limited to those outlined below. It must be noted that the data sets required will be site specific as is the timeframe over which they are collected. Often information may need to be collected at different times of the year to account for seasonal variation.

- Socioeconomic characterization:
  — Current and historic land uses;
  — Archeological and heritage surveys;
  — Identification of all stakeholders;
  — Identification of beneficial uses of land and water;
  — Documentation of regulatory regime under which the project would operate.

- Environmental characterization:
  — Hydrological and hydrogeological conditions;
  — Geological and geochemical characterization;
  — Flora and fauna surveys;
  — Climate data;
  — Soil surveys;
  — Radiological surveys; and
  — Contaminated site assessments.

Baseline data collection is undertaken in order to adequately document the environmental conditions that exist at a site prior to commencing activities that may alter the existing environment. Accurate and comprehensive baseline data will enable a company to reliably demonstrate the environmental and social impacts and performance of the operation as well as remediation works undertaken. Furthermore, it is only with good baseline data that early detection of deviations from expected or predicted performance can be identified. Early detection of such deviations in itself is a best practice principle.

Generally, baseline data collection is done in conjunction with the exploration or conceptual design stage of a project. In addition to the baseline studies, additional best practice activities that may be included during this stage are:

— Designing for roads, drilling sites and other exploration activities (test pitting, bulk sampling, etc.) to minimize erosion and prevent the release of contaminants;
— Remediation plans for exploration activities.

3.2. PUBLIC/STAKEHOLDER INVOLVEMENT

Stakeholder consultation assists in identifying issues of significance and focuses the social component of the baseline data collection programme. This consultation process is a valuable tool in gaining support for the project through demonstrating transparent information exchange and the commitment by the proponent and regulators to address the stakeholders' concerns regarding the project.

Public and stakeholder consultation processes should commence and be managed in parallel with the baseline data collection programme during the exploration or conceptual design stage. This process is critical to determine issues central to the project and will assist in the acceptance of a project. Recognition and response to stakeholder concerns and expectations can minimize the potential for conflict and be of mutual benefit to the communities and the operators.

Identifying stakeholders and then successfully engaging them in a participatory manner is a fundamental building block in the development of a successful project. Without stakeholder involvement, there is a significant risk that the project or components thereof may be rejected by the stakeholders, potentially leading to economic loss for the operator as well as ill feelings between the parties that could develop into an adversarial relationship.

A truly effective programme will involve full stakeholder participation in the planning process at all levels and stages. Stakeholder participation goes beyond the stages of informing or consulting stakeholders and requires the development of high levels of openness and trust between the various parties.

Stakeholders are those individuals or organisations which may have an interest in or be affected by the project at any stage, whether directly or indirectly. Examples of groups or individuals that may be considered stakeholders include but are not limited to:

— Project operator;
— Shareholders;
— Owners of the land impacted by the operation;
— Surrounding landowners;
— Local communities economically dependent on the operation or the land impacted;
— Local government;
— Regulators;
— Employees;
— Unions;
— NGOs;
— Contractors;
— Suppliers.

As can be seen from the above list, the stakeholder group is likely to consist of an extensive group of individuals, businesses and organisations with vastly different skill sets, technical abilities and, most importantly, expectations. Each operation and location will have its own unique group of stakeholders. Bringing these together in order to achieve an outcome that meets most of their expectations is an enormous task that will require specialized skills and resource commitments on the part of the company. It is also a time-consuming process that needs to be given as much time as possible if satisfactory outcomes are to be achieved; hence starting it as early as possible in an operations life cycle is highly desirable.

Key points to consider in bringing about constructive stakeholder participation in the project include:

Selection of participants — participants are representative of the identified stakeholder groups and speak with their authority.

Timing — engagement of stakeholders and their involvement in the project begins as early as possible.

Establishing objectives for the participation process early will assist in ensuring that the activities of those participating are focused on results.

Commitment to stakeholder involvement — if the stakeholders sense that the decision makers are not actively listening and acting on their input, the involvement programme will likely breakdown and may increase mistrust.

External constraints on the project should be clearly communicated to stakeholders. Examples of these may include financial resources and regulatory obligations.

Participation — different stakeholders will have differing levels of skills and resources. To ensure fairness and appropriate representation, it may be necessary to consider allocating additional resources (including information and training) to some groups or individuals in order that they can participate on an equal footing with other stakeholders.

Flexibility — the participation process must remain flexible as the project proceeds in order to allow for input from stakeholders.

The above points demonstrate that effective participation needs to be a dynamic two-way process. Simply dictating to the public or informing the public of decisions cannot be considered stakeholder participation.

In a successful stakeholder participation programme, stakeholders will play a key role in identifying issues and selecting options, in turn generating broad based support and ownership of the strategies that are ultimately selected.

In addition to recognizing stakeholder concerns, it is best practice to discuss the expected and predicted impacts of a proposed operation with the affected local communities and landholders before activities are started. More formally, potential impacts are defined in an Environmental Impact Statement (EIS), which will usually also require a social impact assessment. Social impact assessment is currently the most widely applied tool used to address the impact and mitigation of social issues associated with project development.

It is imperative for project developers to consider the core values, needs and concerns of local communities in order to be able to demonstrate that the operation of the facility will be consistent with their expectations. There are numerous cases where a mining or industrial operator has not adequately addressed local expectations and has then failed to secure stakeholder support for the project, and consequently failed to secure the necessary approvals to proceed with the project. Where there has been inadequate engagement or consultation with stakeholders or where there has been a failure to identify all legitimate stakeholders, the following can result:

— Project delays or cancellation;
— Lack of public support in the project's implementation phase;
— Loss of public trust, which may lead to difficulty in implementing future initiatives;
— Media criticism;
— Legal action;
— Social conflict and violence.

Stakeholder consultation programmes should recognize that socio-political inequality can result in particular groups unable to articulate their needs or concerns in opposition to other groups (e.g. regional or national governments, local elites, dominant political or religious groups). This may result in these groups becoming 'invisible' within the consultation process. Within this is the role of power and power relationships. Relevant issues here include representavity, inclusivity and the exclusion of key groups and individuals. Power influences can manifest themselves among stakeholder groups, between stakeholders and mining operators, and between stakeholders and public decision makers. Appreciating the relative importance and influence of stakeholders consequently becomes a core exercise in public participation process design.

Stakeholder consultation programmes should also consider that the existence of traditional or informal social or cultural structures may not be recognized by the established political system. Further, participation of marginal, unrepresented or vulnerable groups should be a component within the consultation process.

Recognizing these points will enhance the support for a project by negotiation of economic, employment and/or environmental agreements with stakeholders. This will demonstrate to stakeholders that the project proponent is willing to address their needs and concerns.

Stakeholder consultation programmes should extend into stakeholder involvement in the project. This may extend into an extensive training and education programme in order to give the stakeholders sufficient skills and knowledge to be able to effectively participate in the project. Participation may be in the form of committees or groups. One example could be the establishment of an Environmental Quality Committee (EQC) that may conduct and/or evaluate environmental monitoring programmes, provide input to regulators and act as a conduit of information between the company and stakeholders.

There have been many examples where mining operations have resulted in general prosperity during the development and operational phases. However when operations ceased, local communities were left without a source of economic support, resulting in economic and social hardships for the local community. An example of a best practice in stakeholder involvement is when, during the operational phase, companies and stakeholders identify and develop opportunities for sustainable enterprises distinct from the operation.

These enterprises may, in the short term, be linked to the operation, but the intent is that they be sustainable and independent after closure. These enterprises can form a focus of a sustainable development plan for the community that is distinct from but obviously related to the project itself. It is likely that the community will require assistance and resources in order to develop this plan. Another example of an issue that should be covered by a community sustainable development plan is the construction and management of infrastructure (e.g. airstrips, roads, power, water supply systems).

With planning, development of infrastructure can also provide secondary economic benefits. Infrastructure primarily constructed to support the project may be designed so that it can bring benefits to the community both during the mining phase as well as after closure with minimal capital cost to the community. However, it must be remembered that infrastructure must not be left behind after closure unless there is a willingness and ability (particularly financial) on the community's part to undertake ongoing management of the infrastructure.

Effective community participation can be assisted by implementing communication and education programmes. This will ensure that the participants have sufficient understanding of the issues with which to base informed decisions. Joint efforts by the proponent, the government and the local community can provide these programmes as well as training for hiring purposes.

