Faro Mine Closure,

Assessing the Alternatives

An Application of Multi-Attribute Utility Analysis

Final Report of the Faro Closure Core Assessment Team

Submitted to

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Overview

An Assessment Team composed of 11 individuals with diverse backgrounds and affiliations conducted, over an 8-month period, a formal assessment of a screened list of "short-listed" closure alternatives for the Anvil Range Mining Complex, referred to here as the "Faro site." The assessment, which utilized previous-developed information but was driven largely by estimates and assumptions (judgments) provided by Team members, compared the costs, risks, and benefits of the alternatives.

- There are some significant differences among the alternatives, although no clear winner.
- All alternatives were estimated to do well with regard to protecting public health and safety. However, significant risks were estimated for achieving some other objectives, including protecting the environment and avoiding limitations on land use.
- In general, lower-cost alternatives were estimated to most likely perform as well or better than more expensive alternatives, with respect to most objectives. However, lower-cost alternatives were also estimated to carry more downside risk (low-probability potential for poor to very poor performance).
- An aggregated performance metric based the standard, quantitative definition of risk (probability times consequence) that aggregated performance estimates across objectives consistently ranked the lowest-cost alternative highest across a range of weights provided by Team members.
- For nearly all objectives, the incremental benefits of higher cost alternatives were estimated to be, at most, small relative to the benefits available from the lowest-cost alternative. Long-term traditional land use was the only objective for which spending more was estimated to produce a significant increase in benefit (compared to the benefits of the least-cost alternative).

Because the assessment results are a product of the specific judgments provided by the individuals involved, a team composed of different individuals could reach different conclusions even if they used the same assessment methodology.

Background

By late 2006, development of a long-term closure strategy for the Faro site had reached a stage in which the range of technical solutions had been narrowed to a short list of alternatives for addressing key areas of the site:

- One alternative for the Faro Mine Area, the key element of which is to up-grade the Faro Creek diversion;

- Three alternatives for the Rose Creek Tailings area, specified as: (1) stabilize the tailings in the valley and cap with a dry-cover; (2) completely relocate the tailings to the Faro Pit; and (3) partially relocate the tailings to the Faro Pit; and

- Two alternatives for the Vangorda/Grum area, specified as: (1) backfill Vangorda Pit waste rock; and (2) stabilize the waste rock in place and cap with a dry-cover.

An "Assessment Team" was formed and directed to develop and apply a formal method, or "tool," for evaluating and comparing these short-listed alternatives. The purpose of the Team's analysis was NOT to provide "the answer," as the assessment of alternatives will ultimately involve many participants, including but not limited to several Federal and Yukon government departments and the Selkirk and Kaska First Nations. Instead, the purpose of the Team's assessment was to (1) illustrate and test a formal method for evaluating alternatives and (2) provide (through the application of that method) information potentially useful for the decision making process.

The Team conducted its assessment from May through December, 2007. Table 1 identifies the Assessment Team, which included participants from the federal and Yukon governments, the Selkirk and Kaska First Nations and their technical advisors, the project technical advisory team, and the Independent Peer Review Panel.

Table 1: Assessment Team Members

Dan Cornett
Malcolm Foy
Daryl Hockley
R. Anthony Hodge (co-facilitator)
Randy Knapp
Ellie Marcotte
Stephen Mead
Miley W. (Lee) Merkhofer (co-facilitator)
Michael Nahir
Bill Slater
Kathlene Suza

The Assessment Team's Task

Prior to designing the assessment tool, the Team established goals for the assessment (documented in a Team Charter). Briefly, the Team agreed that the tool and application should:

- Account for all important and relevant issues and concerns.
- Apply logical, transparent (explicit) reasoning.
- Identify important commonalities and differences among the alternatives.
- Clarify the implications of different views and values.

The assessment tool designed by the Team characterizes the three components of the decision. As illustrated in Figure 1, these components are: (1) the alternatives (what you can do), (2) the objectives that drive choices and weights indicating the relative importance of those objectives (what you want), and (3) beliefs (what you know and believe about what will happen depending on the choices that are made). The outputs of the tool are a function of the assumptions input to it. Thus, the assessment can, at best, only indicate the logical implications of the aggregated judgments provided by Team members.[1]

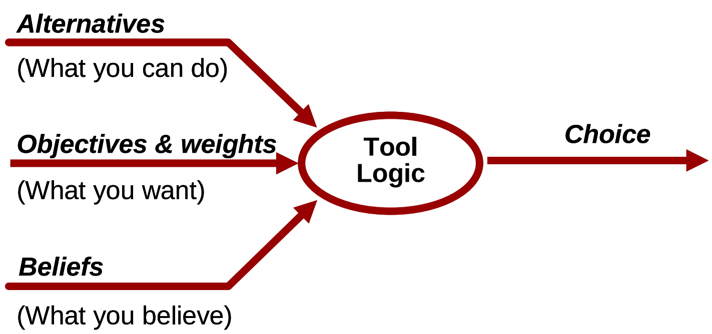

Figure 1: The tool for conducting the assessment represents the three components of the decision.

The Assessment Methodology

To construct the tool for evaluating the alternatives, the Assessment Team employed a methodology known as "multi-attribute utility analysis" (MUA). MUA was applied in a collaborative setting that enabled the different beliefs and preferences of participants to be captured and the implications explored using sensitivity analysis.

The basic steps included:

1. Characterize the alternatives (i.e., define the assumptions to be made about each alternative, including implementation strategy)
2. Define and structure the decision objectives.

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[1] An analogy is provided by the example of a team of individuals tasked with designing and applying a method for judging a sports event, such as an Olympic ice skating competition. The team would need to first agree on rules for scoring each skater's performance—they would need to decide what attributes of the performance should be scored (e.g., how fast skaters go, how smoothly they skate, how high they jump, etc.). Since each judge would need to assign his or her own scores, the team would need to determine how scores should be aggregated, including how to weight the different attributes of the performance. Regardless of the method ultimately used, at the end of the day, the team could not claim that they objectively identified the best skater in the world, the team could only say that applying their method identified one of the skaters as having the best overall evaluation. Any single judge could disagree with the final result, saying that, in his or her personal opinion, someone other than the competition winner actually skated better. However, team members should agree that the scoring rules were fair and appropriate, that scores were captured accurately, and that the final results were correctly tabulated.

3. Assess the performance of each alternative against each objective.
4. Assign weights indicating the relative importance of achieving good performance against each objective, and aggregate the performance estimates according to the weights.
5. Investigate how results change when weights are varied (sensitivity analysis).

The Alternatives—Terminology

The options evaluated by the Team are straightforward combinations of the short-listed alternatives, as summarized in Table 2. "Component alternatives" refer to the three short-listed options for Faro/Rose Creek areas plus the two short-listed options for the Vangorda/Grum areas. "Composite alternatives" refer to the six possible combinations of the component alternatives. The shorthand terms listed in Table 2 are used to reference the alternatives. Key assumptions for the assessment included assumptions for how each of the alternatives would be implemented. For example, it was assumed that the implementation of the alternatives would extend over roughly 15 years (to minimize boom-bust impacts) regardless of the alternative chosen.

Table 2: The Alternatives

Faro Mine

1. Upgrade Faro Creek Diversion

Rose Creek Tailings

1. Stabilize tailings in place, add dry cover
2. Complete relocation of tailings
3. Partial relocation of tailings

Vangorda-Grum

1. Backfill Vangorda Pit with waste rock
2. Stabilize waste rock in place

Shorthand notation:

"Component Alternatives"

Faro/Rose Creek

1. "Dry cover"
2. "Complete relocation"
3. "Partial relocation"

Vangorda/Grum

1. "Backfill pit"
2. "Stabilize in place"

"Composite Alternatives"

1. "Dry cover" plus "Backfill pit"
2. "Complete relocation" plus "Backfill pit"
3. "Partial relocation" plus "Backfill pit"
4. "Dry cover" plus "Stabilize in place"
5. "Complete relocation" plus "Stabilize in place"
6. "Partial relocation" plus "Stabilize in place"

The Objectives

Table 3 lists the objectives specified by the Team that formed the basis for evaluating the alternatives. The terms "maximize" and "minimize" are used merely to indicate direction of preference (all other things being equal); it is recognized that no single objective can be maximized or minimized in isolation from the others and that tradeoffs are necessary.

These objectives encompass all previously defined objectives while achieving technical requirements of the assessment methodology (such as the requirement that there be no overlap, which is necessary to allow the performance of alternatives against objectives to be estimated allow those estimates to be aggregated using weights).

Table 3: Objectives Defined for Assessing Performance

1. Maximize public health and safety
2. Maximize worker health and safety
3. Maximize restoration, protection and enhancement of the environment
4. Maximize local socio-economic benefits
5. Maximize Yukon socio-economic benefits
6. Minimize cost
7. Minimize restrictions on traditional land use
8. Minimize restrictions on local land use

The Assessment Process

The Team scored[2] (estimated the performance of) each alternative against each objective in each of two time frames: near term (the initial 40 years of construction and monitoring) and long term (500 to 1000 years, post-closure). Also, to account for risk, the alternatives were scored under two operating scenarios: under the assumption that the alternative would perform as designed assuming no unexpected risk events (referred to as the "normal scenario") and under "risk scenarios." Team members specified risk scenarios for each alternative and assigned probabilities to indicate how likely they judged these scenarios to be.

Scoring was conducted using zero-to-10 scoring scales, in a manner similar to some sports competitions. In general, a score of 10 designated "ideal performance" against the objective—the best that could be imagined, and a score of zero designated the worst performance that could be imagined. To make the scoring as objective as possible, detailed scales were developed for each objective to more precisely define the meaning of each score. Table 4 provides an example (for the public health and safety objective). As suggested by the bolded phrases in the sample

[2] "Scoring" is the term used by the Team to describe the process of assessing the performance of an alternative against an objective. A "score" is a number whose meaning is defined in a scale (scoring scale) associated with the objective in question.

scale, scoring scales were defined to be logarithmic—a decrease in score of 2 units was intended to approximately represent an outcome that was 10 times worse.

Table 4: Example Scoring Scale — Scale Used for Scoring Public Health and Safety Performance

Scoring Scale for Public Health & Safety	
10	Ideal performance. **No health or safety problems**. Although some might experience "psychological" effects, Western science and traditional knowledge will agree that there are no known physical mechanisms by which people could be harmed.
9	Very good performance. No exceedences of any health/safety-related standards will occur. Any illnesses that plausibly relate to the site will be **minor** and will not require medical treatment. Any injuries will be attributable to very poor judgment on the part of those harmed.
8	Good performance. Some minor violations of applicable health/safety-related standards. At worse, only a **very few moderate, temporary non-life-threatening illnesses and/or injuries** will occur—extreme lifestyle or habits will be a factor. Effects will be temporary and hospitalization will not be required..
7	Fair performance. The alternative will produce a few serious exceedences of applicable health/safety-related standards. There will be **no deaths**, but some non-life-threatening, moderately serious illnesses and/or injuries will occur. Only a small fraction of those exposed will be affected.
6	Mediocre performance. The alternative will produce moderate illnesses and injuries and a few serious injuries and/or long-term illnesses (effects lasting 5 years or more). **Small (30%) chance of a fatality,** but most likely not for anyone with average lifestyles and exercising reasonable judgment.
5	Poor performance. Significant problems. There will be numerous violations, serious injuries and/or illnesses, and **probably one fatality** to a member of the public.
4	Very poor performance. Serious problems. The alternative will result in **a few (e.g., 3) fatalities** and roughly 100 serious injuries or illnesses will occur. Not attributable to bad judgment.
3	Bad performance. Very serious problems. **Ten or more fatalities** and hundreds of serious illnesses and/or injuries.
2	Very bad performance. Major problems. The alternative will result in a **30 or more fatalities** to the public and as many as a thousand serious illnesses or injuries.
1	Terrible performance. Critical problem. **One hundred or more fatalities** and thousands of serious illnesses and injuries.
0	Abominable performance. A public health and safety disaster. The alternative will result in **300 or more fatalities** to the public.

To provide information to support the assessment, selected Team members (those viewed by Team members as having the most expertise with regard to estimating performance against specific objectives) were tasked with preparing briefing packages. Each briefing package (one for each objective) summarized relevant, previously-developed information, identified risk scenarios, and presented estimates of expected impacts. Example risk scenarios included dam breach leading to tailings release, transportation accidents, and failure to provide necessary funding leading to inadequate maintenance and subsequent containment failures. The briefing packages were intended to provide a summary of information useful for forming the opinions and judgments needed to assign scores.

Objective-by-Objective Analysis

The normal- and risk-scenario scores provided by each Team member were used to conduct a probabilistic risk analysis of the alternatives. The scores and risk scenario probabilities were combined so as to compute probability distributions describing possible levels of performance. To summarize and display performance uncertainty, the 1% ("worst case"), 10% (low), 50% (median), and 90% (high) values were derived from the distributions and used to display confidence ranges for performance. Figure 2 provides an example and illustrates how the computed performance ranges may be interpreted based on definitions of scores in the corresponding scoring scale.

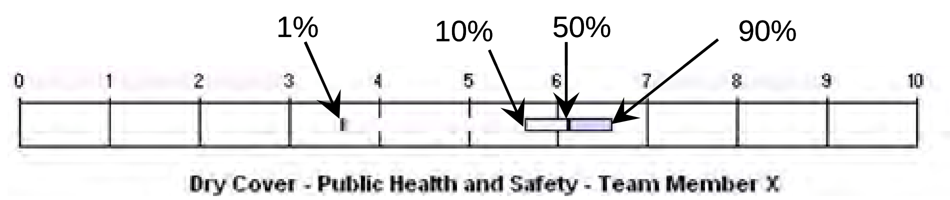


Figure 2: Sample display illustrating risk-adjusted performance ranges computed for a (hypothetical) Team member. Referring to the corresponding scoring scale (Table 4), the Team member's worst-case score (3.5) indicates a belief that there is a 1-in-100 chance that there will be between 3 and 10 fatalities and more than 100 serious injuries/illnesses if the alternative is selected.

The risk-adjusted ranges provided by individual Team members were combined into ranges that captured the differences of opinion across Team members.[3] Figure 3 provides an example of the results the objective-by-objective analysis based on Team ranges. The Team ranges were interpreted as capturing both the uncertainty associated with the potential for risk events and differences of opinion among Team members.

