APPLICATION OF RISK MANAGEMENT TO ABANDONED MINE SITES IN THE CANADIAN NORTH[1]

Michael Nahir[2], Michael van Aanhout, and Stefan Reinecke

Abstract. The Indian and Northern Affairs Canada (INAC) Northern Affairs Contaminated Sites Program (CSP) includes several large abandoned mine sites and is one of the largest contaminated sites programs in Canada. The program has developed a risk management procedure to provide a consistent methodology to evaluate the many types of risk at its sites, ensure that all high-risk items are identified, and provide a basis for prioritizing activities. This risk management procedure has been applied to nine abandoned mine sites. The high-risk scenarios identified for these sites were organized into common themes, or overarching issues. The five most common themes were: tailings impacts, health and safety risks due to public access, tenure issues, stored or spilled hazardous materials and petroleum hydrocarbons, and contracting issues. The most common consequences associated with high-risk scenarios within these themes were cost, health and safety, and community/media/reputation. The other types of consequences, including environmental impacts, legal obligations, and community/media/reputation, were not the main drivers for most of the high-risk scenarios. In addition to ongoing assessment and remediation activities at the abandoned mine sites, INAC is addressing the overarching issues identified by the risk management procedure through program-wide initiatives, including the development of new policies, guidelines, best practices and site-specific initiatives.

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[2] Michael Nahir is Technical Advisor for the INAC NAP CSP, Gatineau, Québec, K1A 0H4, Canada. Michael van Aanhout is president of Stratos Inc., Ottawa, Ontario, K1N 7B7, Canada. Stefan Reinecke is senior consultant at Stratos Inc., Ottawa, Ontario.

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Introduction

Risk management is defined as "the systematic application of management policies, procedures, and practices, to the tasks of analyzing, evaluating, controlling, and communicating about risks" (CSA, 1997). Risk management is becoming increasingly important for organizations engaged in complex projects and facing greater scrutiny by stakeholders and the media.

The concept of risk management is not new to the Indian and Northern Affairs Canada (INAC) Northern Affairs Contaminated Sites Program (CSP). In 1995, the *Northern Environmental Risk Assessment Strategy* (NERAS) was introduced, which applies a limited risk management approach. Since then, and especially in the last five years, the INAC CSP has become one of the largest contaminated sites management programs in Canada. The program has an objective of reducing the federal government's contaminated sites liability in the North, currently over $900 million, and is currently spending about $80 million/year. As the complexity and scale of sites in the NAP contaminated sites inventory increased, there was a collective understanding that existing risk management tools did not provide enough detail and transparency to ensure that risks would be identified and addressed in a consistent manner.

Recognizing this, INAC formed an advisory group of key project and program managers to develop a risk management procedure drawing on federal government and departmental policy and industry best practice. A first version of the procedure was applied at two significant mine sites, Faro Mine (Yukon) and Giant Mine (Northwest Territories). The procedure was then refined based on lessons learned from the application at these two sites. Since then, the procedure has been applied to nine additional mine sites, and is currently being implemented across the program for all priority contaminated sites, including abandoned military sites.

The use of risk-based approaches for managing contaminated sites is supported by departmental policy at INAC, as well by various Canadian federal initiatives, programs, and agencies including the Treasury Board of Canada, the Canadian Council of Ministers of the Environment (CCME), and *Federal Contaminated Sites Accelerated Action Plan* (FCSAAP).

Objectives of the Risk Management Procedure

The objectives of the NAP CSP risk management procedure are as follows:

1. To provide a consistent methodology for developing an inventory and evaluating the many different types of risk at contaminated sites under the control of NAP;
2. To provide a process to ensure that no high risk items are "falling through the cracks"; and
3. To provide a basis for prioritizing risk mitigation or control activities within and among sites.

Current Implementation of Risk Management in CSP

The framework of the CSP risk management procedure draws its terminology and structure from the *Canadian Standards Association Standard, CAN/CSA-Q850-97 Risk Management Guideline for Decision Makers* (CSA, 1997; reaffirmed in 2002), hereafter referred to as the CSA Standard. The steps of the risk management process in the CSA Standard are illustrated in Fig. 1.