Projects can contribute to sustainable development by building human capital through training and education of the work force. Skills acquired while employed in the mining operation can be carried over and have direct application within the local community. Maximizing local employment will assist in reducing employee turnover and retaining corporate knowledge while directly benefiting the community.

Sustainable community development planning is another aspect that must be considered and addressed initially during the project planning phase; however its importance continues throughout the life of the operation and beyond. It may include:

(a) *Adopting a strategic approach:* Development of activities at the operational level are linked to long term strategic objectives for the company and are also aligned with existing and future community and/or regional and national development plans.

(b) *Ensuring consultation and participation:* Local communities are actively involved in all stages of project conception, design, and implementation, including closure and post-closure.

(c) *Working in partnership:* Private, governmental, NGO and community organizations bringing different skills and resources yet shared interests and objectives can achieve more through working together than individually. Formal or informal partnerships can also reduce costs, avoid duplication of existing initiatives and reduce community dependency on the mining operation.

(d) *Strengthening capacity:* Programmes that emphasize strengthening of local community, NGO and government capacity are more sustainable in the long term than the supply of cash, materials or infrastructure without a properly designed forward looking participatory framework. While infrastructure is often essential for the development of remote communities, it will only be sustained if there is an adequate maintenance programme supported by a well designed participatory process including local communities and governments.

Stakeholder involvement and consultation requires a communication strategy that addresses the following as a minimum:

— Objectives of communication strategy;
— Business objectives;
— Communication objectives;
— Background to the project planning, development and closure process;
— Historical issues influencing planning;
— Current communication undertaken or available;
— Communication environment, relevant factors;
— Risks;
— Opportunities;
— Key issues and concerns;
— Key messages;
— Key audiences (primary, secondary, tertiary).

3.3. IMPACT ASSESSMENT

The impact assessment (IA) process identifies potential adverse impacts of the project. This process has evolved into a widely used tool for project planning and decision making that supports sustainable development. The definition of IA is generally a study of the potential effects or impacts that a proposed project, development or activity will have on the environment. It is also important to note that the term environment is broad, encompassing both biotic (i.e. flora and fauna) and abiotic (i.e. water, soil, air) components; including natural resources, human health and socioeconomic security.

IA is a process of identification, communication, prediction and interpretation of information to identify potential (both adverse and beneficial) impacts through the life of a project (i.e. construction, operations and closure) and determine measures to manage these impacts. Impacts are predicted based on the comparison of baseline information and anticipated future conditions both with and without the project occurring. It is at this stage that the identification and consideration of alternative options for mining, processing methodologies and waste management be undertaken. For example, the use of a nearby existing processing facility could be an alternative to building a new facility. Alternative approaches to the project may be found that reduce the production costs and/or overall environmental impact.

Tools for impact assessments range from relatively simple empirical evaluations (e.g. water and geochemical load balances) to very complex deterministic modeling assessments. The objective, regardless of what method or tool is utilized, is to identify potential impacts and issues. Once issues are addressed, analytical methods described and impacts predicted, the significance of the impacts are determined. Determination of 'significance' weighs human values against the impacts of the project (environmental, economic or social).

3.4. RISK ASSESSMENT

Undertaking a formal risk analysis is a fundamental component of the decision making process for the sustainable operation of projects. There are a number of formal risk assessment tools that can assist decision makers to evaluate the risks and benefits of the range of options being considered.

Risk is the probability of an adverse effect occurring as the result of an activity or an event. A risk assessment considers the combination of:

— The likelihood of an event occurring;
— The consequence of that event;
— The management measures required to reduce the residual risk (likelihood, severity and/or consequence) to an acceptable level.

The probability addresses the likelihood of the event occurring, while the adverse effect is the undesired effect or outcome causing concern (e.g. reduced reproduction in fish or toxic effects to the liver or nervous system). The primary objective of risk management is to provide sufficient information to allow decision makers the ability to do the following:

— Achieve acceptable levels of risk, where benefits flowing from a particular action or decision outweigh the potential loss or damage;
— Avoid unacceptable levels of risk, where the likelihood and magnitude of the potential loss or damage outweighs the expected benefits, or where the magnitude of the potential loss or damage, regardless of likelihood, is such that it cannot be reversed or mitigated [2].

Risk assessment can be used to determine the existing level of risk to the social, environmental and economic aspects of a project. Risk assessment can also be used to evaluate the relative risk reduction achieved by various risk management options and is site or project specific.

At the project evaluation stage, the data collected from baseline and monitoring programmes or existing research studies is used. Screening level risk assessment can identify areas of critical uncertainty through the use of sensitivity analysis (i.e. the assumptions, variables and parameters that drive the risk estimate are identified). Additional data collection may then be required to fill in identified critical data gaps, in particular for issues that may carry higher risk.

There are three possible outcomes of the screening level risk assessment:

— All potential risks are ruled out;
— Some potential risks are identified, but risk management decisions are made on the basis of the screening level risk assessment, and no further risk assessment is required;
— Some potential risks are identified, but risk management decisions are too uncertain, and further risk assessment is required.

A screening level risk assessment may show that existing mitigation plans will reduce all potential risks at a facility to levels deemed acceptable. If not, there will be a need to proceed to detailed risk assessment for the identified unacceptable residual risks.

Formal risk assessment processes usually require the following actions:

— Identify and involve stakeholders;
— Establish the context;
— Analyse the hazard;
— Analyse the risk;
— Evaluate the risk and determine acceptability;
— Decide to accept or mitigate the risk;
— Monitor controls and outcomes;
— Have contingency plans ready.

Risk assessment and management is an iterative process consisting of a series of well-defined steps taken in sequence to support decision making by contributing to an insight into the risks and their impacts.

Many jurisdictions will have formalized risk assessment tools available through their local standards organizations, and these may be suitable tools to use for the risk assessment process. An example of a risk assessment tool available from a national standards organization is Standards Australia AS/NZS 4360:1999. This standard provides a generic framework for establishing the context, identification, analysis, treatment and monitoring of risk. As an alternative, there are also many other risk analysis tools available, examples of which include the Failure Modes and Effects Analysis (FMEA) [3], Multiple Accounts Analysis (MAA) [4], SEDSS [5], HIVIEW™ [6] and ExpertChoice™ [7].

MAA is a tool for evaluating different options or alternatives for a project or specific components of a project by weighing the relative benefits and costs (or losses) of a variety of unrelated factors. It is particularly useful when there is a large number of multi-disciplinary or variable factors and stakeholders involved.

Software packages, such as SEDSS or HIVIEW™ allow the user to change physical values or amend weighting factors in real time, which is especially useful for presentational purposes.

In conjunction with risk analyses, sensitivity analyses are also powerful instruments to guide the decision making process and can help to evaluate the impact numerical values of variables have on the outcome of such a process. Sensitivity analyses will help to distinguish between crucial variables and those less so. A variant of this is critical path analysis, which serves to identify those criteria that have to be met in order that the overall process can proceed. The result is a ranking or weighting structure identifying the relative importance of decisions.

Sensitivity analysis is used to examine how robust an alternative is to changes in the information or assumptions used in the original analysis. Sometimes the original information or data set may be limited or not precise in nature. Additionally, the misuse or selection of parts of a data set can lead to the manipulation of the final solution. The application of sensitivity analysis can help to show in a more transparent nature how varying certain parameters can affect the outcome of a decision making process.

Risk assessment and sensitivity analysis are therefore considered fundamental components of the application of best practice principles to the development and management of projects.

3.5. DESIGN

The IA is the summary document that provides baseline knowledge about the environmental setting, assesses possible impacts for environmental components of concern and recommends mitigation procedures to alleviate or compensate for those impacts. Within the IA, careful consideration should be given to the short and long term social, environmental and economic impacts of a project. The project is designed to minimize the potential impacts. This is often called designing for closure.

A great challenge to operational design is that standards continue to evolve over time (i.e. the “goalposts” shift). This is a significant challenge both for operations and regulators, given the long time period that the design must consider.

It is important to understand that any design and subsequent reclamation strategy that does not anticipate and allow for changes in legislative and regulatory requirements, as well as evolving community expectations, carries a high risk of failure.

In 2003, the International Council on Mining and Metals (ICMM) developed [8] the ten Principles for Sustainable Development Performance and requires all members to commit to implementing these principles in their designs and activities and to report on their implementation at regular intervals.