[3] To combine the confidence ranges provided by individual Team members into a range that encompassed nearly all Team-member scores, "Olympic scoring rules" were applied. The Team range was defined to go from the 2nd lowest worst-case score, to the 2nd lowest low score, to the 2nd highest high score. The lowest and highest scores assigned by any individuals were omitted, as in some sports scoring events, to avoid opportunities for gaming.

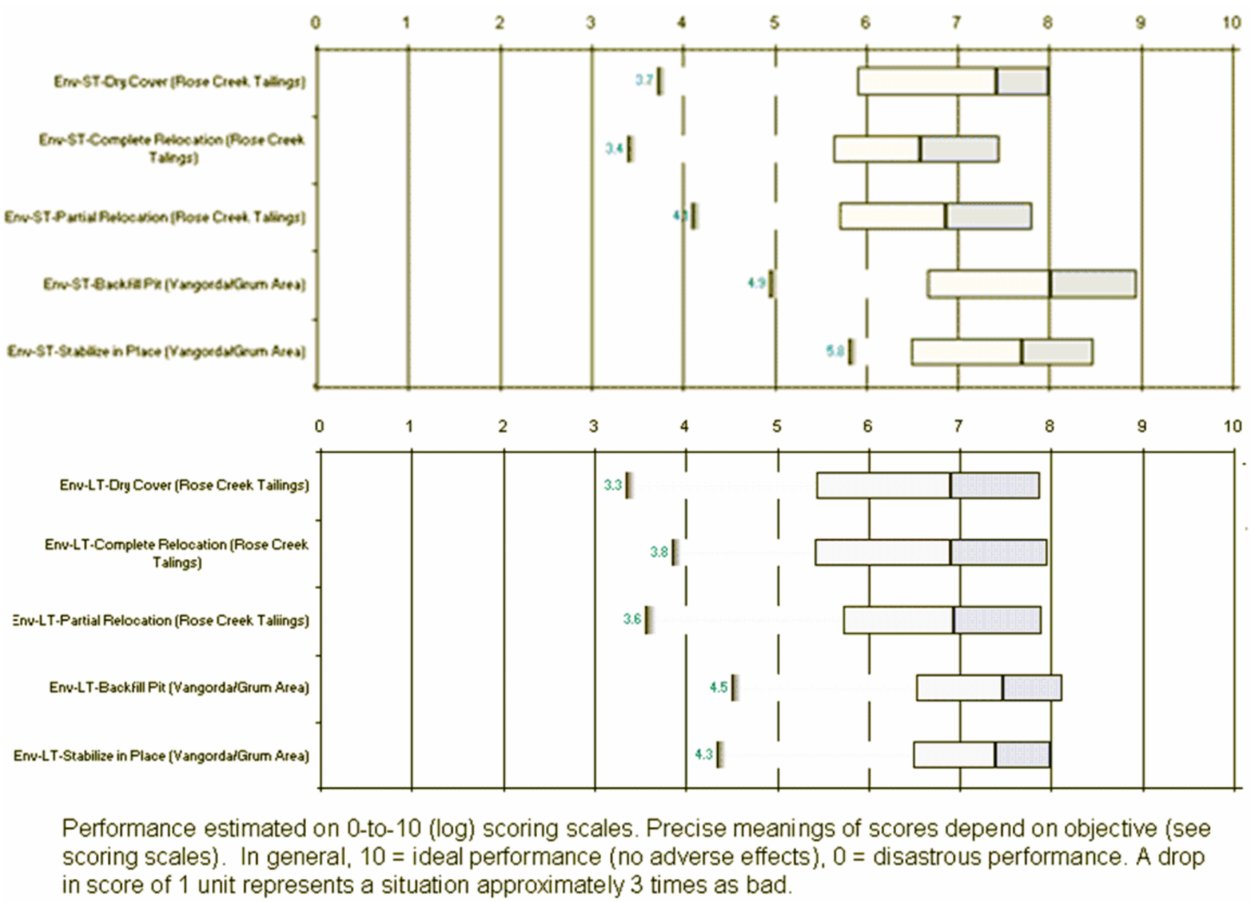


Figure 3: Sample results from the objective-by-objective analysis (environment). The location and spread of the bars indicate that "Dry cover" was estimated to have somewhat better environmental performance during the short-term, but somewhat greater downside risk in the long term.

The key conclusions from the objective-by-objective analysis include:

- The performance assessment results indicate confidence that any of the alternatives will produce fair to good performance protecting public health and safety.
- The results suggest less optimism with regard to performance against worker health & safety, environment, traditional land use and local land use objectives. Here, assessments ranged down to scores suggesting poor and very poor performance.
- For the Faro Mine/Rose Creek Tailings area, over the short term, "Dry cover," was estimated to perform slightly or somewhat better than other alternatives on six of eight objectives. However, in the long-term, "Dry cover" was estimated to pose more down-side risk with regard to the environment, restrictions on traditional land use, and long-term costs.
- For the Vangorda/Grum area, performance estimates tended to be better and closer than for Rose Creek tailings alternatives.

- “Backfill pit” was estimated to most likely perform slightly better in the short term on environment, traditional land use, and local land use; and, during the long term, on environment, traditional land use, local land use, and cost.
- “Stabilize in place” was estimated to most likely perform slightly better in the short term on cost and worker risk.

Aggregated Analysis

The individual objective-by-objective assessments were combined using weights provided by Team members to obtain aggregate measures of performance in the short-term and long-term periods, and overall. In order to aggregate the assessments, it was first necessary to convert the performance scores (expressed on log scales) into measures of performance expressed on a linear scale. The conversion used resulted in performance being expressed on a zero-to-100 scale, where a value of 100 corresponds to scores of 10 (ideal) on all objectives and a value of 0 corresponds to scores of 3 (bad) on all objectives.

Figure 4 shows the short-term and long-term results, using the weights obtained by averaging the weights assigned by each Team member. As indicated, aggregation by time period shows short- and long-term performance tend to compete (alternatives with better short-term performance tend to have poorer long term-performance, and vice versa).

The key conclusions from the aggregated analysis were as follows. For weights representing a range of Team member views:

- Overall performance for the alternatives was estimated to be very close (no clear “winner”).
    - Better performance on some objectives is balanced by poorer performance on others.
    - Better performance in the short-term is balanced by poorer performance in the long-term.
    - Better expected performance is balanced by greater downside risk.
- “Dry cover” was consistently ranked (in terms of probability-weighted performance across all objectives) slightly higher than “Complete relocation” or “Partial relocation.” However, “Dry-cover” was estimated to pose more downside risk.
- “Stabilize in place” was estimated to pose somewhat more risk, but was estimated to most likely perform just slightly better than “Backfill pit.”

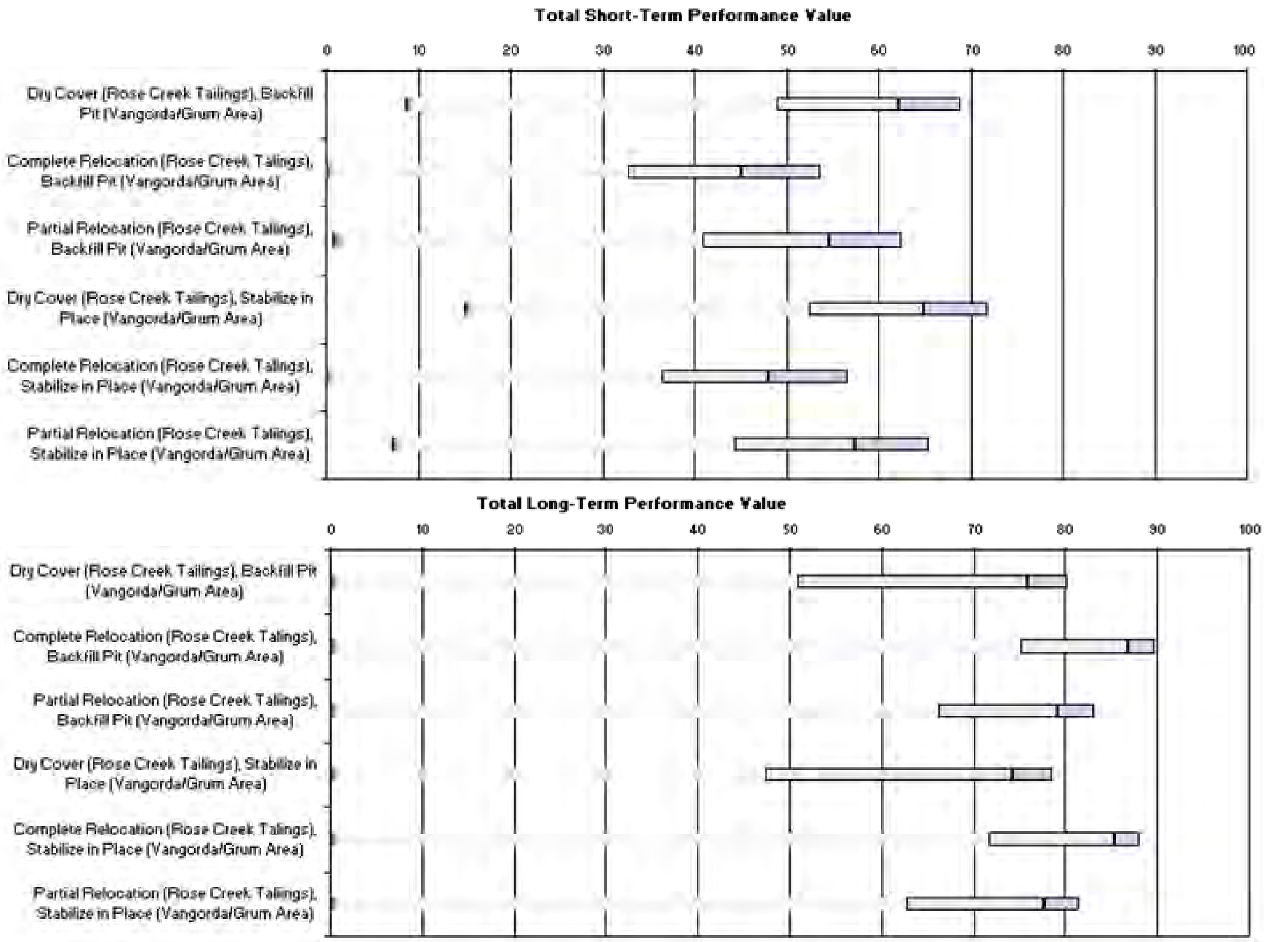
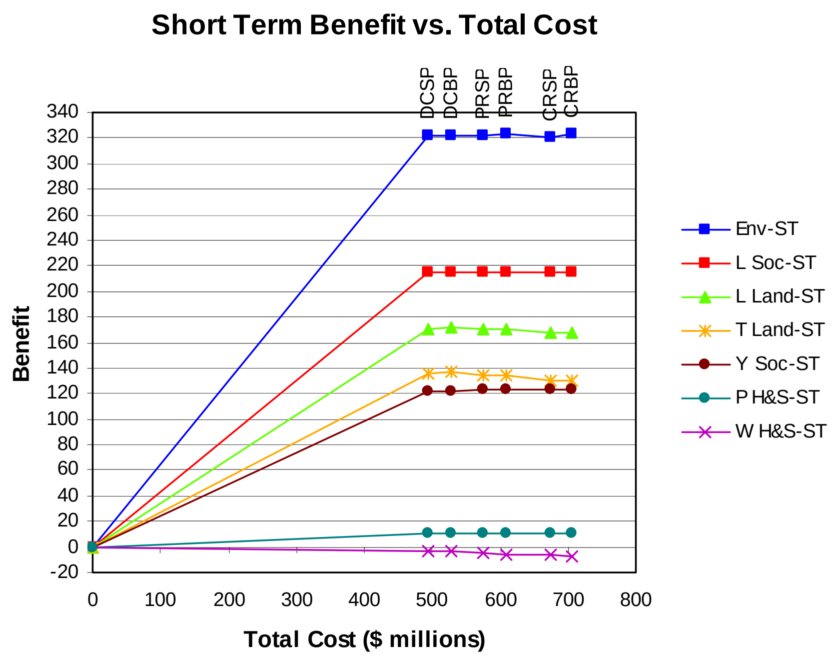
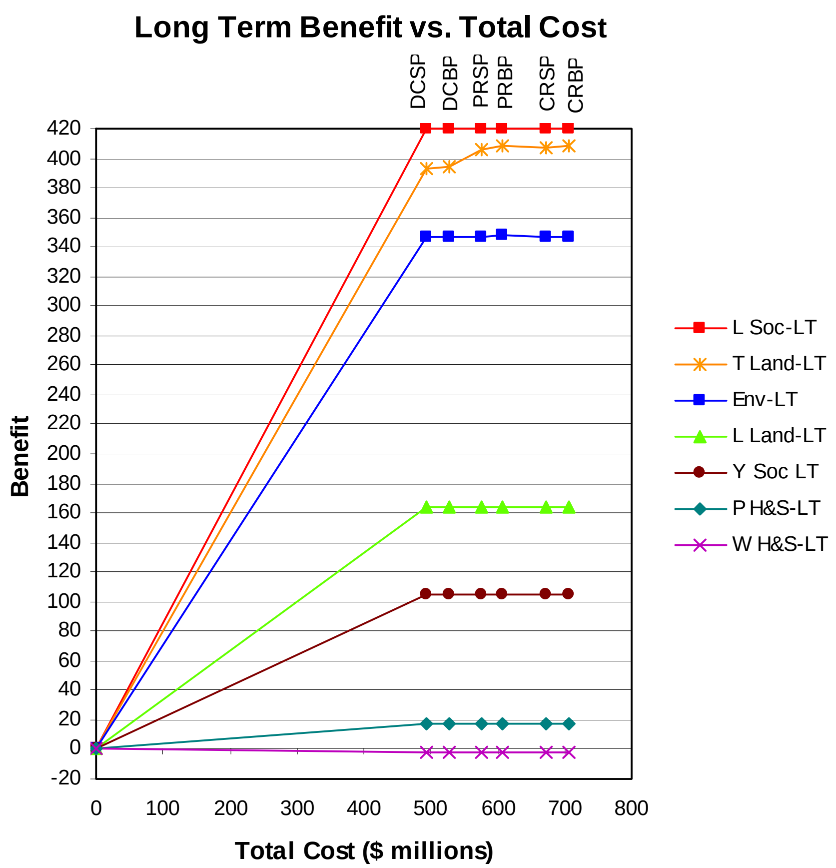


Figure 4: Aggregated performance estimates for the short- and long-term time periods.