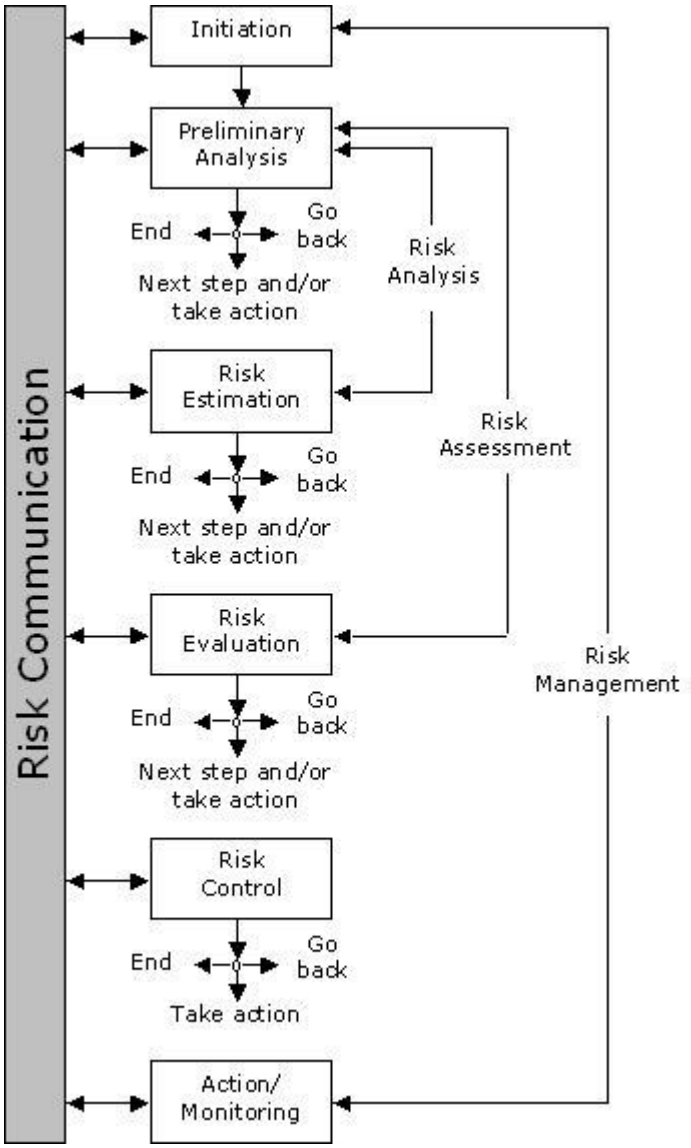

Figure 1. Steps in the Q850 Risk Management Decision-Making Process (CSA, 1997)

The CSP risk management procedure includes the following steps, which are similar to those of the CSA standard: 1. Initiation – Establishing the risk management process; 2. Preliminary Analysis – Identifying hazards and events using risk scenarios; 3. Risk Rating – Analyzing risks by estimating the consequence and likelihood of each event; 4. Risk Evaluation – Deciding whether to mitigate or accept risk; 5. Control/Action – Evaluating methods to mitigate or accept risk and implementing the preferred method; and 6. Monitoring and Review - Monitoring the results.

The following discussion describes how each of these steps has been implemented in the NAP CSP.

Step 1: Initiation

As stated previously, the use of a risk management approach in the CSP is driven by policy requirements and by the scale and complexity of its contaminated sites inventory.

CSP has developed a written Risk Management Procedure for project managers, which is posted together with other corporate procedures on the NAP CSP website on the INAC intranet site.

A central component of the procedure is a risk management workshop (workshop), which is being implemented across the program for all funded sites. A workshop is generally held for each site and is attended by a Risk Management Team consisting of the project manager(s), key staff involved with the site, and internal and external experts. The workshops are led by a qualified Workshop Facilitator (facilitator).

The CSP risk management procedure is supported by a web-based application called the Risk Management Tool (RM tool) that serves as the data entry platform and risk register (database) for all sites in the CSP inventory. The RM tool also has report generation function that enables grouping and sorting of risk events to aid in prioritizing risk mitigation or control activities within and among sites.

The risk criteria of importance to NAP are based on federal and departmental policy, and are reflected in the consequence severity definitions developed for the procedure. The types of consequences that are considered are: i) human health and safety; ii) legal obligations; iii) environmental impacts; iv) special consideration (including traditional land use by First Nations); v) community/media/reputation; and vi) cost.

The definitions of consequence severity and likelihood were established based on pilot testing in workshops for two mine sites. These definitions are described in detail in Step 3.