Recognizing and allowing for the impacts of evolving standards is compatible with the Sustainable Development Principles; the ten principles are:

(1) Implement and maintain ethical business practices and sound systems of corporate governance;
(2) Integrate sustainable development considerations within the corporate decision making process;
(3) Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities;
(4) Implement risk management strategies based on valid data and sound science;
(5) Seek continual improvement of our health and safety performance;
(6) Seek continual improvement of our environmental performance;
(7) Contribute to conservation of biodiversity and integrated approaches to land use planning;
(8) Facilitate and encourage responsible product design, use, reuse, recycling and disposal;
(9) Contribute to the social, economic and institutional development of the communities in which we operate;
(10) Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

Early in 2008, the World Nuclear Association (WNA), following a project in association with the IAEA, published a document entitled “Sustaining Global Best Practices in Uranium Mining and Processing” [9]. This document, subtitled ‘Principles for Managing Radiation, Health and Safety, Waste and the Environment’, is specific to the uranium industry and sets down a corresponding set of principles applicable to the worldwide uranium production industry.

Developing closure objectives is a component of the design process and can be integrated during design to the extent that they can be defined at that time. Once the closure objectives are defined, information can then be reviewed against them to determine whether that information is sufficient to derive closure criteria that will comply with the objectives.

Developing closure objectives that are meaningful and acceptable to all stakeholders requires that they be derived from a number of inputs from both internal and external sources. Generally, these can be expressed as an overall value that can be achieved through meeting a set of more specific objectives.

Sustainable remediation objectives will reflect the overall values that the operator, stakeholders, regulators and the community place on the physical and social environment in which the operation is located. Remediation objectives will typically have a location or regional specific basis.

These overall values will generally address the following points:

— Sustainability;
— Final or sequential land use;
— Human health and safety;
— Social impacts;

— Ecosystem impacts;
— Regulatory requirements;
— Cost optimization.

Examples of how each of the overall values listed above may be represented as a closure objective are presented in the following paragraphs. It should be noted these are only examples for the purposes of illustrating how an overall value may be interpreted as a remediation objective.

Sustainability

Remediation activities will, to the maximum extent practicable, not impact on or limit the potential for development of the site by either the permanent alienation of land from future beneficial land uses or sterilisation of currently sub-economic resources.

Remediation strategies will not cause an ongoing liability or risk to accrue to landowners/stakeholders. Remediation strategies must to the maximum extent practicable be maintenance free and minimize requirements for ongoing management or intervention.

Final or sequential land use

Re-creation of a habitat and ecosystem similar to that existing prior to development of the site, which incorporates traditional human activities.

Human health and safety

Remediation activities will take account of human health considerations in all aspects of planning and execution and will ensure that where the potential for adverse impacts on human health have been identified plans are developed to ensure they do not occur.

Social impacts

Stakeholders are identified, and their values are integrated into the remediation planning process.

Ecosystem impacts

Where an ecosystem impact has been identified, it can either be demonstrated that it will diminish over an acceptable period of time or the extent of the impact is minimized using best practice technologies, and appropriate resources are provided for the ongoing management of identified impacts.

Regulatory requirements

Compliant with current legislation and anticipates changes in international legislative and community expectations over the life of the project.

Cost optimization

Where impacts requiring remediation are identified and appropriate agreed closure criteria have been developed, the most cost and resource efficient method of remediation will be developed, taking into account site specific social conditions.

Every activity (operational and remediation) must be checked against the above objectives to ensure that the activity is compliant or, where it may produce adverse impacts, that the impacts are recognized, and the activity is either modified or control mechanisms are implemented to manage the impacts to levels compliant with the objectives.

Within the design process, there should be an assessment component that provides a means for identifying critical project closure issues. It also provides a tool to assess alternative options for achieving successful decommissioning and remediation of the project early in the stage of planning so that the project design can be revised. Examples of design revisions may include consideration of:

— Alternate mining and processing methods;
— Alternate waste stream storage/disposal methods;
— Anticipated environmental aspects;
— Potential water treatment processes;
— Spill containment plans and response measures;
— Water management;
— Alternative air emission abatement technologies; and
— Monitoring programmes.

Designing and planning for project closure is an iterative process. Therefore, during the early stages of a project, the remediation plan may be conceptual. It does however provide a baseline or framework for ongoing evaluation of the closure plan. Subsequent revisions may be required due to evolving stakeholder requirements, changes to the scope of the operation and changing technologies. Key components that should be considered when determining the most appropriate closure plan or components of that plan include:

— Remediation objectives;
— Characterization results of waste products;
— Location;
— Regulatory requirements;
— Stakeholder requirements;
— Risk;
— Costs;
— Technologies applicable to the site;
— Ongoing monitoring and maintenance requirements.

Further, following best practice principles requires that wherever practicable, remediation is undertaken progressively as soon as opportunities present during the life of the project. Progressive remediation provides the following advantages:

— Cash flow smoothed out with many remediation costs incurred while operating;
— Technical resources and equipment readily available;
— Provides time for remediation methodologies to be evaluated and improvements to be made, should they be required;
— Can project and reinforce positive stakeholder perceptions of the operation and its closure plans.

Incorporated in the design and closure plans are monitoring programmes developed to assess the impacts and performance of mitigation of those impacts. This includes development and utilization of a quality control/quality assurance (QC/QA) programme.

Irrespective of how well designed a project is, if it is not constructed as designed, there is a high likelihood that it will suffer premature failure or subdesign performance with consequent potential safety or environmental impacts among others. Formal QC procedures and QA measures are essential best practice management tools in any project. QC/QA should be all encompassing to extend beyond the construction phase through to the post-closure stewardship and include performance monitoring and compliance monitoring (discussed below) as integral components.

Life of operation costs differ significantly from operational costs, and decisions on operational costs made without full consideration of their long term impacts often increase life of operation costs for apparent short term gain. The term life of operation encompasses all activities from initial exploration through to the long term post-closure stewardship phase. It covers:

— Exploration;
— Project feasibility and design;
— Development and construction;
— Operational phase (mining/processing);
— Decommissioning and remediation;
— Post-closure monitoring;
— Post-closure stewardship.

The above points illustrate that the operational phase only represents a small portion of the total life of the operation. Best practice principles incorporated into the operation of a project can minimize the overall life of operation costs and in particular those associated with post-closure stewardship.

3.6. OPERATION

Best practice principles require that projects incorporate management systems such as an Environmental Management System (EMS) into the operation. A number of EMS standards have been developed for operations to assure they are designed and operated to meet the objectives and specific needs of the project.

Two series of ISO standards are particularly relevant in the area of management systems for environmental performance improvement. They are the ISO 9000 and 14000 series. The ISO 9000 series focuses on quality while the ISO 14000 series defines an EMS based on a commitment to continuous improvement. Companies can achieve certification by meeting the requirements defined in the standards and being audited for compliance by third-party auditors. Certification requires commitment of personnel at all levels and may require the adoption of new technologies and additional employee training. These standards require continuing quality assurance systems, continuing efforts at performance improvement and regular reporting and re-certification. This results essentially in a data management system.

ISO 14000 does have limitations in that it is focused on and audits the adherence to the system performance rather than actual operational performance.

Another operational management tool is the use of key performance indicators (KPI). KPIs are targets that may be either quantitative or qualitative, and, in contrast to ISO 14000, are used to measure performance against specific objectives or set values.

Monitoring provides the data that allows comparison of performance against requirements and targets set out within the EMS and KPIs, as well as the license conditions of the operation. The purpose of monitoring is twofold: firstly, to check whether the operation may be impacting on the environment and if so, to what level; and secondly, to determine whether rehabilitation works are performing as predicted.

The first type is **called impact or compliance monitoring**, and the second is called **performance monitoring**; they serve distinctly different purposes and should not be confused with each other.

The purpose of **impact or compliance monitoring** is to check on a regular basis whether the operation is having an impact on the receiving environment and ensure that commitments and statutory obligations are being complied with. For impact or compliance monitoring to be meaningful, it is necessary to have collected sufficient suitable background or baseline data. It is only when compared with the pre-mining (baseline) conditions that the nature of impacts can be assessed. This reinforces the need to begin collecting baseline information early in the exploration phase, before the site undergoes any significant physical disturbances.

A correctly designed impact/compliance monitoring programme should be able to provide early warning of adverse environmental impacts.