Benefit-Cost Analysis

Benefits were defined as the difference between the level of performance estimated for the alternative and the level of performance assuming nothing was done (a hypothetical “do-nothing” alternative). Benefits were computed objective-by-objective (e.g., public health and safety benefit, environmental benefit, etc.). Figure 5 provides results for the short- and long-term periods. Each benefit is expressed on the same linear scale calibrated such that a swing of 300 points approximately corresponds to the difference in value between “very bad” and “ideal” performance, as defined on the corresponding scoring scales.





DCSP = Dry Cover (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)

DCBP = Dry Cover (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)

PRSP = Partial Relocation (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)

PRBP = Partial Relocation (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)

CRSP = Complete Relocation (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)

CRBP = Complete Relocation (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)

Figure 5. Benefits versus costs.

The key conclusions from the benefit-cost analysis include:

- Ignoring weights, the benefits available from the alternatives appear to be mainly in the areas of the environment, local and traditional land use, and local socio-economics.
- For nearly all of the objectives, spending more than the least-cost alternative does not produce significant benefit increase (compared to the amount of benefit available from the least-cost alternative).
- Only in the case of long-term traditional land use is increased spending estimated to produce significant benefit gain (compared to the benefits of the least-cost alternative).

Inferences and Insights for Moving Ahead

Finding ways to mitigate perceived risks appears important to building consensus:

- The scores assigned by the members of the Assessment Team imply that many Team members perceive significant risks regardless of which alternatives are selected, particularly with regard to the environment and traditional and local land use.
- The perceived risks derive from the risk scenarios identified by the Team, the probabilities assigned to these scenarios, and the degree to which such scenarios are perceived to degrade ability to achieve objectives.
- Given the lack of a clearly superior alternative and the perceived riskiness of all of the options, not to mention the high costs involved, it is not surprising that the choice among Faro alternatives has been contentious.

Actions potentially useful for reducing perceived risks and building confidence and consensus include (1) the design of an effective and confidence-inspiring implementation plan; (2) resolution of risks associated with the lack of financial surety and exploration of permanent funding mechanisms; and (3) the design and implementation of the adaptive management regime for the full life-cycle of the closure project.

Limitations

Limitations of the assessment include the dependence of the estimates on implementation assumptions and the inherent difficulty of the judgments required. In particular, there is tremendous uncertainty regarding technological and other changes that might occur over the next hundreds of years. The Team did not have the benefit of alternative futures analyses and other aids that might have enabled better “out of the box” thinking relevant to the assessment.

Certain potentially important considerations were identified by the Assessment Team that were deliberately not included within the assessment, due to the lack of sufficient information or understanding. These include the impact of the choice on future mining in the vicinity of the site and the impact of the choice on the potential for reprocessing of the tailings.

Finally, as noted previously, the assessment results are product of the collective, aggregated judgments provided by the specific individuals who participated. Individual Team members may not personally agree with conclusions. A group composed of different individuals could well provide different scores and weights, which could lead to different results.

Chapter 1. Introduction

1.1 Background

By late 2006, development of a long-term closure strategy for the Anvil Range Mining Complex (referred to in this document as the "Faro site") had reached a stage in which the range of technical closure alternatives being considered had been significantly narrowed. At that time, the remaining alternatives were subject to review by an Independent Peer Review Panel (IPRP) which reported out in March 2007 (IPRP, 2007). As a result of the IPRP work and subsequent work by SRK Consultants (Canada) Inc., the project engineers, the technical closure alternatives were reduced to short-list that included in summary terms:

- **one alternative for the Faro Mine Area**, the key element of which is to up-grade the Faro Creek diversion;
- **three alternatives for the Rose Creek Tailings area** including: (1) stabilize the tailings in the valley and cap with a dry-cover; (2) completely relocate the tailings to the Faro Pit; and (3) partially relocate the tailings to the Faro Pit; and
- **two alternatives for the Vangorda/Grum area** including: (1) backfill Vangorda Pit waste rock; and (2) stabilize the waste rock in place and cap with a dry-cover.

The next step required assessing which alternatives or combination of alternatives best achieved the multiple objectives at play. The preferred way to accomplish this is to work collaboratively with all interests using a rigorous methodology that would produce a thoroughly defensible result. Such an assessment would contribute to building consensus and provide a strong foundation to guide development of the needed closure strategy. In turn, the closure strategy, subject to federal government decision, will be submitted to the Yukon regulatory review process. An overarching desire is to generate confidence among citizens in general and decision-makers in particular who will be committing something between $500 million and $1billion of public funds to this project.

1.2 Closure Strategy

In general terms, the closure strategy to be developed must:

1. incorporate a design time horizon of at least 500 – 1000 years;
2. respect a number of closure objectives, some of which may be competing;
3. draw from a number of possible technical alternatives that could be applied;
4. include an overarching management component that will address issues common to all technical alternatives, in particular, the surety of required resources - financial, technical, human – and the transfer of knowledge across generations; and
5. manage the significant degrees of uncertainty and risk that will continue to exist, regardless of the path chosen.

1.3 Purpose of the Assessment and Purpose of the Report

The main purpose of the effort described by this report was to design and test a means of assessing which of the closure alternatives would best meet closure objectives. The results of the assessment are intended as an input to development of the closure strategy.

Following review of various possible assessment methodologies, the Faro Closure Oversight Committee opted for the use of a methodology known as “multi-attribute utility analysis.” This same methodology had been recommended by the Independent Peer Review Panel (see IPRP, 2007, p. xiv).

Formal assessment methodologies that evaluate alternatives based on the achievement of multiple objectives are known as “multi-criteria” methodologies. Multi attribute utility analysis is widely recognized as one of the most effective of such multi-criteria techniques, particularly for collaborative applications involving multiple interested parties each of whom may reflect different perspectives and values.

The purpose of this report is to document the assumptions, inputs, and results of the assessment, both in terms of process and substance.

1.4 Assessment Process and Methodology

The project described here was initiated in early spring, 2007. An eleven-person Assessment Team was convened for the first time on May 9 – 11, 2007. During the following seven months, the Team designed, tested, and applied the assessment methodology. Community input was sought along the way. Chapter 2 provides a full description of the project Terms of Reference and the Charter that the Assessment Team created to guide its work. Project organization, Principles of Participation and the overall project time line are provided in Chapter 3. Chapter 4 provides an overview of the methodology.

The performance of the various alternatives was assessed against eight objectives. The evolution of the closure objectives is documented in Chapter 5, the short list of closure alternatives subject to the assessment are summarized in Chapter 6, and the various assumptions anchored in the Implementation Strategy and important to the assessment are listed in Chapter 7.

The assessment involved a process of estimating the ability of alternatives to achieve objectives. Doing so required the development of a performance scale for each objective to serve as a basis for measuring how well an alternative performs for that objective. The performance of each alternative was assessed for both normal operating conditions and under various less likely but potentially significant risk scenarios. In addition, two time periods of analysis were employed, a short-term period consisting of the initial 40 years of operations (15 years of construction and 25 years of monitoring and adjustment) and a long term time period extended out to 500 to 1000 years. The details of the performance assessment process are provided in Chapter 8.

1.5 Assessment Results

Three sets of results emerged:

1. **An objective-by-objective assessment** of each alternative. The objective-by-objective results do not involve aggregating performance estimates against different objectives. The results of this part of the assessment are reported in Chapter 9.
2. **An aggregation of the objective-by-objective results plus a sensitivity analysis** that varies the weights in the aggregation equation. The results of this part of the assessment are reported in Chapter 10.
3. **A benefit-cost analysis**, in this case also undertaken on an objective-by-objective format. The results of this part of the assessment are reported in Chapter 11.

Insights from all three of the above are brought together in Chapter 12. These insights are intended as input to the decision-making process. They do not provide, nor are they intended to provide, a definitive choice of closure design and strategy. Also, key limitations of the assessment are discussed and some thoughts are offered on actions potentially useful for reducing perceived risks and building confidence and consensus in the path forward.

The assessment results suggest that the final decision about which combination of alternatives to proceed with may require making a choice between (a) a less expensive combination of alternatives that is perceived most likely to perform slightly better in the short term but which will pose somewhat higher risk, higher cost and slightly lower performance in the long term and (b) a more expensive combination that is perceived to most likely be slightly poorer performing in the short term but characterized by lower risk, lower cost and slightly better performance over the long term (Figure 1.1 below).

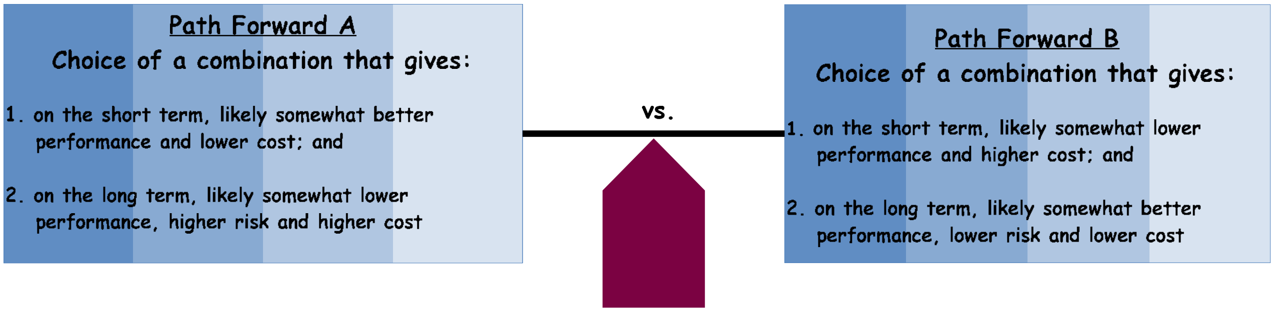


Figure 1.1. The choice ahead.

However, a more overarching conclusion is that the best path forward may be yet to emerge – and may result from a strategy that combines elements of current thinking in a way that improves performance on some or all of the objectives while reducing risk. This does not imply a different technical alternative but rather an implementation strategy that more thoroughly addresses some of the issues of greatest concern to people.

Two issues in particular require priority attention. The first is the issue of financial surety. If there were greater confidence that resources to ensure ongoing implementation would be available when required, the pessimistic estimates of performance under various risk scenarios might be ameliorated.

Second, it is clear that there remain significant unknowns about technical performance in the long term. Experience at design and implementation of engineered systems with time horizons of hundreds of years is only now accumulating. Although technical research can enhance understanding and is needed to do so, there will inevitably be surprises within the hundreds of years that this system will be in place. Therefore, an important way to build confidence in system performance is to design, implement, monitor, and adjust to the inevitability of changing and unexpected conditions. This is the heart of the adaptive management approach that has been committed to for the project but remains to be fully defined.

The following Chapters describe the process that began with the initial meeting in early May and brought us to the above conclusions seven months later.

Reference

IPRP, 2007. Final Report of the Independent Peer Review Panel. Review of Remediation Alternatives for the Anvil Range Mine Complex, Final Report. March 2007. .

Chapter 2. Project Terms of Reference

2.0 Introduction

This Chapter sets out the two components that together comprise the project Terms of Reference: the project objectives and the Team Charter. The former is drawn from the formal contract that governed the project and the later was generated by the Assessment Team.

2.1 Project Objectives

The proposed assessment process was designed to achieve the following two objectives.

1. **To build trust and respect for the assessment process from key interests through effective engagement.**

   It is essential that the assessment process is trusted and respected by the various interests involved in the decision. Thus it is important to involve the interests in a way that is effective and appropriate. These interests include:

   - Government of Canada;
   - Government of Yukon;
   - Selkirk First Nation at Pelly Crossing;
   - Ross River Dena Council; on behalf of the Kaska Nation
   - The Town of Faro;
   - A range of other interests such as: the Yukon business community who will provide the goods and services required in implementation; the Yukon environmental community; and the mining industry within and beyond the Yukon who are watching this project in terms of the precedent that it sets.

Although it may be impossible to fully involve are parties or achieve full consensus over a preferred approach to Faro, the evaluation process should promote agreement and consensus, not disagreement and distrust.

2. **To build a strong technical basis for the Federal Treasury Board Submission**.

   The methodology and its application must be defensible and produce accurate conclusions in order to provide the necessary strong foundation for the Federal Treasury Board submission required for confirmation of project funding.

   - <u>Defensibility.</u> The evaluation process must be such that if, at the conclusion of the effort, independent experts in the relevant methodologies were to conduct a peer review of the evaluation process, those experts would conclude that the steps taken were appropriate and applied in accordance with best practice.

   - <u>Accuracy</u>. The evaluation process should produce accurate results. Using a defensible approach will help ensure accuracy, but not guarantee it. Accuracy requires that the evaluation properly account for all important and relevant considerations. A defensible approach that leaves out important considerations or points of view gives, at best, the right answer to the wrong question. No decision model can capture everything, but an effective model will correctly address all of those considerations that are critical to identifying the preferred alternative.

2.2 Team Charter

Drawing on the above, the Assessment Team developed the following Charter to guide its work.

Faro Core Assessment Team Charter

Closure planning for the Faro Mine has been built on a foundation of mutual trust and respect. Building on this foundation, we will develop a tool for assessing options that will take into account information and inputs from all interested parties, apply that tool using our best judgments, and effectively convey the tool and the results of the assessment to others. We will:

1. Identify important commonalities and differences amongst the options.
2. Account for all important issues and concerns.
3. Document (and make publicly available) and communicate to interested parties relevant context, assumptions, judgments, opinions, and reasoning (be transparent).
4. Obtain feedback on what is important to stakeholders using a collaborative process that provides opportunities for external parties to review, comment on, and participate in the assessment.
5. Use sensitivity analysis (and other techniques) to understand the implications of differences in the views held by different people/groups.
6. Take full account of all values, particularly those of communities and First Nations.

The outputs will provide a rigorous basis for the decision makers.

Chapter 3. Project Organization, Principles of Participation, Time Line and Activities

3.1 Project Organization

The project was organized to promote information flows related to community involvement (the communities of Ross River, Pelly Crossing and the Town of Faro) and the decision making process. This is shown schematically in Figure 3.1.