Step 2: Preliminary Analysis

The identification of events (hazards) in the Risk Management Procedure is carried out in the workshop based on the input from internal and external experts. The experts are individuals who have conducted scientific, engineering, or economic studies or inspections in accordance with professional standards in their field (e.g. dam inspection by a professional engineer) or individuals who are involved in management or stakeholder consultations for the site. Therefore, the effectiveness of the workshop relies significantly on the experience and knowledge of the Risk Management Team and their input.

Two lists of standard site *element* categories have been developed. As shown in Table 1, one list is for mine sites, and the other list is for military and other sites.

Table 1. Standard Site Element Categories

Mine sites	Military and Other Sites:
Dams	Buildings and Structures
Diversions	Dumps
Tailings and Sediments	Barrels and Site Debris
Open Pits	Fuel Tanks
Underground	Contaminated Soil
Waste Rock Dumps	Site Administration
Water Treatment	
Infrastructure	
Buildings, Tanks, Structures	
Site Administration	

The element lists provide a logical framework for the identification of events, and to ensure that significant risks are not overlooked. For a given site, there may be several elements in an element category (e.g. several dams in the *Dam* category; a road, airstrip, and a dock in the *Infrastructure* category). Likewise, certain element categories may not be applicable to a site.

The facilitator guides the Risk Management Team through a brainstorming session to define events for each element that should be considered in the risk assessment. An example of an event could be "Failure by piping of dam leads to release of tailings and contaminated water into lake" (i.e. environmental impact). Events are recorded using the RM tool.

Step 3: Risk Rating

The CSP risk management procedure uses a qualitative approach to analyzing risk. The qualitative approach is better suited to analyzing the wide range of risk types that are important to INAC. However, this does not preclude the use of quantitative tools for assessing particular risks at a site. The background information used during the risk management workshops may include quantitative risk analyses for particular elements (e.g. human health and ecological risk assessment, failure risk of engineered structures). Also, the risk management workshop may lead to a requirement for quantitative risk analysis of a particular element.

The risk of an event is determined by the consequence severity of the event and the likelihood that it will occur. The first step is to determine the consequence severity using the definitions shown in Table 2. The definitions were developed specifically for the CSP and are an expression of INAC's risk tolerance for each consequence type. The table also shows what constitutes equivalency for each severity level between consequence types.

The second step is to estimate the likelihood of occurrence of the consequence using the definitions shown in Table 3. The qualitative definitions under the 'Descriptive' heading are generally the most practical, whereas the definitions in the last two columns are only useful when health risks or engineering risks have been quantified by a previous study. If more than one type of consequence is assigned to an event, then the likelihood of each consequence is to be determined individually.

Table 2. Definitions of Consequence Severity

Consequence Categories	**Severity**				
	Low	*Minor*	*Moderate*	*Major*	*Critical*
Environmental Impact	No impact.	Minor localized or short-term impacts.	Significant impact on valued ecosystem component.	Significant impact on valued ecosystem component and medium-term impairment of ecosystem function.	Serious long-term impairment of ecosystem function.
Special Considerations	Some disturbance but no impact to traditional land use.	Minor or perceived impact to traditional land use.	Some mitigable impact to traditional land use.	Significant temporary impact to traditional land use.	Significant permanent impact on traditional land use.
Legal and Other Obligations	No non-compliance but lack of conformance with departmental policy requirement. Informal advice from a regulatory agency. No land claim or other agreement.	Technical/ Administrative non-compliance with permit, approval or regulatory requirement. Warning letter issued. Land claim or other agreement requires the Crown to satisfy administrative obligations (e.g. notification).	Breach of regulations, permits, or approvals (e.g. 1 day violation of discharge limits). Order or direction issued. Land claim or other agreement requires the Crown to respond, but no time frame is specified.	Substantive breach of regulations, permits or approvals (e.g. multi-day violation of discharge limits). Prosecution. Land claim or other agreement requires the Crown to exercise its obligations within a specified time frame (i.e. 2-5 years)	Major breach of regulation – wilful violation. Court order issued. Land claim or other agreement requires the Crown to exercise its obligations within a specified short time frame (i.e. 1-2 years)
Consequence Costs	< $100,000	$100,000 - $500,000	$500,000 – $2.5 Million	$2.5 – $10 Million	>$10 Million
Community/ Media/ Reputation	Local concerns, but no local complaints or adverse press coverage.	Public concern restricted to local complaints or local adverse press coverage.	Heightened concern by local community, criticism by NGOs or adverse local /regional media attention.	Significant adverse national public, NGO or media attention.	Serious public outcry/ demonstrations or adverse international NGO attention or media coverage.
Human Health and Safety	Low-level short-term subjective symptoms. No measurable physical effect. No medical treatment.	Objective but reversible disability/ impairment and/or medical treatment injuries requiring hospitalization.	Moderate irreversible disability or impairment to one or more people.	Single fatality and /or severe irreversible disability or impairment to one or more people.	Multiple fatalities.