Monitoring data is of little value if it is not reviewed regularly. Historically, too often operations have collected vast amounts of expensive monitoring data and then failed to interpret it adequately. Interpretation initially may be as simple as the responsible site personnel entering it into a spreadsheet then plotting the data to check what trends are occurring over time. Operators need to be aware of the potential impacts of a change in an operation's scope over time and the potential implications to the monitoring programme (i.e. it may need to be modified to reflect the new scope of operation). Monitoring programmes should be reviewed regularly to ensure that they remain relevant both in terms of the parameters being monitored as well as the monitoring locations and frequency.

The purpose of **performance monitoring** is to check the performance of remediation works against predicted or required outcomes; this will help to ensure that closure criteria will be met. An additional outcome of performance monitoring is to provide actual field-scale data that can be used to refine and calibrate models used in the design of remediation works; this applies in particular to groundwater and cover designs.

Monitoring data can be used as input to the technique of adaptive management. Adaptive management is an iterative process of assessing issues and adapting the response to them through a cycle of identification, design, implementation and monitoring until the desired objectives are met. This cycle continues until the uncertainty associated with any new policy, practice or system has been minimized and the performance has been optimized.

It is important to remember that adaptive management is an iterative process and is beneficial only if it leads to continual improvements. Adaptive management continuously seeks a balance between the operational activities and the response of the site, including social, economic and environmental aspects. Adjustments are made to either the facility operation (e.g. human) or the facility design (e.g. equipment) to ensure optimum performance is attained without losing the long term balance with environmental and socioeconomic impacts.

Another best practice management system for operations is the environmental emergency response plan (ERP) that is required anywhere that dangerous goods (or hazardous materials) are transported, used, stored or handled. Facility management must take all reasonable precautionary measures to eliminate or control the causal factors for emergencies, which is typically done through the development of an ERP.

The following definitions are taken from National Standard of Canada CAN/CSA Z731-95 Emergency Planning for Industry and are applied in this section:

- Emergency: a present or imminent event that requires prompt coordination of actions or special regulation of persons or property to protect the health, safety or welfare of people, or to limit damage to property and the environment.
- ERP: a written detailed programme of action to minimize the effects of an emergency.

Factors requiring consideration when developing an ERP include but are not limited to:

- A risk assessment to identify, characterize and prioritize emergency situations;
- A training and guidance document;
- Procedure for post-emergency evaluations;
- Provisions for training;
- Contractual arrangements where hazardous material transport occurs;
- Communications systems;
- Regular inspections;
- Availability in multiple languages as needed.

A variety of dangerous goods (or hazardous materials) are required to support the production of uranium. The following discussion focuses on the transport of dangerous goods using ground (road or rail) transport with particular emphasis on large quantity (i.e. bulk) shipments. Transport may be performed on private, semi-private or public roads.

Transport accidents involving radioactive or non-radioactive dangerous goods may result in significant environmental harm, serious regulatory sanctions and widespread, negative publicity for the project. Transport accidents create the potential to significantly expand the sphere of impact for the project far beyond the production site's boundaries. A serious off-site accident may result in significant loss of confidence among the stakeholders in management's ability to operate the project in a safe and environmentally sound manner.

Production facilities may employ contractors to transport dangerous goods. The production facility must consider not only the financial costs but the risks of performing such transport using in-house versus external people and equipment. In any case, it is important that production facility management be able to demonstrate that the transport is being performed at all times by qualified and competent personnel using safe and suitable transport equipment. Appropriate emergency preparedness and response procedures must be established to deal with hazardous material transport emergencies. All shipments must be made in full compliance with applicable national and international regulations.

Examples of dangerous goods commonly in use at uranium production facilities include:

- Sulphuric acid;
- Hydrogen peroxide;
- Kerosene;
- Ammonium nitrate;
- Anhydrous ammonia;
- Petroleum products;
- Explosives; and
- Miscellaneous reagents for laboratory analysis.

Some projects transport dangerous goods to the site as raw materials for production of other dangerous goods. An example is molten sulphur that is delivered to a site for conversion into concentrated sulfuric acid for a leaching circuit. Some dangerous goods are utilized for ancillary activities, such as fuel for vehicles and power generation equipment.

Uranium production also necessitates the transport of the final product, also a dangerous good, whether in liquid, paste or solid form, to another facility for further processing. Such processing facilities may be located within a few kilometres of the original production site or on a different continent. Products may be delivered to a sea port for transfer onto ocean transport vessels.

3.7. WASTE

Best practice related to the management systems required for waste products associated with a mine or processing facility are site specific and in some cases region specific.

In certain uranium producing areas, there have been a growing number of waste management facilities within a particular region. As a result of this, some jurisdictions are planning for the use of underutilized waste disposal opportunities at adjacent production sites. For example, this may take the form of:

- Development of a regional milling facility and associated tailings management to limit the number of mills and tailings disposal sites in a particular area.
- Transport of potential contaminants (e.g. waste rock, domestic waste or industrial waste) to a centralized waste disposal location.

For example, uranium producers in northern Saskatchewan (Canada) have identified environmental and economic advantages through the extended utilization of the existing mill and tailings management facilities at the Key Lake project. Following depletion of the Key Lake mining reserves, a plan was developed, approved and implemented in which ore from the McArthur River Project is slurried and transported for processing at the Key Lake plant. Resultant tailings are then disposed of in the Key Lake's tailings management facility. This approach has resulted in an operational situation that has avoided the cost of licensing and constructing a new mill and tailings disposal site at the McArthur River mine. In turn, this has also limited the size of the development footprint required at McArthur River and restricted the number of point sources within the region that can contribute contamination to the environment.

Also in northern Saskatchewan (Canada), the Cigar Lake uranium mine will have its slurried ore transported to both the McClean Lake and Rabbit Lake mills for processing, with the associated tailings being disposed of at the McClean Lake and Rabbit Lake TMFs. Another way in which waste storage repositories are minimized in northern Saskatchewan is by shipping the potentially acid generating waste rock from Cigar Lake to the mined out Sue C pit at McClean Lake for disposal.

Typically, regional optimization of waste management is not feasible, and each site must manage their own waste streams, which generally include:

— Water;
— Waste rock;
— Process residues;
— Radiologically and chemically contaminated equipment.

Water

Water management typically consists of water collection systems designed to divert, collect, recycle and treat all potentially contaminated wastewater. Effluent must meet site specific standards or discharge requirements. For example, in Canada, the Metal Mining Effluent Regulations (MMER) outline acceptable levels for contaminants and other water quality parameters (e.g. dissolved oxygen, pH); these regulations are strictly enforced by regulatory agencies. One of the basic principles of water management is the diversion of non-contaminated water away from potential sources of contamination (i.e. keep clean water clean).

Sewage collection and disposal must also be properly managed.

Examples of techniques to minimize impacts to surface and groundwater are:

— Establishment of restricted release zones (RRZs) as water control areas;
— Creation of surface water diversion ditches around potentially contaminated areas (i.e. tailings piles, waste rock piles, mill terraces and ore storage pads);
— Installation of dewatering wells around mining or tailings pits;
— Isolating catchments to minimize the flow of surface waters into potentially contaminated areas;
— Management of water storage facilities.

Waste rock

Waste rock/overburden is the material excavated during mining that contains less than economic amounts of the target commodity. This material requires specific handling and characterization of its geochemical and radiological properties (acid rock drainage, metal leaching, etc.). It is important that this is undertaken during the planning phase of a proposed project so that appropriate management strategies can be designed.

Examples of waste rock management options include:

— Storage on pads that have an impermeable base to minimize downward movement of contaminated leachate into groundwater systems.
— The application of cover systems minimizes water and air ingress and the potential for significant contaminated surface runoff.
— Disposal of waste into a zone where oxygen and water content are limited/controlled (e.g. within a pit containing limited groundwater flux) can also reduce the risk of contamination resulting from waste rock seepage.

Process residues

For most operations, the term ‘process residues’ refers primarily to tailings. Tailings, the name given to the residue from the milling of uranium ore, comprise leached solids, process water and sometimes chemical precipitates created during recovery.

Disposal of mill tailings often represents the greatest challenge in a conventional uranium processing operation. Approximately 85% of the radioactivity in the original mill feed remains in the tailings after the ore has been processed and the uranium recovered. The tailings also contain heavy metals and process chemical contaminants from the production process. Best environmental management practices require that the tailings are geochemically and radiologically characterized and managed appropriately.

Disposal must, at a minimum, address the following concerns:

— Post-closure physical and chemical stability of the tailings;
— Optimizing settled density of the tailings;
— Minimizing radon release rate from tailings;
— Minimizing the potential for the release (including estimation of the contaminant flux rate) of contaminants into the air, and groundwater and surface water systems.