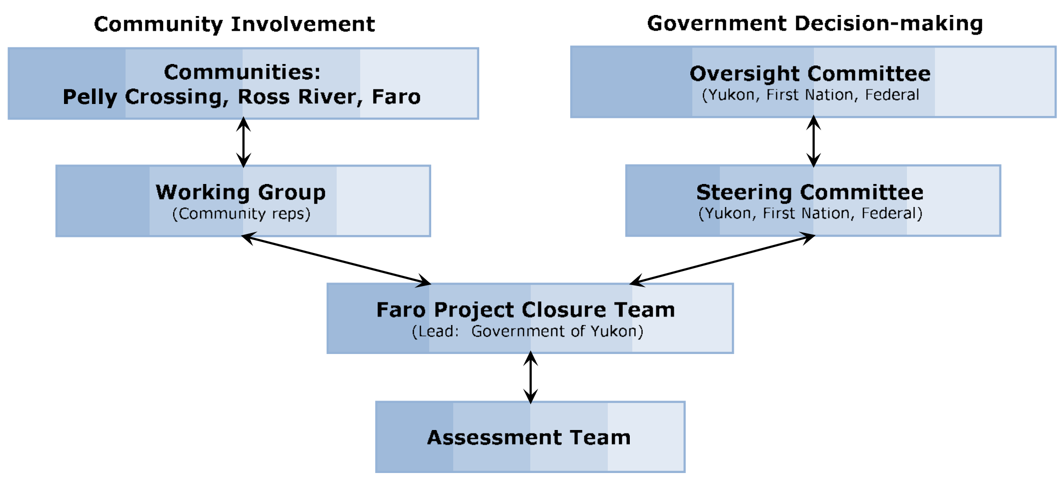


Figure 3.1.   Project information flows: (1) in support of community involvement; and (2) in support of government decision-making.

Responsibility for managing these information flows rests with the Faro Project Closure Team housed in the Assessment and Abandoned Mines Branch of the Yukon Department of Energy Mines and Resources.

3.2 Assessment Team Membership

The Assessment Team included the following eleven individuals:

Dan Cornett
Malcolm Foy
Daryl Hockley
R. Anthony Hodge (co-facilitator)
Randy Knapp
Ellie Marcotte
Stephen Mead
Miley W. (Lee) Merkhofer (co-facilitator)
Michael Nahir
Bill Slater
Kathlene Suza

Short biographies of each of the Team Members is provided in Appendix 1.

3.3 Principles of Participation

The Assessment Team agreed on a set of "principles of participation," shown in Table 3.1, that served as a protocol to govern the project.

Table 3.1. Principles of Participation

It is the intent of the Assessment Team to:

1. share experience and learn from dialogue among participants;
2. understand and respect the diversity of perspectives brought to the table;
3. build working relationships; and
4. identify areas of common ground, of differences and the various underlying reasons.

Participation

Participants in the Assessment Team have been selected to reflect a range of values, interests, and experience and to share these with other participants. There is no expectation that participants will report back to or seek approval from any organization of interest. Rather, the assessment process is designed to include a three-tiered engagement process that includes the Assessment Team, a broader Working Group, and the three communities themselves: Pelly Crossing, Faro, and Ross River.

Ultimately, the Government of Canada will make a decision about what closure strategy will be adopted for moving forward through the regulatory process. The assessment process we are now embarking on is intended to generate the best possible foundation as input to that decision. However, participation in the Assessment Team is not to be seen as an endorsement by any participant of any decision-making on the part of the Governments of Canada or Yukon.

Reports

Reports will be prepared and distributed to the Assessment Team for review before being finalized. The report will include a list of participants as well as these Principles of Participation. No specific attribution of any comment made by any participant will be referenced in the reports unless specifically requested by a participant.

3.4 Time Line and Activities Description

Project implementation followed the time line shown below in Figure 3.2.

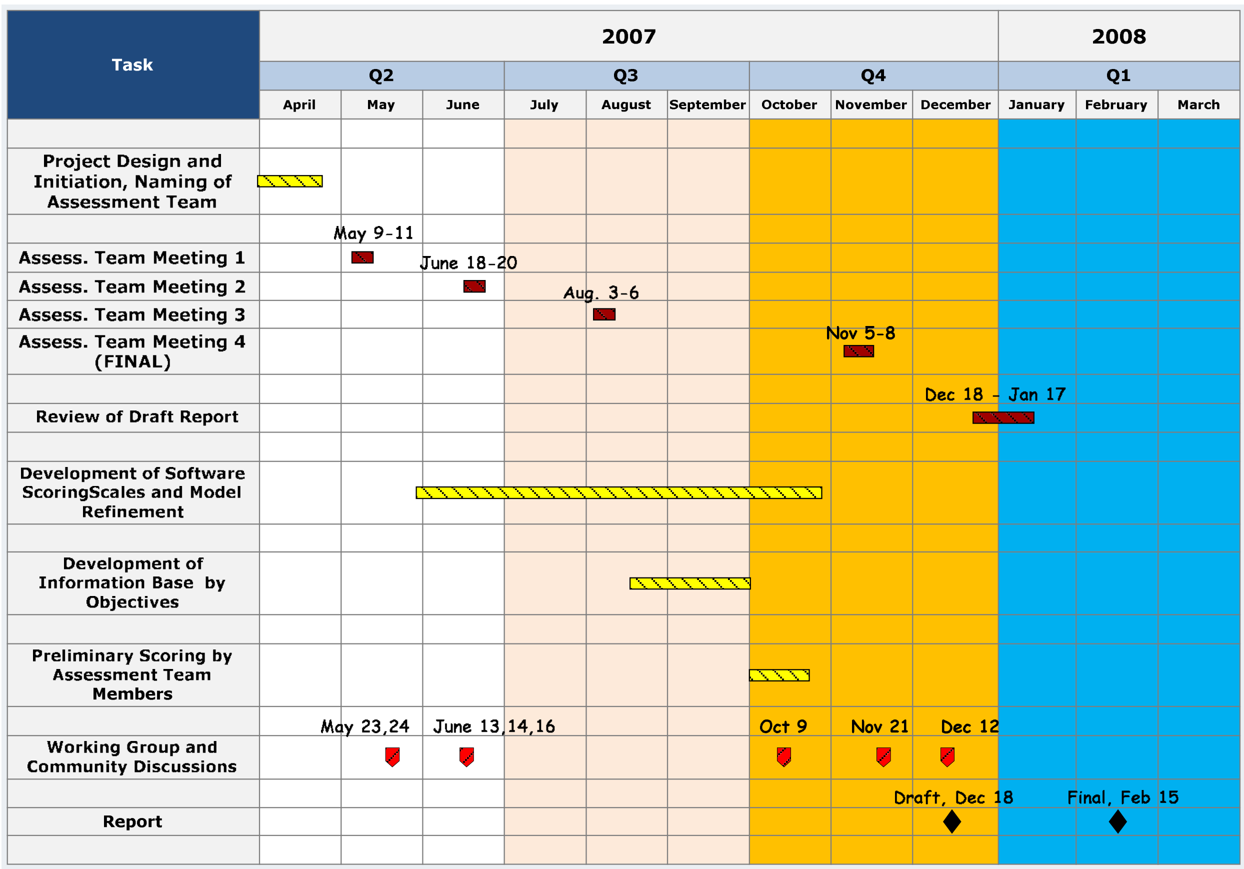


Figure 3.2. Project time line.

The following provides a more detailed description of the various activities undertaken at the Assessment Team meetings.

Meeting 1, August 9, 10, and 11, Boardroom, SRK Consulting (Canada) Inc., , Vancouver

- Introduction to the initiative; initiative objectives
- Process: principles of participation; project timeline; project organization – roles and responsibilities; Team Charter
- Methodology: overview, steps, roadmap
- Assessment Objectives; the Objectives Hierarchy
- Closure alternatives and combinations

- Factors influencing performance – influence diagrams, test with examples for Public Health and Safety, Environment, and Traditional Land Use
- Preparations for meetings: Working Group, Steering Committee, Oversight Committee

Meeting 2. June 18, 19, and 20, Boardroom, SRK Consulting (Canada) Inc., Vancouver

- Process review, revisit roadmap and Team Charter
- Community feed-back
- Establish short- and long-term time frames
- Review by each of the eight objectives: influencing factors (complete influence diagrams), drivers, risk scenarios, review of information base, gap analysis
- Initiate background information gathering:
  - Cultural implications of off-normal risk scenarios
  - Worker risks
  - Off-site environmental consequences associated with off-site transportation, lime production, energy sources for the various alternatives,
  - Metrics and simple logic for estimating impacts of alternatives on local social well-being, confidence, trust in future, etc.
  - Provide traffic statistics, mine safety, other stats relevant to assessment public and worker risks under "normal" scenario
  - Work on alternative implementation strategies that would smooth peaks and valleys in employment levels and thereby offer more effective socio-economic implications to local communities and Yukon in general
  - Significance of the impacted area relative to other opportunities for traditional land use
  - Implications of dam failure
  - Descriptions of Alternatives

Pre-Meeting 3 Preparation

- Software development

Meeting 3, August 3, 4, and 5; Dunsmuir Lodge, University of Victoria, Sidney B.C.

- Process review, revisit roadmap and Team Charter
- Review of Alternatives and their description
- Review work on the "pace" of development and the decision to use a 15 year common construction period for each alternative
- Objective-by-objective simulation and test run of the assessment process and software: review of influencing factors, normal operating conditions, risk scenarios, data/information base
- Review of data needs and who will compile data and information for each assessment by objective and prepare a "briefing note" for the team
- Definition of the "do-nothing" reference alternative for facilitating the benefit-cost analysis

- Re-design initiative time line based on adjusted set of activities

Pre-final Meeting Preparation

- Software refinement and testing
- Preparation and distribution of briefing notes for the assessment under each objective
- Pre-meeting scoring by each Assessment team member

Final Meeting, November 5, 6, 7, 8, and 9, SFU Centre for Dialogue, Vancouver

- Process review, revisit roadmap and Team Charter
- Scoring of performance for eight objectives – short and long time horizons, under normal operating conditions and risk scenarios
- Assignment of probabilities for risk scenarios
- Discussion of the re-processing issue, decision taken to remove its consideration from the assessment process on the basis of advice from SRK Consulting Inc.
- Aggregation of results, weighting of objectives and sensitivity analysis
- Preliminary discussion of results

Review of Draft Report and Final Submission

- Draft report submitted December 18, 2007
- Assessment Team reviewed report and then met on January 17, 2008 to discuss with the authors
- Results were presented to the Oversight Committee on January 27, 2008
- Final report submitted February 15, 2008

Chapter 4. Summary of the Methodology

4.1 What is an Assessment Methodology?

Formal, assessment methodologies are methods of analysis used to help people and organizations understand and solve difficult problems. Like other forms of analysis, an assessment methodology is based on a strategy of decomposition. The complex, real world problem is split into component pieces, and the individual components are analyzed and addressed separately. Understanding the components and their relationships as a first step is often easier than initially trying to grapple with the problem as a whole. Logic can then be used to synthesize conclusions based on an understanding of the individual components and how they relate to one anther.

Decision analysis is an assessment methodology for aiding decision makers faced with complex decisions. According to decision analysis, there are three basic components to a decision: (Figure 4.1): (1) what you can do (your alternatives), (2) what you want (your objectives) and (3) what you know and believe (about how well each alternative will achieve each objective). A good decision is one that is logically consistent with these components; that is, it is the choice that you believe will best achieve your objectives.

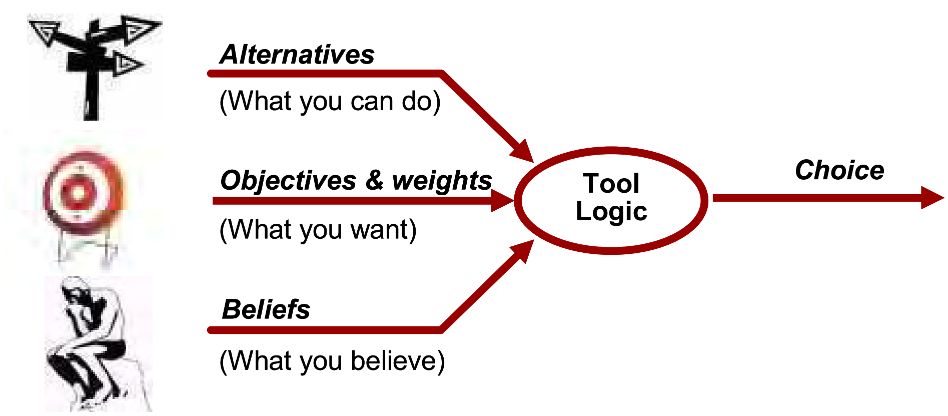


Figure 4.1: Three components of decision-making.

Even if people agree on the alternatives that are available for a decision, they may disagree on the preferred alternative because they have different objectives (or because they want to weight the objectives differently). Likewise, people may disagree because they have different beliefs about how well the various alternatives would perform against objectives. An assessment methodology for decision making provides a framework that allows decision makers and others to explore, in a transparent way, the implications for the choice of making different assumptions about what is desired and what may happen.

The goal of the assessment methodology described here was to assist the Assessment Team in documenting its beliefs and preferences and to investigate the implications of those judgments for selecting alternatives for addressing the Faro site.

4.2 Multi-Attribute Utility Analysis

Multi-attribute utility analysis (MUA), also called multi-criteria decision analysis, is a formal assessment methodology intended for decision situations wherein there are multiple (rather than only a single) decision objectives. MUA provides a way to create and compute a single measure of how well an alternative performs against multiple objectives. In other words, it provides a means for combining different measures of performance defined against different objectives (i.e., a way of combining "apples and oranges").

Faro closure is a decision situation of this type because there are multiple objectives that must be achieved in order to fully resolve the problems of the Faro site (objectives—see Chapter 5—include, for example, protecting public health and safety, protecting and restoring the environment, and ensuring continuing opportunities for traditional land use).

Because MUA allows estimates of performance against different objectives to be aggregated, it provides a way of comparing alternatives in the common situation wherein none of the available alternatives is superior to the others with regard to every objective. With MUA, it is necessary not only to identify the multiple objectives that the choice should achieve, it is also necessary to express one's willingness to trade-off achievement of the objectives against one another (i.e., to provide inputs that indicate the relative importance of achieving each of the various objectives).