Table 3. Definitions of Likelihood

Assigned Likelihood	**Descriptive**	**Health Events Only**	**Frequency of Occurrence for Other Events**
Almost Certain	Happens often	1 case / 100 person-years	High frequency (more than once per year)
Likely	Could easily happen	1 case / 1,000 person-years	Event does occur, has a history, once every 1-10 years
Possible	Could happen and has happened elsewhere	1 case / 10,000 person-years	Occurs once very 10-100 years
Unlikely	Hasn't happened yet but could	1 case / 100,000 person-years	Occurs once every 100-1000 years
Very Unlikely	Conceivable, but only in extreme circumstances	1 case / 1,000,000 person-years	Occurs once every 1000-10,000 years

Table 4 is the risk matrix that defines the risk ratings for every combination of consequence severity and likelihood. The risk ratings are only meaningful to the extent that each category triggers certain levels of action. The matrix was developed such that each risk rating leads to a level of action that is consistent with the objectives and risk tolerance of the CSP.

Table 4. Risk Matrix

Likelihood	**Consequence Severity**				
	Low	*Minor*	*Moderate*	*Major*	*Critical*
Almost Certain	Moderate	Moderately High	High	Very High	Very High
Likely	Moderate	Moderate	Moderately High	High	Very High
Possible	Low	Moderate	Moderately High	High	High
Unlikely	Low	Low	Moderate	Moderately High	Moderately High
Very Unlikely	Low	Low	Low	Moderate	Moderately High

In the workshop setting, the facilitator guides the Risk Management Team through the risk analysis for each event and marks the event on a poster-sized risk matrix table. The consequence severity and likelihood information are also recorded using the RM tool, which automatically records and displays a risk rating.

Step 4: Risk Evaluation

A common industry practice for evaluating risk is to use the "ALARP" or "ALARA" principle (As Low As Reasonably Practical/Achievable), which is illustrated in Figure 2. The ALARP framework describes three possible outcomes: i) the risk is acceptable at its current level; ii) the risk is unacceptable at any level; or iii) risk control measures are required. ALARP incorporates the notion of cost benefit into the analysis.

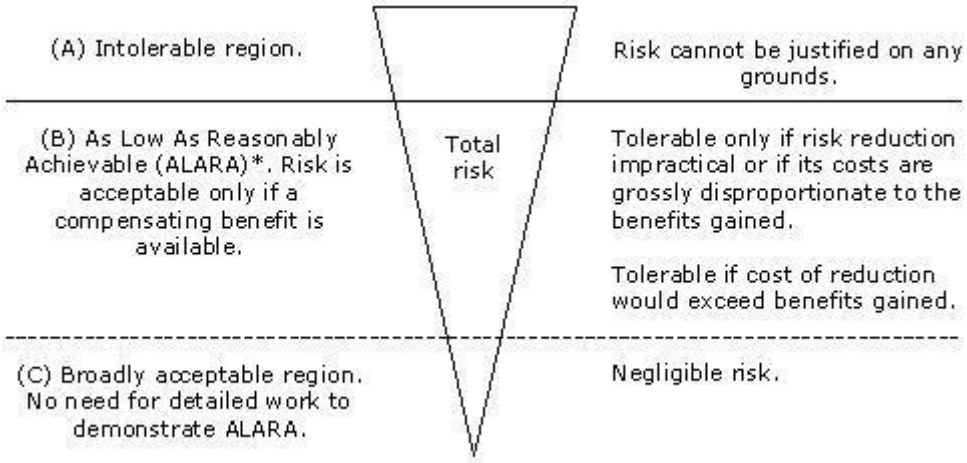

Figure 2. ALARA/ALARP – Framework for Risk Criteria (CSA, 1997)

The risk matrix used in the CSP risk management procedure has been divided into three regions, based on the ALARP framework, as shown in Table 5.