Examples of tailings disposal options include:

— Disposal below grade (below ground level), either in specially designed pits or as backfill in underground mine workings (e.g. the McClean Lake, Key Lake and Rabbit Lake Mines in Canada, and the Nabarlek and Ranger Mines in Australia) or in specifically excavated underground storage (e.g. as proposed for the projected Jabiluka mine in Australia).
— Conventional tailings disposal (i.e. above surface), such as in the Russian Federation, Ukraine and at Rössing (Namibia); such systems would require covering in some manner.

Radiologically contaminated equipment

Radiologically contaminated equipment (e.g. process piping) is often difficult to decontaminate and therefore requires separation from uncontaminated irems in order to minimize the potential for impacts to the environment. Segregation of these materials in a purpose-built area rather than co-mingling these wastes with other non-contaminated wastes is required.

Best practice management of wastes on closure typically requires construction and placement of a cover system to encapsulate the wastes. The use of cover systems or “capping” is one of the most common remediation methods used for controlling infiltration into and radon emanation from waste rock dumps, tailings storage facilities and heap leach pads. They have been used for many years by the mining industry throughout the world with varying success.

There was a time when simply placing a ‘cap’ over the surface of a waste rock dump or tailings dam was considered adequate for remediation and if vegetation was established on it, it was judged successful. Current best practice for cover system design must consider the following questions:

— Why are we going to cover the waste facility?
— What are the issues we are trying to manage/control?
— What do we want the cover to do?
— How will the cover achieve what we want it to do?
— What variables will affect the cover’s performance?
— How will we measure whether the cover is performing as required?
— For how long will the cover remain effective?
— Will the cover’s performance increase or decrease over time?

Generally cover systems need to have some or all of the following characteristics, depending on site specific circumstances:

— Limiting radon release;
— Radiation shielding;
— Limiting moisture infiltration to a predetermined amount;
— Limiting oxygen diffusion to a predetermined amount;
— Long term erosion resistance;
— Containment of the covered material within the structure;
— Support for vegetation communities;
— Prevention of capillary rise of oxidation products to the surface.

Covers can be broken up into two basic types: wet covers and dry covers. Wet covers, as the name implies, are where the waste material is covered by a layer of water (e.g. placed in an open pit then flooded, or contained behind a dam designed to hold a water cover over the waste on closure and into perpetuity). Dry covers vary greatly in design and complexity from simple single layers of uncompacted soils through to multilayered designs that may incorporate low permeability layers, capillary layers, oxygen consumption layers, etc. The choice of a cover layer design will depend on a range of site specific factors, which include:

— Climatic conditions;
— Hydrogeological conditions;
— Acceptable levels of impacts to the receiving environment;
— Type of cover system selected;
— Physical, geochemical and radiological properties of the material to be covered; and
— Physical and geochemical properties of available cover materials.

3.8. CLOSURE

Continued stewardship of an operation post-closure is also required to meet the best practice of sustainable development. This may consist of but not be limited to:

— Ongoing monitoring;
— Collection and treatment of contaminated water;
— Management and storage of water treatment sludges;
— Maintenance of facilities such as water diversion structures, covers, etc.

Appendix I

CASE STUDIES: APPLICATION OF BEST PRACTICE PRINCIPLES

I.1. SASKATCHEWAN'S TRIPARTITE PLANNING FRAMEWORK FOR URANIUM DEVELOPMENT

An obvious benefit of public consultation and involvement can be a shift in the level of positive support for the established uranium production facilities and proposed new operations. Such an observation has been noted, where public confidence polling results for the uranium industry in northern Saskatchewan has experienced a marked reversal in the level of acceptance demonstrated by the local communities. Table 1 depicts this Canadian experience.

The report goes on to make two observations with respect to the northern community consultation mechanism established by the uranium industry:

- Tripartite planning (Fig. 1) [10] involving the industry, governments and the local communities has gone a long way to resolving the items of concern identified during public consultation;
- The regional presence of the uranium mines, in conjunction with the environmental, educational, training, employment and business developments undertaken by the Athabasca Working Group Impact Management Agreement, has served as a catalyst for the sustainable community development of northern Saskatchewan. It is envisioned that the skills learned in relation to the uranium industry are sustainable and translatable to other mining ventures and resource development activities such as forestry or tourism.

I.2. ENVIRONMENTAL QUALITY COMMITTEE

Both the Canadian Federal and Saskatchewan Provincial Governments recognized there was conflict occurring in northern Saskatchewan due to uranium mining and that the previous attempts to alleviate the tension through public involvement had failed. They set up a Joint Panel to study the matter. While there were many issues the panel brought forward, two stood out the most. The first issue identified from the study was a need to establish a mechanism that would efficiently involve the communities of northern Saskatchewan in the issues surrounding the development and operation of the uranium industry. The second issue was the necessity of ensuring that government authorities consider the concerns and suggestions of the northern residents when arriving at regulatory and socioeconomic decisions relative to the industry.

As a response to the Joint Panel's findings, the Northern Mines Monitoring Secretariat (NMMS) was created by the Saskatchewan government. The role of the NMMS manager is to be a liaison with a number of provincial and federal government departments and agencies, as well as the public through Environmental Quality Committees (EQC). EQCs were created in northern Saskatchewan to provide an effective means for community participation in monitoring the uranium mining industry, influencing decision making about the industry and providing two-way communication between northern communities and the industry and/or the government departments tasked with regulating the industry. A handbook was created to assist in the management of the EQCs and clearly defines the roles and responsibilities of various members of the NMMS and EQCs as well as the organizations themselves.

TABLE 1. NORTHERN SASKATCHEWAN PUBLIC CONFIDENCE POLLING RESULTS

Poll results at each time point	Public confidence throughout Province	Public confidence among northern population in uranium mining
1977	14%	10%
2003	83%	87%

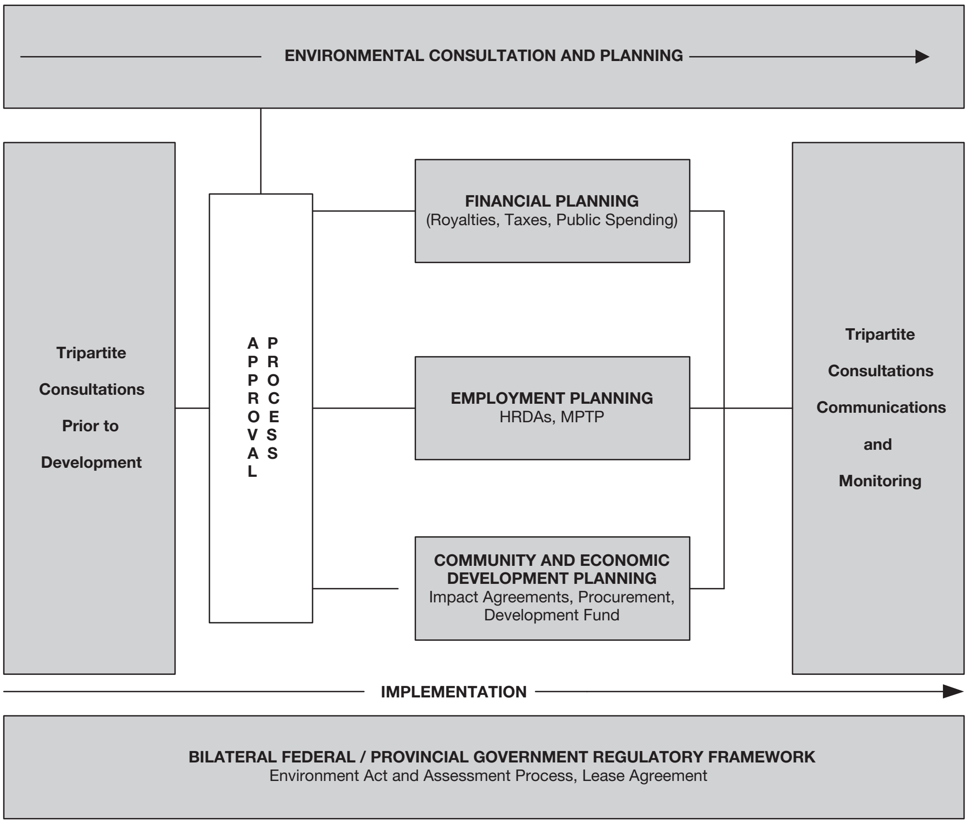

FIG. 1. Saskatchewan's tripartite planning framework for uranium development [10].