Many books and professional papers have been written on the topic of MUA[1], and there have been many applications of MUA to support choices for a wide variety of decision problems, in Canada, Great Britain, the United States, and in many other countries. For example, MUA has been used to help make decisions related to railways,[2] land use planning,[3] computer networking strategy,[4] energy,[5] and choosing sites for hazardous facilities.[6]

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[1] See, for example, Keeney, R.L. and Raiffa, H. (1976), *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*, Wiley, New York.
[2] Bana e Costa, C., Nunes da Silva, F. and Vansnick, J.-C. (2000), "Conflict Dissolution in the Public Sector: A case Study," *European Journal of Operational Research*.
[3] Beinat, E. and Nijkamp, P. (eds.) (1998), *Multi-Criteria Evaluation in Land-Use Management*. Dordrecht: Kluwer Academic Publishers.
[4] Brooks, D. G. & Kirkwood, C.W. (1988), "Decision Analysis to Select a Microcomputer Networking Strategy," *Journal of the Operational Research Society*, 39, pp. 23-32.

Like other forms of analysis, MUA has limitations. Any complex, real world problem, including the Faro site, involves more considerations and dimensions than can possibly be captured in a mathematical model. Similarly, because of “unknown unknowns,” risk estimates based on analytic methods may overlook real risks. Thus, the results derived from MUA are necessarily based on an incomplete world view. At best, MUA can only hope to aid decision makers in reaching reasoned choices; it cannot be used to make the “right” choices.

A key characteristic of MUA is its emphasis on the judgments of the team the analysis is intended to serve. This is sometimes interpreted as a weakness, in the sense that applications may appear overly subjective. Judgment, however, is inherent in most important decisions, and this is especially so in the case of choosing a closure strategy for Faro. The fact that MUA makes those judgments open and explicit is an advantage. Since the judgments and assumptions are represented as a decision model, interested parties who were not involved directly in the assessment can explore whether they would make similar judgments and, if not, change the model or its inputs to see how the changes would alter conclusions.

4.3 Risk Analysis

Risk can be important to decision making when there is uncertainty regarding the consequences of making different choices. Risk occurs when there is a possibility (but not the certainty) that something undesired may happen. The amount of risk depends both on how likely it is that the undesired results will occur and on how undesirable those outcomes are.

Risk analysis is a component of a formal assessment methodology that involves characterizing and quantifying uncertainty over the consequences of choosing an alternative. In particular, risk analysis involves identifying the various outcomes to the choice that may occur and then estimating the likelihood of the possibilities by assigning probabilities.

The uncertainties that impact a decision can take a number of different forms. One distinction that is sometimes useful separates “continuous uncertainties” from “discrete uncertainties.” A continuous uncertainty occurs if a factor important to a decision can take on any value within a continuous range of possibilities. For example, the effectiveness of a cover intended to limit the amount of rain and surface water that penetrates into contaminated soil might be regarded as a continuous uncertainty, since (depending on the thickness of the cover and other factors) the percent of available water that reaches the zone of contamination might be anywhere within a range of possibilities. Conversely, the possibility of a failure of a dam that holds back contaminated water might be regarded as a discrete uncertainty. The uncertainty is discrete because there are only two possibilities—either the dam will fail or it will not fail.

It is important in risk analysis to address both continuous and discrete uncertainties. The methodology developed for use by the Assessment Team considers both the continuous uncertainties that may exist if a given alternative is selected (referred to as “normal operating

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[5] Hope, M, Hope, C. and Hughes, R. (1990), “ A Multi-Attribute Value Model for the Study of UK Energy Policy,” *Journal of the Operational Research Society*, 41, pp. 919-29.

[6] Merkhofer, M.W. & Keeney, R.L., “A Multiattribute Utility Analysis of Alternative Sites for the Disposal of Nuclear Waste,” *Risk Analysis*, 7(2), pp. 173-94.

uncertainties" or the "normal scenario") and the discrete risk events that might occur (referred to as "risk scenarios"). Chapter 8 describes how the Assessment Team developed risk scenarios to better understand the uncertainties associated with the performance of various alternatives.

4.4 Short- and Long-Term Time Horizons

The alternatives under consideration for the Faro site will require continuing activities (e.g., monitoring, treatment of contaminated water) at the site for hundreds of years. Thus, the actions that are chosen by people living in this generation will create obligations for people living in future generations, as well as potential risks to those future generations. Accordingly, the Assessment Team focused on estimating the performance of alternatives in two distinct time periods:

Period 1. **"Short Term."** The first 40 years, including a 15 year construction period and a 25 year period of monitoring and adjustment.

Period 2. **"Long Term."** The post closure period, stretching beyond the initial period out to 500 to 1000 years.

A limitation of this approach is that, while it may be reasonable to ask Team members to express objectives for selecting alternatives that are relevant to the current generation of Canadians, we cannot know with any certainty the preferences of the future generations that will be impacted by the decisions that this generation will make. Recognizing this limitation, the Assessment Team nevertheless reasoned that the objectives of future generations would likely be similar to those of current Canadians, and that an assessment that focused separately on performance in the two distinct time periods would, therefore, be useful.

4.5 Benefit-Cost Analysis

A final component of the assessment methodology is an application of benefit-cost analysis. Because resources are limited, it can be useful to compare the benefits of taking a proposed action with its costs. Traditional benefit-cost analysis seeks to express benefits in equivalent dollar values (for example, by inferring a dollar value for benefits from prices observed in the marketplace for similar benefits, or by conducting "willingness-to-pay" surveys in which people are asked how much they might be willing to pay to obtain the benefits). There is much debate about whether the dollar values assigned through such techniques accurately measure the value of benefits. Nevertheless, many organizations and governments use benefit cost analysis because decision makers believe it helps them decide whether costly actions represent efficient uses of limited funds.

Benefit-cost analysis can be useful even if benefits are not expressed in dollar terms. For example, if a non-dollar measure of project benefits can be developed (e.g., by using MUA), then it may be possible to explore whether and to what degree such a benefit measure increases if more costly actions are taken. The approach may not tell us whether a particular expenditure is "justified" based on its costs and benefits; however, it may help in other ways. For example, such reasoning may shed light on where spending more money to enhance the performance of an alternative might increase benefits. In order to obtain such insights, the assessment methodology used by the Assessment Team includes a comparison of the relationship between benefits (expressed in non-dollar units) with costs for various Faro alternatives.

4.6 Six-Step Assessment Process

The basic premise of the assessment methodology is that the best alternative for addressing the Faro site is the alternative that will best achieve objectives. The roadmap consisting of the six steps for applying this logic is shown in Figure 4.2 and described in the adjacent paragraphs.

1. Identify the available alternatives and their characteristics.
2. Specify the objectives for the decision.
3. Estimate how well each alternative would perform against each objective.
4. Assign weights to express willingness to tradeoff performance against the various objectives.
5. Combine performance estimates and weights to obtain overall measures of how well each alternative would perform and conduct sensitivity analyses.
6. Use the results as an aid to the decision-making process.

Step 1. Define and Describe the Alternatives

The first step is to identify the alternatives to be analyzed. Chapter 6 describes the alternatives and how they were characterized, and what assumptions were made for the purposes of the assessment.

Step 2. Identify and Structure the Objectives

The second step is to identify what the objectives of the decision are. Objectives answer the question, “What do you want?” In order for the process to produce reliable and defensible results, it is necessary that the objectives be defined and structured to satisfy certain requirements. For example, for the “math to work,” objectives may not be defined so that they overlap one another or “double count.” For such reasons, it was necessary to restructure objectives previously specified for Faro in order to meet the technical requirements of the assessment methodology. Chapter 5 describes the objectives and how they were structured for the assessment.

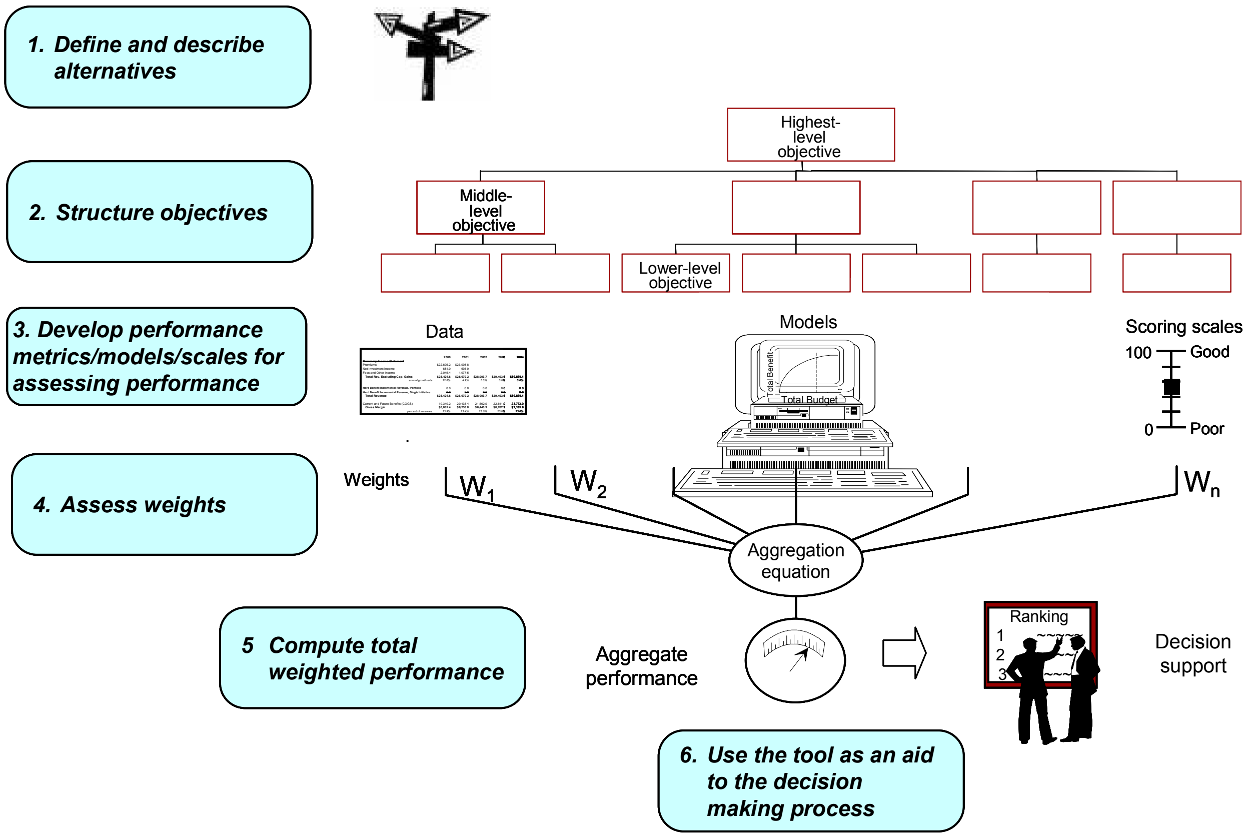

Figure 4.2: Roadmap showing the steps for applying the assessment methodology.

Step 3. Estimate Performance

Once decision objectives have been clearly identified and structured, the next step is to estimate the degree to which each available alternative would achieve each objective. In other words, for each objective and each alternative, a best-effort is made to answer the question, "How well would this alternative achieve this objective?"

To answer such questions, it is helpful to first identify the factors and characteristics of the alternatives that determine or influence how well that alternative would achieve each objective. Therefore, prior to estimating performance, the Assessment Team created "influence diagrams" that identify graphically the factors that must be considered and their relationships.

Information provides the foundation for the assessment. This includes information regarding the alternatives and information regarding factors identified in the influence diagrams. Chapter 9 provides a summary of the information used to assess performance against the objectives.

To facilitate the expression of judgments regarding the performance of each alternative, scoring scales were defined. The scoring scales (provided in Chapter 9) are zero-to-10 scales wherein each possible score describes a different level of performance, ranging from 10 ("ideal performance") to zero ("abominable performance"). Each scoring scale is specific to an objective and is based on the factors identified in the corresponding influence diagram. Thus, the influence diagrams were critical to defining the scales for the scoring of alternatives against the objectives.

Performance estimation in this case also involved comparing costs and benefits, where the benefit of an alternative was defined as the amount of improvement in the achievement of an objective that would be obtained from the alternative compared to doing nothing.

Step 4. Assign Weights

Because the Assessment Team recognized that no alternative would likely be estimated to be superior on every objective, weights were assigned to represent judgments regarding the relative importance of performing well against the various objectives. Each Team member assigned his or her own subjective weights, and the results were used to define a "base-case" or "nominal" weighting set (chosen to be the average of the weights assigned by the various Team members). In addition, the range of weights assigned by the individual Team members was used to define several additional weighting sets for use in sensitivity analysis. Chapter 10 describes this process.

Step 5. Combine the Assessments and Conduct Sensitivity Analyses

The primary usefulness of assigning weights is to explore the extent and conditions under which different value judgments would cause different alternatives to be preferred. Although the assessment methodology does not allow the different values and weights Canadians might assign to be simultaneously represented, the assessment methodology does allow for "what-if analysis" in which various alternative weights can be assigned. This may be useful, for example, to investigate the range of value judgments for which each alternative might appear superior. Chapter 10 describes the results of conducting such a sensitivity analysis to weights.

Step 6. Use Results as an Aid to Decision Making

No analysis based on a mathematical model can capture all issues relevant for decision making. Thus, it is important to recognize that decision makers must make final choices. As indicated previously, at best, an analysis such as that described here is an aid to the decision making process, not a device for making decisions.

Chapter 5. Closure Objectives

5.0 Introduction

As noted in the previous chapter, for the proper application of any multi-criteria evaluation methodology, the objectives that drive the assessment must satisfy certain technical requirements.[1] . Specifically, (among other requirements) they must be articulated in a form that:

1. Defines a clear direction of preference—each criterion must be something that we want to either maximize or minimize (all other things being equal). For example:
   - more **health and safety** for the public and workers is better than less;
   - more **environmental restoration and protection** is better than less;
   - more local and Yukon socio-economic benefits is better than less;
   - less **cost** is better than more;
   - less **limitation on traditional land use** is better than more; and
2. Result in no overlap or double counting—each criterion must represent a distinct end goal and be independent of the others. For example, the two objectives:
   - Restore the environment, and
   - Manage environmental risks

   overlap one another because it is unlikely that the environment could be completely restored if environmental risks are not well managed.
3. Be unambiguously defined and measurable (i.e., it ought to be possible, after the approach has been chosen and the mine has long been closed, to observe and measure the degree to which each of the objectives was achieved).

Any objectives that do not meet the above technical requirements must be restructured or refined to meet these requirements if they are to be used in a multi-attribute utility analysis.

[1] These requirements are described in most books on multi-criteria decision making, including Chapter 2 of R. Keeney and H. Raiffa, *Decisions with Multiple Objectives*, Wiley 1976 and Chapter 2 of C. Kirkwood, *Strategic Decision Making*, Duxbury Press, 1996.