Table 5. Risk Matrix with ALARP Regions

Likelihood	Consequence Severity				
	Low	Minor	Moderate	Major	Critical
Almost Certain	Moderate	Moderately High	High	Very High	Very High
Likely	Moderate	Moderate	Moderately High	High	Very High
Possible	Low	Moderate	Moderately High	High	High
Unlikely	Low	Low	Moderate	Moderately High	Moderately High
Very Unlikely	Low	Low	Low	Moderate	Moderately High

Intolerable Region

ALARP Region

Broadly Acceptable Region

Action levels for each risk rating are described in Table 6. The two-year time limit for high-risk events was deemed to be a reasonable time period in which to mobilize to a site and mitigate risks based on winter mobilization requirements for many remote sites and fiscal constraints.

Table 6. Action Levels by Risk Rating

Region	**Risk Rating**	**Action**
Intolerable	Very High	Must mitigate immediately
	High	Mitigation imperative within two years or as soon as possible
ALARP	Moderately High	Must have mitigation plan in place, and should implement plan within two years or as soon as possible
	Moderate	Must have mitigation plan in place and should implement within five years
Broadly Acceptable	Low	Monitor

Step 5: Risk Control/Action

If the risk evaluation has identified unacceptable risks or risks requiring mitigation, then options to mitigate the risk need to be developed, evaluated, implemented and monitored. The facilitator may guide the Risk Management Team through a discussion to develop and evaluate preliminary options to mitigate unacceptable risks. However, the development of risk control plan is usually done outside of the workshop. Project managers are required to include the risk management workshop results and plans to mitigate unacceptable risk in their detailed work plans for each site.

Following the workshop, the Project Manager will conduct a more detailed evaluation of the preferred risk mitigation measures and, if required, develop detailed plans for the implementation of these measures. Alternatively, the Project Manager may develop evaluate mitigation options entirely outside of the workshop.

Step 6: Monitoring and Review

The monitoring and review step is not unique to risk management, but rather is more broadly viewed as part of project or program management. As stated in Step 4, the detailed work plans contain a summary of the results of the risk management procedure and strategies and plans for addressing unacceptable risks. These plans should also include a monitoring program to ensure that high-risk items are acted upon and to monitor conditions related to lower risk items. The detailed work plans are updated annually and should reflect any changes in the risk profile at the site, based on new information or on remediation completed.

At the discretion of the Project Manager, a follow-up workshop can be held to solicit additional input from the Risk Management Team. A follow-up workshop may be especially appropriate if the initial workshop was held before the development of a remediation plan. Once a remediation is in place, the risks associated with implementation of the remediation plan and the residual risks following implementation can be examined.

The RM tool has a reporting function to generate site-specific, regional, and national reports for review and monitoring of risk management information and prioritization of mitigation actions across the program.

Risk Management Results Highlights

Overview

The following is a summary of the results for the nine sites for which the risk management procedure was applied. The discussion focuses on events with risk ratings that place them in the Intolerable Region (high and very high risk) and those classified as moderately high, which are in the ALARP Region. These categories represent the highest priorities for action, as they include items where mitigation is imperative or should be implemented within two years or as soon as possible.

For the nine sites, 705 risk events were developed, of which 351 were rated as *moderately high*, *high*, or *very high*. The number of events for each site varied depending on the length of the workshop, the participants, and the nature of the site. Therefore, the distribution of events for a site is expressed in terms of normalized percentages for comparison purposes. Table 7 shows the average distribution of *moderately high* risk to *very high* risk events by consequence type.

Table 7. Distribution by consequence type of moderately high, high risk, and very high risk events

	Average distribution of consequence types		
Consequence Type	**Moderately High Risk Events (246 events)**	**High Risk Events (100 events)**	**Very High Risk Events (5 events)**
Environmental Impact	15%	8%	0%
Special Considerations	9%	6%	0%
Legal Obligations	14%	7%	0%
Consequence Cost	21%	21%	100%
Health and Safety	22%	34%	0%
Community Media and Reputation	19%	24%	0%

The following observations can be drawn from this table:

- Only three sites had *very high risk* events and all of these events had cost consequences.
- Eight of nine sites had *high risk* events. These events were dominated by health & safety consequences (34%), cost consequences (21%) and community/media/reputation consequences was also high (24%).
- All sites had *moderately high* risk events, which were relatively evenly distributed between all six consequence types, though health & safety, cost and community/media/reputation consequences were slightly dominant.