In a review of this type of public consultation, Barsi [11] observes that "the achievements of the EQCs have been notable. In addition to their providing routine consultative advice to government and industry, the committees have also clearly influenced the decisions of federal and provincial regulatory authorities. They have participated in the amendment of government policy with regard to uranium development and have taken an active role in advising regulatory agencies during the company operating license renewals, proposal evaluations, and industry planning for site modification or close-out."

The EQC process has significantly increased the level of understanding the northern communities have towards the uranium operations. It has also led industry and government to better understand the concerns of the communities. Both of these new understandings have resulted in an increase in the level of trust felt between these three groups. While there have been many positive results from these EQCs, it is an evolving system with room for improvement.

I.3. IMPACT AND BENEFITS AGREEMENT

The Athabasca Working Group (AWG) was created by the uranium industry in northern Saskatchewan in response to the demand for community involvement within uranium operations in northern Saskatchewan. They wanted to create an opportunity where industry and the impacted communities could discuss issues face to face. The group is comprised of representatives from seven of the primarily impacted communities and the two uranium companies. This group was able to negotiate an Impact Management Agreement that deals with the following three issues:

— Environmental protection and compensation;
— Employment, training and business development opportunities;
— Benefits sharing.

This agreement has been successful as many of the terms of the agreement have been completed while others are being planned or implemented.

One of the major projects and successes is the community-based environmental monitoring programme. The objective of the environmental monitoring programme is to identify contaminants within local air, water, sediment, plants and animals through regular sampling. Individuals from the communities collect the samples, often from sites identified through traditional knowledge, and an independent contractor is used to interpret the data and write the reports. This approach has led to an increase in the level of comfort the communities have with the results. Barsi [11] notes that this is the first time in northern Saskatchewan that communities have had a mechanism where they can participate directly in the resolution of the benefit sharing conflict.

I.4. AUSTRALIAN PUBLIC CONSULTATION PROCESS

There have been similar successes with public consultation in Australia. Nuclear activities (including uranium mining and milling) are deemed matters of ‘National Environmental Significance’ under Australian Commonwealth legislation. This legislation requires a public consultation process to occur as part of the environmental assessment process.

In South Australia, public consultation continues past assessment with the establishment of Environment Consultative Committees, comprised of representatives of Federal and State regulators, non-government organizations and the respective company’s environmental staff. These meetings occur on a semi-annual basis to discuss environmental performance, such as: any environmental incidents that may have taken place, changes to environmental management and monitoring programmes, and company achievements or milestones obtained during the previous six months.

Industry also undertakes ongoing consultation with the communities in which they operate to inform them of developments and also to assuage any concerns that may exist due to the presence of radioactive substances. At WMC Resources’ Olympic Dam Operations (Australia), newsletters are disseminated and public tours are conducted, with non-government organizations specifically encouraged to visit the site. Annual family days are held within the local community at Roxby Downs, and environmental staff also attend meetings with neighbouring pastoralists to discuss issues of concern, such as water management and uranium production. Tourists throughout the region are encouraged to visit the site via information billboards on highway rest stops and advertisements at the local visitor’s information centre. Environmental information is also made publicly available on the company’s website, including past environmental reports and incident notifications. A brief description of each reportable environmental incident is included on the WMC Resources’ website at the time of the incident.

I.5. ORE TRANSPORT ACCIDENT — EMERGENCY RESPONSE (USA)

The Cotter Corporation transports uranium–vanadium ore from West Slope Mining Operations (>300 km), and for 50 years until 2001 uranium ore from the Schwarzwalder mine (200 km) to the Canon City Milling Facility (CCMF), utilizing trucking contractors. The Schwarzwalder mine is approximately 30 km west of Denver, Colorado, a metropolitan area with a population of approximately two million.

A 25 t transport from the Schwarzwalder Mine was involved in a traffic accident in Colorado Springs, Colorado, population 400 000, on the Interstate freeway during the evening rush hour. Most of the ore spilled onto the highway. Response authorities immediately closed down the highway, initially in both directions, and re-routed traffic.

Notifications were made according to the Schwarzwalder Emergency Response Plan to regulatory agencies as well as to the Schwarzwalder Mine and the CCMF. The local response authority assumed incident command. Both sites dispatched monitoring personnel with a pre-made emergency kit to assist in the cleanup, monitoring and evaluation of the incident.

The CCMF personnel arrived first, about one and a half hours after the incident, and reported to the incident commander. These monitoring personnel were joined one hour later by the representative from the Schwarzwalder Mine. These Cotter personnel provided technical information on the relative hazard of spilled ore (0.5% U_3O_8) to incident command, recommended the necessary precautionary measures for response personnel, assisted with cleanup and provided cleanup verification. The trucking contractor dispatched personnel, another transport tractor-trailer, a front-end loader, shovels and brooms, arriving at the accident site approximately two hours after the incident.

The spilled ore was loaded into the new tractor-trailer and delivered to the CCMF. The damaged tractor-trailer was loaded on a transport and also sent to the CCMF for further accident investigation, decontamination and release. Both transport operations were completed according to U.S. Department of Transportation (DOT) shipping requirements. Cleanup and verification monitoring were completed, and the Interstate freeway reopened approximately twelve hours after the accident. Monitoring results indicated no significant radiological exposure to accident victims or to response personnel. A follow-up report of the incident was submitted to the regulatory authority, the Colorado Department of Public Health and Environment (CDPHE).

Subsequently a month later, a meeting was held with response authorities, regulatory agencies, Cotter personnel and the transport contractor to evaluate the incident. Generally, the response went well, including the public information aspects, with the exception that some passers-by in the vicinity of the accident were initially advised by incident command to report to a medical facility for evaluation.

I.6. ADAPTIVE MANAGEMENT — MCCLEAN LAKE OPERATION (CANADA)

The process of adaptive management has been adopted at the McClean Lake Operation as a routine feature of the management culture. This allows the policies and practices used in the on-site management system to be adjusted in light of environmental and socioeconomic performance. In order for this approach to function, AREVA must ensure that the necessary components of adaptive management are in place and that they are functioning. The following example outlines the adaptive management process at the McClean Lake Operations.

Following the discovery of uranium mineralization at the McClean Lake site in 1979, environmental baseline data was collected and stakeholders within the area were consulted. An Environmental Impact Statement was compiled, which evaluated the uncertainties of the proposed project from the environmental, social and economic perspectives. The Federal and Provincial governments commissioned the Joint Federal Provincial Panel on Uranium Developments in Northern Saskatchewan to conduct a thorough public review of the project. The Panel highlighted specific issues with the project, including the facilities, support infrastructure, and health and safety of both the workers and the environment. The Panel also put forth a series of recommendations.

AREVA took the initiative and began to develop practical solutions to the issues that were raised by the Panel. It was important that any solutions incorporated a degree of conservativeness reflecting the level of uncertainty at the time. For example, a number of programmes were developed to address the socioeconomic challenges of the local communities. It was important to develop a tailings management facility that would meet or exceed the stringent long term environmental requirements at the time of decommissioning. A number of follow-up environmental programmes were also developed as a way to track the accuracy of the environmental predictions and ensure compliance with regulations. These programmes are important because they allow for mitigating measures to be implemented early if the regulations are violated or if the predictions are not met.

Additional management systems, including the quality management system and the environmental management system, have been implemented as measures to control environmental, and health and safety issues on-site. Social responsibility has increased in recent years, and a number of programmes directed at social partnerships with local communities, communication and training, have been established. These programmes are important because they help to establish mutual trust between AREVA and the local communities as well as support local and regional socioeconomic development.

The managers and department heads are accountable for the continuous improvements at the McClean Lake Operations. Ongoing evaluations are conducted and appropriate comparisons are made with the performance objectives and regulatory requirements. Appropriate changes are implemented as necessary to meet the criteria established for protection of the environment, the health and safety of workers and the public as well as the maintenance of national security.

I.7. MANAGEMENT OF CONTRACTORS — INKAI PROJECT (KAZAKHSTAN)

For the Inkai project, management has developed and approved a documented policy describing how contractors (including subcontractors) will be managed from an environmental, and health and safety (EHS) perspective. The policy, along with the project's overall health, safety and environmental policy, is communicated to prospective contractors during initial contract discussions. A copy is provided to the contractor as an addendum to the contract.