5.1 The Objectives Approved by the Faro Oversight Committee

During the period 2004 – 2006, the then Faro Closure Office initiated a broad ranging discussion with Yukoners about closure objectives. Issues and concerns that emerged from this process for inclusion in closure objectives were compiled in the following documents:

- Faro Decision Objectives with input from the Selkirk First Nation, Ross River Dena/Kaska, Government of Yukon, Environment Canada, and the Department of Fisheries and Oceans, December 15, 2004
- Faro Decision Objectives with input from the Town of Faro, January 23, 2005
- Faro Decision Objectives with input from INAC, January 27, 2007

As a result of this work, the Faro Closure Oversight Committee approved five overarching objectives for driving the Faro Project (Objectives Approved by the Oversight Committee, July 6, 2006). These five objectives are listed below in Table 5.1.

Table 5.1 Objectives approved by the Faro Oversight Committee, July 6, 2006.

1. *To protect human health and safety;*
2. *To restore to the extent practicable the air, land, and water environments including protection of fish and wildlife;*
3. *To reclaim the land to pre-mining uses where practicable;*
4. *To maximize both local and territorial socio-economic benefits; and*
5. *To manage long term environmental and engineering risks in a cost effective manner.*

Prior to their use in a multi-criteria decision model, the objectives listed in Table 5-1 required refinement to meet the technical requirements of multi-criteria analysis, including the three noted above.

The main (though not only) problem in the articulation of objectives in Table 5.1 has to do with the use of the phrase "cost-effectiveness" in Objective 5. For the following reasons, objectives defined in terms of cost-effectiveness cannot be used directly in multi-criteria models.

- A critical requirement is that objectives are independent of each other. In this case, "effectiveness" is a concept that is defined by all the other objectives. Thus, "cost-effectiveness" is a dependent variable, not independent.
- Further, "cost-effectiveness" is a "values" question, not a technical question. Some people will believe that it is cost-effective to spend a lot to reduce risks to near zero. Others will believe that it is cost-effective to spend no more than is required to meet legally mandated risk standards. There is no way for people with such different values

to agree on the cost-effectiveness of an alternative. If asked to rate approaches on cost-effectiveness, an individual that believes very high costs are justified to reduce risk to a low value might, for example, rate a very costly and inefficient approach that produces a relatively low level of risk over a highly efficient, low cost approach that leads to a slightly higher level of risk. However, this is surely not the intent of including such an objective.

- Lastly, even presuming that meaningful performance evaluations against cost-effectiveness could be obtained, there is no meaningful way in which the objective could be weighted relative to the other objectives. If I am asked to assign a weight to "managing long-term risk in a cost-effective manner," I need to know whether the definition of "cost-effective" is consistent with how I want cost and risk traded off (in which case I might assign a high weight) or whether cost-effective is defined in a way that is very inconsistent with my risk versus cost tradeoffs (in which case I would assign a low, or even negative weight). In other words, I would need to know what weights are assigned to cost and risk before I could score or otherwise evaluate the cost-effectiveness of an alternative. [2] In short, Objective 5 in Table 5.1 cannot be used as it is articulated within any defensible multi-criteria analysis.

Failure to meet the technical requirements for the definition of objectives has important, practical implications. First, if an attempt is made to implement a methodology that fails to follow principles of good practice, participants will find the process of generating inputs difficult and frustrating, reducing the credibility of the process. Second, if, after completing the process, the resulting observations and conclusions are challenged and the methodology used to evaluate alternatives is reviewed by experts in decision analysis, they will be highly critical of the application. Third, such errors can very easily result in biases in the ranking, making it possible that the alternatives will be incorrectly ranked.

5.2 The Hierarchy of Objectives Used for the Assessment

During the afternoon of the Assessment Team's first meeting (after establishing the Team Charter) the Team agreed to use the eight objectives listed in Table 5.2 and shown graphically in Figure 5.1 (referred to as the Objectives Hierarchy) as the basis for evaluating alternatives:

[2] This suggests that one potential solution is to split Criterion 5 into two criteria, long term risk and cost. However, defining "minimizing risk" as a criterion carries its own problems.

Table 5.2 The eight closure objectives defined for use in this assessment.

1. *To maximize public health and safety*
2. *To maximize worker health and safety*
3. *To maximize restoration, protection and enhancement of the environment*
4. *To maximize local socio-economic benefits*
5. *To maximize Yukon socio-economic benefits*
6. *To minimize cost*
7. *To minimize restrictions on traditional land use*
8. *To minimize restrictions on local land use.*

The above objectives were judged to fulfill the technical requirements of multi-attribute utility analysis, including the 3 listed at the beginning of this Chapter. In addition, they ultimately facilitate an assessment of cost-effectiveness on anybody's part through a comparison of any one or more of the non-cost objectives to the success achieved on the cost objective. If such comparisons are made, the person doing so can apply her/his values to the results to reach conclusions.

In developing these objectives, care was taken to ensure that the issues and concerns identified in the community review of objectives were all covered. An analysis that shows how all the various issues and concerns are addressed in these objectives is included in Appendix 2 and a "crosswalk" which shows the relationship between the above eight objectives and the five approved by the Faro Oversight Committee in July 2006 is provided in Appendix 3.

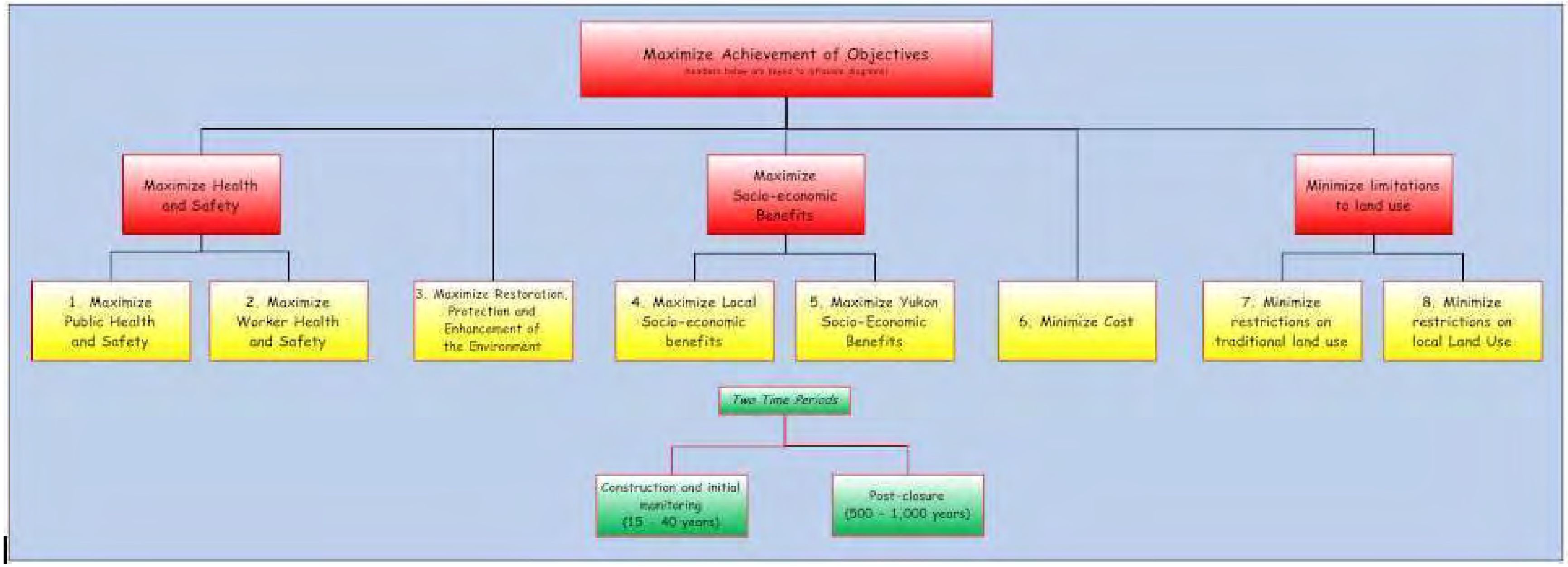

Figure 5.1. Objectives Hierarchy.

Chapter 6. The Short List of Alternatives

6.0 Introduction

The alternatives evaluated by the Assessment Team were derived from the following short-list of options:

> **Faro Mine Area**, one alternative, the key element of which is to up-grade the Faro Creek diversion;
>
> **Rose Creek Tailings area**: three alternatives, (1)stabilize the tailings in the valley and cap with a dry-cover; (2) completely relocate the tailings to the Faro Pit; and (3) partially relocate the tailings to the Faro Pit; and
>
> **Vangorda/Grum area**: two alternatives, (1) backfill Vangorda Pit with waste rock; and (2) stabilize the waste rock in place and cap with a dry-cover.

For the purposes of this assessment, the single alternative for the Faro Mine area was combined with each of the three alternatives for the Rose Creek Tailings area. In other words, the following three alternatives were assessed for the Faro/Rose Creek areas:

1. "Dry cover": Actions that include upgrade of the Faro Creek diversion plus stabilizing in place the tailings in the Rose Creek tailings area,
2. "Compete relocation": Actions that include upgrade of the Faro Creek diversion plus completely relocating the Rose Creek tailings to the Faro Pit,
3. "Partial relocation": Actions that include upgrade of the Faro Creek diversion plus partially relocating the tailings to the Faro Creak.

The following two alternatives were assessed for the Vangorda/Grum areas:

1. "Backfill pit": Actions that include backfilling the Vangorda pit with waste rock, and,
2. "Stabilize in place": Actions that include stabilizing the waste rock in place and cap with a dry cover.

6.1 The Components of the Alternatives

The following tables provide a summary description of the components of each of the alternatives considered in this assessment. Table 6.1 lists elements common to all; Table 6.2 deals with the single approach that has been accepted for the Faro Mine area; Table 6.3 describes the three alternatives remaining for the Rose Creek Tailings area; and Table 6.4 describes the two alternatives remaining for the Vangorda/Grum area. The material presented is drawn from the Description of Alternatives provided by SRK Consulting (Canada) Inc., 19 September 2007.

Table 6.1 Elements common to all alternatives

Common Element for all Alternative
1. **Covering of Waste Materials**. All remaining waste rock and tailings will be regraded and covered with soil to prevent dust release and direct uptake by animals, and to reduce infiltration. Regrading will consider aesthetic and landscape values trying to integrate the reclaimed areas into natural surroundings The selection of cover thicknesses will be based on cost-benefit analyses, with the more reactive waste areas generally receiving thicker covers. The covered areas will be revegetated, but maintenance will be required. Surface water management facilities will be required for covered areas, including channels and sediment control facilities. Channels on the cover areas will require continued maintenance over the long term.
2. **Upgrade of Diversions.** The Vangorda Creek and Faro Creek diversions will be moved to stable locations and upgraded to pass their respective 1:500 year floods. Except in the complete tailings relocation option, the Rose Creek Diversion and tailings pond will be upgraded to pass a probable maximum flood. Long-term maintenance of all remaining diversions will be required.
3. **Long-term Groundwater Collection** – Despite the soil covers, waste relocation, and surface water diversions, some water will continue to reach the waste materials and become contaminated. That water will need to be captured, probably as groundwater, and treated. Efficient groundwater capture systems will be required in all cases. In the Faro area, Rose Creek will be placed in a lined channel to maintain segregation of clean and contaminated water. With the lined channel, contaminated water that escapes the groundwater collection systems in the mine area could, if necessary, be captured downstream of the tailings, which is expected to be the best location for a highly efficient collection system.
4. **Long-term Water Treatment** – Contaminated water will be stored in the pits and then treated. Long-term water treatment will certainly be required on the Faro side of the property, and will be at least a contingency on the Vangorda/Grum side. Water treatment requires construction of new treatment plants, long-term supply of labour, power, and lime, regular maintenance and equipment replacement, and a system and location for disposing and storing sludge
5. **Adaptive Management.** The current level of knowledge of the site is at a level that is commensurate with good mine closure and environmental protection practices elsewhere in the world. However, there remain many uncertainties that no amount of additional studies will resolve. It will therefore be necessary to modify elements of any closure plan as the site matures. An “adaptive management plan” that describes uncertainties and the changes that might be needed, will be required in all cases.
6. **Ancillary Facilities, and Roads.** Unnecessary buildings and facilities will be demolished and the areas regraded, covered and revegetated. Unnecessary roads will be scarified, regraded covered and revegetated.
7. **Hydrocarbon Contaminated Soils**. Hydrocarbon contamination has been delineated on the site. The materials will be relocated to centralized land-farming facilities for remediation of hydrocarbon contamination. Depending on residual metal concentrations, remediated materials will be placed on waste rock dumps or used for cover construction.

Table 6.2 The single alternative for the Faro Mine Area

Component	Combined Alternatives 2 and 4
Faro Creek	Relocate and upgrade diversion to 1:500 year flood
North Fork Rose Creek	Remove North Fork Rock Drain and construct channel to isolate creek from contaminated groundwater
South Fork Rose Creek	If seepage escapes along North Fork and contaminated groundwater reaches South Fork, construct channel to isolate South Fork Rose Creek from contaminated groundwater. Establish monitoring program to identify need for response
Groundwater Collection	Construct and operate local collection systems at ETA, S-wells, Zone II pit and Zone II outwash. Establish monitoring programs and additional collection wells where needed in other areas.
Water Treatment	Store water in pit. Extract water for treatment in HDS treatment plant (combined with tailings area water treatment). Continue for long term.
Oxide Fines/ Low-Grade Ore	Consolidate and construct low infiltration or very low infiltration covers, or relocate to pit with lime
Sulphide Cells	Construct low or very low infiltration covers. Consolidate isolated pockets to larger cells.
Faro Valley Dump	Construct low infiltration cover.
Other Waste Rock	Re-slope and construct rudimentary cover. Include surface water runoff swales and ditches.
	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake for storage of contaminated water prior to treatment.
	Relocate tailings and construct groundwater collection system.