Most events with significant health and safety consequences involve accidents due to public access to the site, specifically to buildings, pits, and mine openings. Many of events were originally cast as events with environmental impacts, but following the risk analysis (Step 3), were found to be driven by other consequence categories such as community/media/reputation and cost.

Common Themes

The risk events were organized into themes, or overarching issues, that were common to several sites. This was done to identify areas where risk control and mitigation efforts could be focused on a regional or program levels, and to identify specific policy and expertise requirements. The five most common themes are, in order of frequency (highest to lowest):

1. **Tailings impacts** [all 9 sites] **–** These events involve the release of tailings and/or contaminated water from tailings containment areas (TCAs) due to dam/dyke failures, diversion failures, seepage, or failure of pumping/treatment systems. The consequences categories associated with these events are wide-ranging (i.e. all types).
2. **Health and safety risks due to public access** [8 sites] – These events involve public access to unsafe areas (building, underground, pits, rock piles) resulting in fatality or serious injuries (health and safety consequence) due to falling, falling debris, underground collapse, electrocution, drowning, or exposure to hazardous material.
3. **Tenure issues and Land Claims** [8 sites] – These events involve legal rights over the property (mineral rights, authority to remediate/close site, third party use of site infrastructure, unresolved or ambiguous Land Claims), and typically result in project delays (cost consequences) or community concerns (community/media/reputation consequences).
4. **Hazardous materials and petroleum hydrocarbons** [5 sites] – These events involve hazardous material (e.g. mine reagents) and petroleum hydrocarbons stored on site, as well as contaminated soil and groundwater from historical spills of petroleum hydrocarbons. Consequences are primarily legal obligations and cost (due to legal obligation to clean-up). It is noted that environmental impact was generally not the driving (highest risk) consequence category for these events.
5. **Contracting issues** [5 sites] - Events involve contracting issues including government processes, labour and contractor shortages, and procurement. Consequences are primarily cost (due to delays), but also community concerns and health and safety.

Program Approach to Addressing High-Risk Items

As set out in the risk management procedure, moderately high risk to very high risk issues need to be addressed immediately or within two years, depending on the risk rating. Remediation plans are being developed and executed by project managers based on the priorities identified, or reaffirmed, by the risk management procedure.

Project managers must identify the skills and resources required to develop mitigation plans and assemble working groups or seek advice as required. The risk management procedure is designed to identify a wide range of risks, which may require a wide range of control and mitigation approaches including:

- Developing site-specific solutions to unique technical, communications, and consultation issues using internal and external experts.
- Developing region-wide or program-wide plans to address common but straightforward technical and logistical issues (e.g. signage around mine openings and buildings, removal of accessible hazardous materials).
- Seeking legal advice from legal services or from other departments to develop guidance around common legal issues (e.g. responsibility for airstrips); and/or
- Make recommendations to program managers and headquarters concerning any issues requiring policy changes or program-wide guidance.

The CSP is currently addressing program-wide issues identified by the risk management procedure through the following initiatives:

- A technical advisory committee has been established to develop technical guidelines and protocols to ensure an appropriate level of consistency in remediation approaches applied across the program on a variety of issues such as tailings covers, remediation of hydrocarbon impacted soils, use of permafrost-based liners and covers, and PCBs in paint.
- A discussion paper on tenure issues and water licenses is being developed with input from senior managers from the department.
- A health and safety management audit has been conducted to examine systems, roles, and responsibilities currently in place and the applicability of federal and territorial health and safety regimes.
- Regional procurement strategies are being developed to ensure clarity, financial accountability, and consistency with departmental objectives with respect aboriginal capacity-building.

The outcomes of these initiatives should provide program and project managers with best practices that will significantly reduce many of the common risks identified by the procedure, or provide clear guidance on developing mitigation strategies.

Summary

A risk management procedure has been implemented in the Contaminated Sites Program of the Northern Affairs Program. The procedure is modelled on best practice in the private sector and on the *Canadian Standards Association Standard Risk Management Guideline for Decision Makers*, and has been customized to address, and be consistent with, departmental priorities and policies. The procedure is providing program and project managers with a powerful and useful tool to enhance the quality of decision-making for contaminated sites.

Building on the success and the lessons learned from the initial application of the procedure, the risk registers for the nine mine sites will be updated and the procedure will be applied to other sites in the program.

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