The contractor management policy affirms that Inkai management will assume a leadership role in managing the contractor's EHS performance. Additional key environmental elements of the contractor management policy are:

- Inkai management affirms that contractors must not only adhere to regulatory requirements for EHS management but also to Inkai EHS standards, which in many instances include best practices that exceed regulated minimums. Several of these practices and their strict enforcement are literally foreign to many of the contractors. This necessitates careful communication of the standards and then close monitoring and follow-up to ensure conformity.
- Affirmation that Inkai's active involvement in contractor management in no way detracts from the responsibility of contractor management, supervisors and employees to meet applicable regulatory and contractual obligations regarding EHS performance.
- Where practicable, Inkai management will employ only those contractors who demonstrate a willingness to conform to Inkai's EHS standards. Where performance is deemed inadequate, individual workers or managers may be prohibited from further work on the project. The contract may be terminated in extreme cases.
- Inkai's EHS department and the designated contract manager from Inkai will monitor EHS performance and require corrective action where deficiencies are identified. These evaluations are used in determining the ongoing suitability of the contractor for performing future work for the Inkai project.
- Contractor management is responsible for ensuring qualified workers and supervisors are provided for the performance of all work.
- Contractor management will report to Inkai managers all instances of injury, damage or near misses so that an internal investigation can be conducted in accordance with project standards.
- Inkai will provide on-site EHS orientation for all contractor personnel prior to starting work.

The Contractor's EHS performance is included in the assessment of overall project EHS performance.

I.8. DANGEROUS GOODS TRANSPORT

The transport route

- Perform a risk assessment on the transport route to identify areas of higher risk (i.e. settlements, water courses). Consider possible alternate transport routes that may reduce the risk in case of accident (i.e. less populated, less traffic, less water). Solicit input from managers, supervisors, workers, contractors and external stakeholders during this process.
- Where not otherwise provided, arrange for the installation of barriers, berms, edge of road warning markers, traffic signs where needed. Regular maintenance of these installations will be necessary.
- Designate and document a specific transport route. If possible, avoid transport through populated areas. Some jurisdictions require that dangerous goods transport routes be state approved prior to initiating hazardous material shipments.
- Where practicable, perform baseline assessments of the radiological and non-radiological conditions of the soil and water courses along the transport route. This may be beneficial if cleanup is later needed following a dangerous goods release or if it is necessary to demonstrate that no releases have occurred.
- Ensure the transport route is in good condition and arrange for maintenance as needed. Routinely perform and record transport route inspections and ensure tracking and timely follow-up of any identified deficiencies.

— To the extent practicable, consider opportunities to communicate with residents and/or first responders along the transport route about the nature and frequency of hazardous material shipments. Transport of uranium products may be a source of added concern for residents and first responders. Provide honest and open awareness training on the hazards, risks and preventive measures being taken or planned for where indicated.

Preparing for transport

— Develop clear and straight-forward written procedures describing the means for ensuring safe transport of dangerous goods.
— Ensure an effective emergency response plan exists. Personnel must be trained and periodically re-trained in their specific roles and responsibilities in a transport emergency situation.
— Ensure the transport vehicle and containers bear all proper safety markings in accordance with applicable regulations and that all required shipment documentation is provided.
— Ensure only approved containers and vehicles are used for transport.
— Ensure shipments are made with proper safety markings, documentation and with properly trained and certified personnel.
— Where contractors are involved in the transport, use only those with proper licenses, certificates and emergency response plans and capabilities.
— Ensure all required permits, licenses or other approvals for transport are in place whether self-transporting or contracting out the delivery.
— Ensure the transport vehicle has current emergency response instructions.
— Perform a final check on the transport vehicle to ensure all containers are properly closed, are in good condition and secured from movement.
— Ensure the transport equipment is in safe operating condition through regular inspections and preventive maintenance.
— Provide the transport driver or pilot car with an effective means of emergency communication (e.g. two way radios, cellular or satellite phones).
— Establish maximum hours of driving and minimum required rest periods for drivers to minimize the risk of drowsy drivers.
— Where available or required, register your dangerous goods transport emergency response plan with authorities. Identify the availability of emergency hotlines for reporting dangerous goods transport emergencies (i.e. Canadian Transport Emergency Center (CANUTEC) in Canada) and receiving guidance on response.
— Some jurisdictions require that transport drivers undergo pre-trip examinations of drivers to ensure they are fit to safely complete the trip. Consider the benefit of doing so in other jurisdictions.
— Establish, maintain and periodically re-evaluate the transport emergency spill response resources and training requirements for their use. Equipment may be carried on the transport equipment, pilot car (if provided), at the point of origin for the shipment, the shipment destination or designated points in between.
— Perform regular drills or exercises to test and improve transport release emergency response capabilities. Involve contractors where possible.
— Provide the shippers, carriers and receivers with current Material Safety Data Sheets available in clear language. Consider use of the generic International Labour Organization (ILO) Chemical Safety Cards as a possible source of information where manufacturer-specific MSDSs are not available or required.
— Ensure trucks carry suitable tyre chains when snowy or icy road conditions may be encountered.

Making the shipment

— When transporting dangerous goods through higher risk areas (i.e. heavy traffic areas), consider the use of pilot vehicles and drivers to escort the trucks. A key responsibility of the pilot car driver is to ensure vehicle speed is closely controlled in accordance with speed limits, and road and visibility conditions. The pilot car driver can also play an important role in initiating notification of an emergency to project management, establish initial scene security and initiate containment until response team personnel arrive.

— Evaluate means to monitor conformance of employees or contractors involved in transport and take immediate corrective action where non-conformances are identified. Conduct unannounced spot checks to ensure shipments are being properly conducted.
— Encourage drivers to pull over and stop in safe areas to refresh themselves if they are feeling drowsy at any time.
— Encourage drivers to report any problems or near misses during the shipments to facilitate investigation and follow-up as required.
— Establish clear procedures for making planned or unplanned stops along the transport route. Do not leave the transport vehicle unattended.
— Provide means for ensuring that transport equipment does not travel at excessive speed. Tachographs or Global Positioning System (GPS) units may be used to provide real time monitoring of speed. Hand-held GPSs may be used to record maximum and average speeds for post-shipment evaluation of conformance.
— Minimize shipments during hours of darkness where practicable.
— For transport along extended routes, establish designated checkpoints at which the transport vehicle will stop for inspection by the driver and/or pilot car driver. These checks provide an opportunity to verify load securement and determine if there is any evidence of loss of containment of contents.
— Monitor road, weather and visibility conditions to the extent practicable along the transport route. Be prepared to delay shipments until conditions improve.
— Instruct and train drivers to install tyre chains in icy or snowy road conditions.

Use of contractors

In many instances, companies may lack the resources or regulatory approvals to perform certain shipments of dangerous goods. This may necessitate the use of contractors for the performance of the deliveries. Production facility management should ensure contractors are performing these deliveries in accordance with regulatory requirements and company standards. In the event of a transport accident by the contractor, the production facility may still be held legally liable by regulatory authorities and other stakeholders.

Recommended practices with respect to contractors include:

— Verify that the contractor firm, its transport equipment and transport drivers possess all required licenses or permits necessary to perform the shipments within the jurisdiction(s) involved. All approvals must be kept current.
— Ensure the contract clearly specifies the status of ownership of the material being transported at all points along the delivery route. The contract should also specify responsibilities for emergency notifications and response of the company, regulators and the public at risk.
— Send a qualified representative to any transport emergency scene involving project-owned hazardous material to supervise response activities (including cleanup and disposal activities).
— Include a commitment in transport contracts that the contractor will adhere to regulatory and project environment, health and safety standards during shipments. The contract should provide for appropriate penalties for non-conformance.
— During contractor selection, evaluate their maintenance and inspection practices, and the condition of their equipment. The integrity of containment structures must be routinely tested and any repairs made only by qualified personnel using appropriate techniques and materials of adequate quality.