Table 6.3 The three alternatives for the Rose Creek Tailings Area

Component	Option 1 Stabilize in Place	Option 2 Complete Relocation	Option 3 Partial Relocation
Rose Creek Diversion	Upgrade section along Secondary Dam to Probable Maximum Flood (PMF). Upgrade remainder to 1:500 or 1:1000 year flood. Enhance fuse plug to allow floods greater than channel capacity to flow over tailings to PMF spillway.	Re-route to valley floor after tailings relocation and groundwater cleanup are complete	Upgrade section along Secondary Dam to PMF and re-route remainder to valley floor after tailings relocation and groundwater cleanup are complete
North Wall Interceptor	Upgrade and maintain	Reroute to Rose Creek after tailings relocation and groundwater cleanup are complete.	Reroute to Rose Creek after tailings relocation and groundwater cleanup are complete
Lower Guardhouse Creek	Collect and treat until water quality improves sufficiently for direct discharge.	Collect and treat until water quality improves sufficiently for direct discharge.	Collect and treat until water quality improves sufficiently for direct discharge.

Groundwater Collection	Install cutoff wall and groundwater collection system along the toe of either the Cross Valley or Intermediate Dam. Collect contaminated groundwater from tailings and any escape seepage from mine area.	After tailings are relocated, install local groundwater capture systems where aquifer is contaminated. Operate for at least 20 years. Include contingency for long-term collection of escaped mine area seepage.	Install cutoff wall and trench or drain below toe of Secondary Dam. After tailings are relocated, install local groundwater capture systems where aquifer is contaminated. Operate for at least 20 years. Include contingency for long-term collection of escaped mine area seepage.
Water Treatment	Store water in pit for seasonal treatment or treat year-round in HDS (High Density Sludge) treatment plant. Continue for long term. Provide collection - treatment upset facility downstream of collection system	Store water in pit for seasonal treatment or treat year-round in HDS treatment plant. Continue for 20 years. Include contingency for long-term treatment of escaped mine area seepage. Provide collection - treatment upset facility downstream of collection system	Store water in pit for seasonal treatment or treat year-round in HDS treatment plant. Continue for long term. Provide collection - treatment upset facility downstream of collection system
Intermediate	Regrade tailings re: surface water manageemnt Construct rock/soil cover. Armour channel where extreme floods would pass over tailings. Provide facilities for sediment control	Relocate to Faro Pit with lime addition to neutralize acidity Regrade valley and revegetate, considering aesthetic and landscape values.	Relocate to Faro Pit with lime addition Regrade valley and revegetate, considering aesthetic and landscape values
Original & Secondary			Regrade tailings re: surface water management Construct rock/soil cover Provide facilities for sediment control
Cross-Valley	Remove or breach	Remove or breach	Remove or breach
Intermediate	Expand spillway to pass PMF.	Remove or breach	Remove or breach
Secondary	Upgrade to MCE	Remove or breach	Upgrade to MCE (maximum credible earthquake)
Original	No Action	Remove or breach	No Action

Table 6.4. The two alternatives for the Vangorda/Grum Area

Component	Option 1 Backfill Vangorda Pit	Option 2 Revised Stabilize in Place
Vangorda Creek Diversion	Re-route into lined and erosion-protected channel over backfilled Vangorda Pit. Design and construct channel to pass 1:500 year flood.	Relocate upslope to stable location and upgrade to pass 1:500 year flood.
Grum Creek	Maintain diversion for long term.	Maintain diversion for long term
Groundwater Collection	Install groundwater collection system below Grum waste rock. Include contingency system to collect contaminated groundwater, if any, from backfilled Vangorda Pit.	Install groundwater collection system below Grum waste rock. Upgrade groundwater and seepage collection system below Vangorda waste rock. Include contingency system to collect escaped seepage, if any, from Vangorda waste rock pile.
Water Treatment	Use biological method to pre-treat water in Grum Pit. Discharge pre-treated water directly if contaminant concentrations are low enough. If not, periodically extract and treat water using active HDS plant and discharge to control pit water level. Provide collection/treatment upset facility downstream of collection system	Periodically extract contaminated water from Vangorda Pit and treat using active High Density Sludge plant, and discharge to control pit water level. Use biological method to pre-treat waste in Grum Pit. Discharge pre-treated water directly if contaminant concentrations are low enough. If not, periodically extract and treat using active HDS plant and discharge to control pit water level. Provide collection/treatment upset facility downstream of collection system.
Vangorda Waste Rock	Relocate to Vangorda Pit, with lime addition to neutralize acidity. Compact during deposition to minimize hydraulic conductivity and settlement.	Cover with low infiltration or very low infiltration soil cover
Grum Sulphide Cell	Cover with low infiltration or very low infiltration soil cover	Cover with low infiltration or very low infiltration soil cover
Other Grum Dump	Cover with rudimentary or low infiltration soil cover	Cover with rudimentary or low infiltration soil cover
Ore Transfer Pad	Relocate part to Vangorda Pit. Cover remainder with rudimentary soil cover.	Relocate part to Grum Sulphide Cell. Cover remainder with rudimentary soil cover
Overburden Dump	Use part for cover construction. Re-vegetate remainder.	Use part for cover construction. Re-vegetate remainder.
Haul Road	Regrade and remove stream crossings, consider future land uses, access, aesthetic values and landscape values.	Regrade and remove stream crossings, consider future land uses, access, aesthetic values and landscape values.
Vangorda Pit	Backfill with waste rock to cover all exposed highwalls.	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake for storage of contaminated water prior to treatment.
Grum Pit	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake to store and pre-treat contaminated water.	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake to store contaminated water prior to treatment.

Chapter 7. Implementation Strategy Assumptions

7.0 Introduction

As the assessment process evolved, many issues surfaced that were as dependent on the nature of the implementation strategy as they were on the choice of technical alternative. For example, one technical alternative for the Rose Creek tailings involves complete relocation of the tailings to the Faro Pit. It is the implementation strategy that defines the rate at which the relocation will take place and therefore controls the employment levels and pace of expenditures on services and supplies that will result.

Similarly, when the Faro Pit, Rose Creek Tailings and Vangorda/Grum areas are considered as a whole (as well as the linking areas between), there is considerable flexibility in when the various activities across all parts are scheduled. This scheduling needs to be done carefully to take advantage of the equipment and manpower in the most efficient possible way. But it needs to be undertaken in a manner that is consistent with the off-site socio-economic objectives of the project as well.

The issue of financial surety is of concern to many. The implementation strategy impacts this factor as well as the cost requirements of the technical alternative that is selected. Thus, what is assumed about financial surety has a dramatic effect on the assessment of performance success for any given alternative.

As a result of the critical role of the implementation strategy, a meeting was convened on August 14th, 2007 in Vancouver to define some of the key assumptions and characteristics that it will contain. The following seven individuals participated:

Dan Cornett
Malcolm Foy
Daryl Hockley
Tony Hodge
Stephen Mead
Michael Nahir
Luigi Zanasi

The meeting developed a preliminary listing of assumptions regarding closure implementation under normal operating conditions. The listing was intended to provide the assessment process with a clear specification of what to assume about how each alternative would be implemented, a foundation that was required for the assessment to proceed. Once the preferred way forward is decided upon, these assumptions will be re-visited and refined with input from a range of interests to ensure that all social, environmental, economic, and cultural factors have been considered.

The following description of Implementation Strategy assumptions is drawn from the results of the above referenced meeting (S.P. Mead, 13 Sept 07. Future Implementation Scenarios to Support Assessment Options. Unpublished Discussion Note).

7.1. Project Administration

Project administration was assumed to be made the responsibility of a distinct entity that would follow an “alternate service delivery” model such as a dedicated agency or a crown corporation. Federal, Yukon, local and First Nation orders of government would all be involved. Implementation would involve some mix of public and private sector elements. During the construction and initial adaptation phase (1-40 years) a much more sophisticated administration regime would be required than during the subsequent long term care and maintenance phase.

7.2. Financial Assurance

Costs for both site operation (including contingencies for unforeseen problems), and for project regulation and oversight were included in the consideration of financial assurance (or financial surety). Under normal operating conditions, the following assumptions were made:

1. The Devolution Transfer Agreement remains in place;
2. Federal Coordinated Sites Action Plan continues to provide resources;

3. Treasury Board Major Capital Projects Approval is obtained to provide secure funding for the 0 -15 year construction phase;
4. Federal government agrees to provide funding for long term care and maintenance; and
5. A suitable mechanism to deal with emergency funding requirements is in place.

In short, under normal operating conditions, financial surety was assumed.

7.3. Availability of Support Services

The following support services were considered: transportation, power, materials supply, and professional services. The following related assumptions were made:

1. Government will ensure that publicly-provided services are maintained over the long term.
2. Long-term project funding (see Section 7.1 above) ensures adequate mine site maintenance;
3. Normal market forces will govern the supply of power and materials. During the short term time horizon (0-40 years) no major supply issues are foreseen. Over the long term (up to 1,000 years, the redundancy built into the system will provide a degree of insurance against long-term supply shortages, and a procurement plan will be in place designed to further mitigate risks of supply shortages.

7.4. Long Term Maintenance and Monitoring

The following assumptions were made regarding long term, post closure care and maintenance and monitoring programs:

1. Implementation will include a First Nation/Private Sector care and maintenance contractor that is effective in implementing the overall program, and is required to meet the terms and conditions of a post-closure water licence.
2. Monitoring and water treatment will be the responsibility of the First Nation.
3. A normal regulatory oversight regime will be in place and will work effectively

7.5. Emergency Preparedness

The following assumptions were made regarding provisions for emergency response:

1. In the short term, provisions for emergency response will be included in the terms of the Water Licence. The care and maintenance contractor will be required to carry errors and omissions and environmental liability and general liability insurance
2. Over the long term, an instrument will be in place that facilitates the availability of resources in the event of an emergency.

3. There is an agreement to negotiate potential compensation in the event of a catastrophic failure, and the principles for guiding these negotiations will be included within the implementation strategy.

7.6 The Use of Adaptive Management

The following assumptions were made regarding design and implementation of a system of adaptive management:

1. Adaptive management plans are developed for all aspects of the project and incorporated into the implementation strategy.
2. Adapative management plans will incorporate both socioeconomic and environmental aspects, and be included as part of any future water licence.
3. All adaptive management plans will include clearly defined responses to various trigger events, and be reviewed on a five-year cycle.
4. A regulatory oversight mechanism will ensure implementation of adaptive management plans.

7.7 Strategic Phasing of Component Activities

In an attempt to balance the maximization of future socio-economic opportunities with the achievement of project efficiencies, a series of phasing assumptions were made as follows:.

1. There will be a 2-3 year ramp up period; a 15 year total construction period; and a 25 year initial adaptation period;
2. Site management and water treatment will be required in perpetuity;
3. During the implementation period, there will be a heavy “civilian” fleet, a heavy mining fleet, and a specialized trade team.
4. In some options there will also be a tailings relocation team.
5. The heavy “civilian” fleet will have approximately 15 years of work in all cases.
6. The heavy mining fleet will have approximately 15 years of continuous work in all cases except when tailings are relocated.
7. The specialized trades team will require a variety of different skills and equipment, spread over 15 years.
8. When tailings are relocated the tailings relocation team will be required for 15 years, but the heavy mining fleet for only 5-6 years
9. Throughout implementation and the long-term phase, there will be a care and maintenance and water treatment team, and an overall monitoring team.

7.8 Overarching Socio-Economic Assumptions

The following overarching socio-economic assumptions were made:

1. Timelines will be as outlined above in Section 7.6: a 2-3 year ramp up period; a 15 year total construction period; and a 25 year initial adaptation period; and, site management and water treatment in perpetuity.
2. Faro and Ross River will both continue to exist as communities.
3. There will be no camp housing of workers; the majority of workforce will be resident in either Faro or Ross River with short-term accommodation made available as needed within Faro.
4. Through to the end of the construction period:
   - The objectives of the project will remain stable;
   - Relevant public standards and expectations will remain stable;
   - The selected alternative (approach) will remain stable; and,
   - The technology used will achieve the expected outcomes.
5. Socio Economic Participation Agreements (SEPAs) will be required as a mechanism for formalizing the commitments of participating parties to mutually agreed upon objectives.

7.9 Employment, Demographics and Human Resource Development

The following assumptions were made regarding employment, demographics and human resource development:

1. **Overall Demographics.** Given the amount of employment and the time period of construction, demographic composition and population will not change significantly.

2. **Employment Levels**
   - ♦ About 60 workers directly employed annually during construction over 15 years; another 10 professional/technical/management (peak employment expected to reach 70 to 85 workers depending on the alternative selected);
   - ♦ The majority of workers will come from Faro and Ross River, with some people moving into the communities and some commuting from elsewhere for variable periods of time (accommodated in rental housing in Faro);
   - ♦ Post-construction expectation of 10 workers permanent, 5 seasonal, resident in Faro and Ross River plus another 5 workers related to technical and First Nation traditional environmental monitoring, land stewardship, and research in the post-construction phase.

3. **Project Responsibilities**

- Project will ensure the availability of employee assistance program, training, apprenticeships, scholarships, mentoring at a senior level (starting with current care and maintenance contract);
- There will be requirements in all contracts to ensure these human resource requirements are met;
- There will be oversight and performance evaluation requirements of the executive to ensure this is done.
- YSEAA will require these commitments to be made in public (socio-economic monitoring program)
- Socio-economic Participation Agreements (SEPAs) will be set to formalize these agreements
- Longer term contracts will be encouraged to promote greater investment in physical and human capital.
- Training, Education, and Succession Planning (transferable skills development) will enhance employment opportunities and long term regional employability.
- Shift design, commuting requirements, implications for municipal infrastructure.

7.10 Business Opportunities and Indirect Employment

The following assumptions were made regarding business opportunities and indirect employment:

1. The project Socio-economic Partnership Agreements (SEPAs) will provide for local, regional and territory-wide business opportunities connected with the project that will support community sustainability and economic diversity.
2. To the extent feasible, business opportunities will be geared toward local capacity.
3. Business opportunities may include: Analytical services; Fuel supply; Supply of lime; Air services; Catering services; Hospitality industries; Retail trade; Equipment rental, supply and service; Specialized trades; Commuter, freight and courier services; Other activities yet to be determined.