Transport emergency response considerations

Despite all reasonable precautions, transport accidents and releases of hazardous cargoes may still occur. Persons involved in the shipment, delivery or receipt of dangerous goods should be prepared and capable of responding in a timely and effective manner to mitigate impacts. Section 3.2.3 refers to general emergency preparedness and response best practices. However, specific key points regarding responses to hazardous material transport emergencies include:

— Ensure cleanup is performed promptly and to baseline conditions where practicable. Store or dispose of any waste materials from the cleanup in approved facilities.
— Be prepared to deal with ancillary issues that may be associated with a transport-related environmental emergency. Examples of these issues include fire, injury, traffic control and scene security.
— Notify at-risk members of the general public immediately if there is any risk posed to them or their property by a transport release. Be prepared to err on the side of caution when deciding if notification should be made.
— When notifications are to be made to the location of emergency response personnel, consider who might receive the call. Examples exist where mis-recorded or misunderstood information from a caller has resulted in a confused and inefficient response. The ideal situation is to utilize a dedicated and supervised emergency response number during hazardous material transport. The call recipient is trained specifically to notify the appropriate emergency response personnel and forward details of the situation so a response can be formulated and implemented. However, in many organizations, this is not a practicable arrangement. Incoming calls may be received by a wide variety of personnel. If this is the case, all potential recipients of the calls require training on the information that must be obtained from the caller regarding the incident and logged on the incident report form. Once completed, the form is immediately forwarded to the emergency response team.
— Consider the need to retain the services of a qualified emergency response organization where in-house response expertise does not exist or transport emergencies may occur at a site that is very distant from the project site. Having a contractual arrangement in place is a preferred practice as it tends to ensure their availability when an emergency occurs.
— Become familiar with the regulatory reporting requirements and notification system of the jurisdiction(s) through which transport occurs. This includes means for notifying first response personnel such as fire and police along the transport route. Notification protocols for regulatory authorities must also be understood and communicated to those involved in transport or response to transport emergencies.

Useful guidance on transport emergency response best practices is also available in a UNEP publication [12].

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Annex*

PAPERS PRESENTED AT AN IAEA TECHNICAL MEETING HELD IN SASKATOON, CANADA, 22–25 JUNE 2004 (available on the attached CD-ROM)

Remediation of the Sierra Pintada mine during operation
A. Castillo
Radiometric baselines in uranium exploration production areas of Chubut Province, Argentina
L. López
Water quality monitoring in the Cerro Solo U district Chubut, Argentina
L. López, R. Ferreyra, G. Tomellini, L. Fanfani, R. Cidu
Environmental management and regulation at an Australian in situ acid leach uranium mine: Beverley
S. Paulka
Water management at Australian uranium mines
R.J. Ring, R. Lucas, B. Day, J.A. Davidson
Environmental management studies related to new Brazilian uranium mining and milling
H.M. Fernandes, W. Pereira, M.R. Franklin, F.F.L. Simoes Filhoamego, V. Perezc, G. Viana
Environmental management of the Pocos de Caldas open pit mine
A.M. Tavares
Planning for decommissioning at the Cluff Lake uranium mine in northern Saskatchewan
G. Acott, B. Pollock
Canadian experience in decommissioning of uranium tailings facilities — Elliot Lake, Canada
L.C. Botham
Environmental and quality management system at AREVA/COGEMA Resources, Inc.
P. Fullman, P. Wollenberg, M. Neal
Hydrogeology and groundwater modelling of the Collins Creek Basin
F. Guerin, M.A.J. Tremblay
Canadian Nuclear Safety Commission regulation of uranium mines and mills
C. Gunning
Maintaining public involvement — Saskatchewan style
B. Hutchinson
Overview of environmental monitoring programmes required by Canadian uranium producers
A. Langhorne, S. Stark, K. Himbeault
An analytical approach for environmental assessment and management of uranium mining operations
D.L. Lush, R.V. Nicholson, B.T. Rodgers, G. White
Beaverlodge mine/mill operation and decommissioning: Best practices of the day (1950–1985) and issues and challenges for tomorrow (1986–2004): A case study
R. Phillips, D. Hovdebo
Establishing effective environment and safety performance indicators: A best practice approach in uranium production
D. Rezansoff, G. White
Environmental assessment, continual improvement and adaptive management within the AREVA sustainable development framework
A. Rosaasen, S. Frostad
Tailings management best practice: A case study of the McClean Lake Jeb tailings management facility
J. Rowson, M.A.J. Tremblay
Improving regulatory certainty in Canada's uranium mining industry
B.E. Sigurdson, T.S.T. Moulding, K.T. Nagy

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The Athabasca Working Group environmental monitoring programme in northern Saskatchewan — building relations between indigenous groups and the uranium mining industry

K. Wells, J. McIntyre

The present environmental practice of uranium mining and milling in China

S. Gao

Polymeric coats for the stabilization of contaminated surfaces of uranium mill tailings

S.V. Mikheykin

Decommissioning/closeout of uranium milling facilities in Ukraine: Current state, legislative bases, licensing process

V. Holubiev, V. Ryazantsev

Ground and surface water restoration technologies

J.G. Harrington

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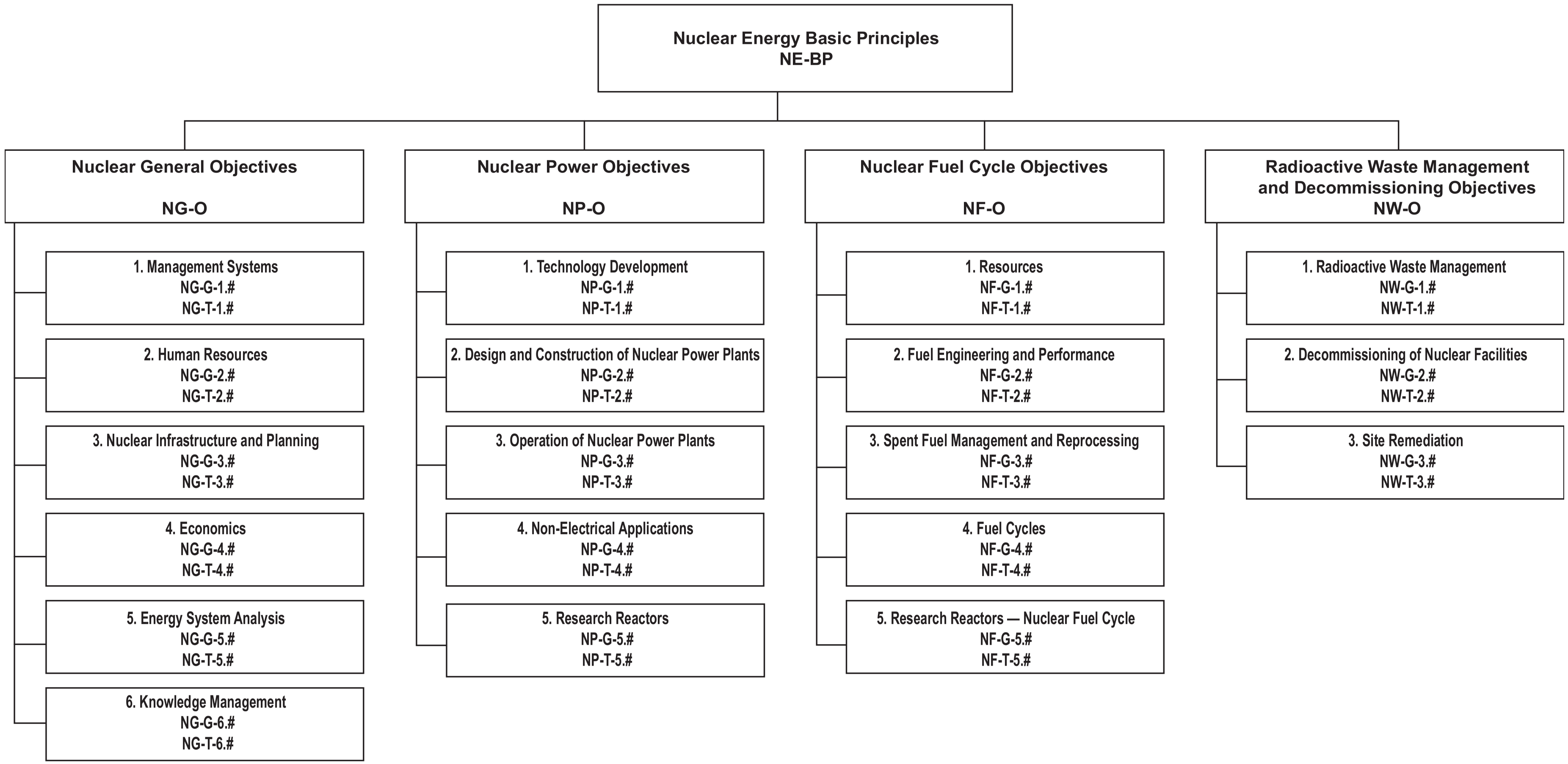

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