7.11 Infrastructure and Services to the Communities

The following assumptions were made regarding regarding infrastructure and services to the communities:

1. Governments ensure that required public services are provided: health, education, policing, justice and social services;

2. Funding will be available to provide, operate and maintain required municipal infrastructure and Faro is able to up-grade sewer and water infrastructure

7.12 Contribution to Community Health and Well-being

The following assumptions were made regarding project contribution to community health and well-being:

1. Public education, communication and engagement in project planning and implementation will contribute to community empowerment and public participation in decision making.
2. The project will, in conjunction with communities, employers and contractors, establish objectives to do as little harm as possible and where feasible, make a positive contribution to community health and well-being.
3. Selected community specific indicators of community health status, social cohesiveness and the social determinants of health and well being will be identified and tracked during implementation.
4. Strategies will be developed to ensure the availability of options for supporting a healthy lifestyle for individuals, families and the community as a whole, including traditional First Nation options.
5. Options for healthy recreation and re-creation, including traditional First Nation options, be maintained and enhanced through project activities and outcomes.
6. Social capital will be strengthened through the design and implementation of dispute resolution mechanisms that bring the best of First Nation traditional knowledge together with other participative approaches.
7. Implementation will be managed to support fairness and equity among community members in accessing opportunities.
8. Best attempts will be made to mitigate any differential negative impacts by analysing possible impacts at a sub-community level to ensure opportunities and impacts are equitably distributed across the local population (no “winners” and “losers”).
9. Implementation will contribute to community stability and sustainability to the extent reasonable and possible.
10. The preferred closure option gives fair and equitable consideration to the views, needs and differing aspirations of those local communities most directly affected (Faro & Ross River)

7.13 Regional Land Management

It was assumed that a system of regional land management would be in place to address such issues as:

1. traditional and non-traditional land use
2. access
3. interim land use (during construction)
4. future land use (land use plans, development strategy)
5. tourism

7.14 Cultural Continuity and the Traditional Economy

The following assumptions were made regarding cultural continuity and the traditional economy:

1. Traditional knowledge research will support implementation in providing information to ensure, to the extent desired by First Nation communities, that cultural continuity with historical and traditional values, beliefs and practices.
2. Employment policies will be designed to guard against forced acculturation and support cultural continuity in seasonal cultural activities such as fishing, hunting and gathering in order to support wild food consumption.
3. The project will contribute to the revitalization and sustainability of the traditional land based economy and the non-traditional, mainstream economy.

7.15 Knowledge Development, Management and Transfer

The following assumptions were made regarding knowledge development, management and transfer

1. Knowledge will be developed through traditional knowledge and scientific research and documentation of the experience of the project.
2. Scientific and traditional knowledge and the keepers of the knowledge will be equally valued as important contributors to comprehensive understanding of the past, present and future of the region.
3. Lessons learned about northern mine reclamation of this nature and related innovation will be documented and shared to the extent possible and feasible.
4. Knowledge will be managed in order to support future economic and social opportunities for using and transferring accumulated knowledge to others.

Chapter 8. Performance Assessment Process

8.0 Introduction

This chapter describes the process by which the Assessment Team generated its estimates of how well each alternative would perform against each objective.

8.1 Scales for Scoring Alternatives Against the Objectives

To facilitate the Team's task of estimating how well each alternative would perform against each objective, scoring scales were developed. In each case, the scale is a zero-to-10 scale, where a score of 10 denotes "ideal performance" and a score of zero denotes "abominable performance." The precise definitions of the scores depend on the objective in question. The definitions of the scores that make up the various scales are expressed in terms of factors identified in the influence diagrams, which, as described in Chapter 4, were constructed by the Team to document the factors that should be considered for assessing performance against objectives. Since it was critical that the scales address the factors that the Assessment Team agreed were important, the Assessment Team spent several days developing and refining the influence diagrams (the influence diagrams are provided in Chapter 9).

As an example of one of the scoring scales, Table 8.1 provides the scale for estimating public health and safety performance. Assigning a score of 10, "ideal performance," to an alternative means that for the time period under consideration, the assessor believes that no health or safety problems whatsoever will occur should that alternative be selected. Assigning a score of less than 10 means that performance is less than ideal. Performance is defined in terms of factors believed by the Team to "influence" the level of public health and safety achieved. The lower the score, the more adverse these factors are. In particular, scores less than 10 mean that there is a possibility or an expectation that there will be violations of standards relevant to health and safety, some number of injuries and/or illnesses, and, perhaps, one or more fatalities to members of the public. The greater the number of anticipated injuries and fatalities, the lower the score.

Table 8.1 Example Scoring Scale – Public Health and Safety Performance.

Scoring Scale for Public Health & Safety	
10	Ideal performance. **No health or safety problems.** Although some might experience "psychological" effects, Western science and traditional knowledge will agree that there are no known physical mechanisms by which people could be harmed.
9	Very good performance. No exceedences of any health/safety-related standards will occur. Any illnesses that plausibly relate to the site will be **minor** and will not require medical treatment. Any injuries will be attributable to very poor judgment on the part of those harmed.
8	Good performance. Some minor violations of applicable health/safety-related standards. At worse, only a very **few moderate, temporary non-life-threatening illnesses and/or injuries** will occur—extreme lifestyle or habits will be a factor. Effects will be temporary and hospitalization will not be required..
7	Fair performance. The alternative will produce a few serious exceedences of applicable health/safety-related standards. There will be **no deaths**, but some non-life-threatening, moderately serious illnesses and/or injuries will occur. Only a small fraction of those exposed will be affected.
6	Mediocre performance. The alternative will produce moderate illnesses and injuries and a few serious injuries and/or long-term illnesses (effects lasting 5 years or more). Small **(30%) chance of a fatality**, but most likely not for anyone with average lifestyles and exercising reasonable judgment.
5	Poor performance. Significant problems. There will be numerous violations, serious injuries and/or illnesses, and **probably one fatality** to a member of the public.
4	Very poor performance. Serious problems. The alternative will result in **a few (e.g., 3) fatalities** and roughly 100 serious injuries or illnesses will occur. Not attributable to bad judgment.
3	Bad performance. Very serious problems. **Ten or more fatalities** and hundreds of serious illnesses and/or injuries.
2	Very bad performance. Major problems. The alternative will result in **30 or more fatalities** to the public and as many as a thousand serious illnesses or injuries.
1	Terrible performance. Critical problem. **One hundred or more fatalities** and thousands of serious illnesses and injuries.
0	Abominable performance. A public health and safety disaster. The alternative will result in **300 or more fatalities** to the public.

To enable the scoring scales to span a very wide range of possible levels of performance, the scales are logarithmic. [1] With a logarithmic scale, the score is related to the logarithm of magnitude of the item being measured. The logarithmic scoring scales are designed so that a drop in score of 2 units typically represents a situation that is approximately 10 times as bad (this feature may be observed in Figure 8.1 by the fact that the numbers of anticipated and fatalities, shown in bold font, generally increase by a factor of 10 when the score declines by 2 units.

All of the scoring scales are provided in Chapter 9, along with the influence diagrams from which they were derived. In all cases, the same scoring scales were used for scoring performance in the short- and long-term time periods.

[1] Logarithmic scales have been used previously for the Faro site, specifically, in support risk-rating efforts. Examples are provided in the following three references: (1) SRK Consulting (Canada) Inc., 2006. Results of Risk Rating Workshops. Attachment C in "Example Alternatives for Closure of Anvil Range Mining Complex, Draft for Peer Review, September 2006." Report prepared for Deloitte & Touche Inc. on behalf of the Faro Mine Closure Planning Office, Whitehorse., (2) Slater, Bill, 2007. Draft Faro Risk Matrix. Prepared for the Faro Closure Office based on the work of Jonathan Huggett and others., (3) Risk Management Procedure Components, Version 2.0, September 2006. Indian and Northern Affairs Canada, September 2006.

8.2 Normal Scores, Risk Scenario Scores, and Scenario Probabilities

As described in Chapter 4, the assessment included risk analysis, wherein the uncertainty over the performance of the alternatives was quantified. To obtain inputs for the risk analysis, Team members provided three estimates:

(1) Estimates of the range of uncertainty over performance assuming that no “risk events” occur (this range is characterized by “normal scores”),

(2) Estimates of the range of uncertainty over performance assuming one or more “risk events” occur (this range is characterized by “risk scenario scores”), and

(3) Estimates of probabilities indicating how likely the relevant risk scenarios are.

In the case of each range, the low and high ends of the range were specified to be the values such that the Team member believed there was only a 10 percent chance that the actual value would be either below or above the range. In other words, the specified ranges represent 80% confidence intervals; the Team member believed, with a confidence of 80%, that the actual level of performance, should the alternative be selected, would fall within the range indicated by the scores.

When assigning risk scenario scores, Team members were advised to think of the possible risk scenarios that, if they were to occur, would result in significantly poorer performance against the objective. Risk scenarios that the Team agreed all Team members should consider were identified by the Team during the second Team workshop, and are shown in Table 8.2. The table also shows the Team’s initial collective opinion of the significance of each scenario.

Table 8.2 Risk Scenarios that the Assessment Team agreed should be considered

Risk Scenario	Closure Objective							
	1. Public H&S	2. Worker H & S	3. Environ.	4.Local Socio-Ec.	5. Yukon Socio-Ec.	6. Cost	7. Trad'l. Land Use	8. Local Land Use
Performance Uncertainties under normal operating conditions	O	+	X	-	-	+	-	-
Transportation accident	X	O	X	X	O			
Failure of groundwater collection and treatment system	-	O	+	X	X		X	-
Failure of creek diversions	+	O	X	X	X		X	X
Dam breach and tailings release	+	- *Increased labour hours for response*	+	X	X	X	X	X
Non-catastrophic maintenance failures	-	O	-	O	O		-	-
Other off-normal scenarios	?	- *collapse or liquefaction of face*	?	?	?			

<u>Key</u>

O	not likely to be a discriminator	X	potential discriminator
-	possible discriminator of lesser significance	+	possibly a discriminator of greater significance

Although Table 8.2 indicates the Team's collective opinion regarding whether or not these risk scenarios would likely discriminate among the options, during the scoring process, individual Team members were free to make their own judgments, and they were advised to identify and take into account any additional risk scenarios that might concern them (the major risk scenarios considered by Team members for each alternative objective are documented in the subsections of Chapter 9 describing the logic used by the Team members). When estimating the likelihoods of risk scenarios, Team members were advised to enter probabilities indicating the likelihood that any one or more of their risk scenarios would occur and produce the lower performance indicated by their risk scenario scores.

An Excel software tool was developed to collect, document, and process the estimates provided by Team members. Separate worksheets were used to document estimates for each objective, time period, and alternative (100 sheets in all). Figure 8.1 shows how the estimates were tabulated on a given worksheet. Although all Team members were asked to submit as many scores as they could, not all Team members provided inputs for all objectives and time periods. However, a minimum of 4 members submitted scores for each assessment, and most assessments were based on scores submitted by 6 to 8 members. If a Team member provided scores for any objective, that Team member was required to submit scores for all alternatives for that objective.

Obj-Time-Alt: *P H&S-LT-DC*

Load Scores

		Norm Scores		Scen Score		Scen prob	
	Member	Min	Max	Min	Max	Min	Max
☑	1	7	8.5	5	6	0.2%	0.5%
☐	2						
☑	3	7	8	5	6	0.1%	1.0%
☐	4						
☐	5						
☐	6						
☑	7	7	8	6.6	6.8	0.01%	0.1%
☐	8						
☐	9						
☑	10	8	9	6	7	1.0%	1.5%
☐							
☐							

Figure 8.1. Tabulation of performance estimates. Portion of a spreadsheet illustrating how Team member inputs were documented. The title, P H&S-LT-DC indicates that the scores are for the objective public health and safety (P H&S) for the long-termtime period (LT) and for the alternative “Dry cover” (DC).

8.3 Pilot Test

In an effort to help Team members fully understand the scoring process and its outputs, the entire 3rd workshop (3½ days) was devoted to a “pilot test ” or dry run, of the methodology. The “road map” for the assessment process was explained in detail, and individual Team members were assigned responsibility for providing each type of assessment score, allowing them to practice and to illustrate to one another the types of judgments required. The scores were input into the software so that Team members could observe the types of outputs to be produced.

Although the Assessment Team practiced assigning scores for all short-term and long-term objectives, care was taken to avoid creating a bias by prematurely showing a direct comparison of scores between any alternatives. Specifically, one sample alternative was used as an example for providing short-term scores and another used as an example for practicing long-term scores, and the scores for each objective were provided by only one individual (or by a team of two individuals). It was felt important that Team members not be able to conclude from the dry run how their colleagues were likely to rank the alternatives, because such knowledge might conceivably motivate some Team members (even subconsciously) to alter their subsequent scores slightly to obtain a desired ranking. It was recognized that some Team members might desire more opportunities to practice and to see how others would score the alternatives, but the dry run was deliberately limited in scope to maintain the integrity of the scoring process.

8.4 Scoring Process

The "official" scoring exercise was conducted in two steps. First, as indicated previously, selected Team members (those mutually identified as the "experts") prepared briefing packages documenting information relevant to scoring against specific objectives. Each briefing package (one for each objective) identified relevant risk scenarios and projected impacts on objectives. Using the briefing packages as a foundation of understanding, selected Team members were tasked with providing performance estimates (on objectives within their areas of primary expertise).

Recognizing the importance and difficulty of the scoring process, the Team was given a total of 18 working days for developing scores.[2] Detailed scoring instructions and materials were distributed to Team members on October 11, and the Team scores were finalized on November 8.

8.5 Risk Analysis

The risk analysis consisted of combining the normal and risk scenario scores to obtain probability distributions describing the uncertainty over performance. This involved fitting probability distributions to the range of normal and risk scenario scores and then combining the probability distributions, taking into account the probabilities assigned to the risk scenarios.[3] Essentially, the analysis involved simulation, wherein possible futures were considered in which risk events would or would not occur, with the simulation based on the probabilities assigned to the risk events. The results were then used to define probability curves describing the relative likelihoods of the various possibilities. Figure 8.2 illustrates the type of risk curves generated (each curve is for a particular alternative, objective, time period, and Team member).

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[2] Scoring materials were distributed on October 11, with an initial target date for submitting preliminary scores by October 24 (9 working days). Team members were advised that they could continue working on scores until November 4 (the first day of the 4th workshop), but were informed that it might not be possible to preload scores into the software if the scores were submitted after October 24 (5 working days). During the final scoring workshop (4 – 8 November), an additional 4 days were spent refining and augmenting scores.

[3] Specifically, the mathematical steps were as follows. First, probability distributions were fit to the range of scores assigned by each member's scores (the form of the distribution was typically the beta distribution, however, if the Team member's range was too narrow to be fit using a beta distribution, a uniform distribution was used instead. Next, the continuous, fitted, distributions were converted to 7-level discrete approximations using Gaussian quadrature. An event tree was constructed to combine the normal and risk scenario possibilities.

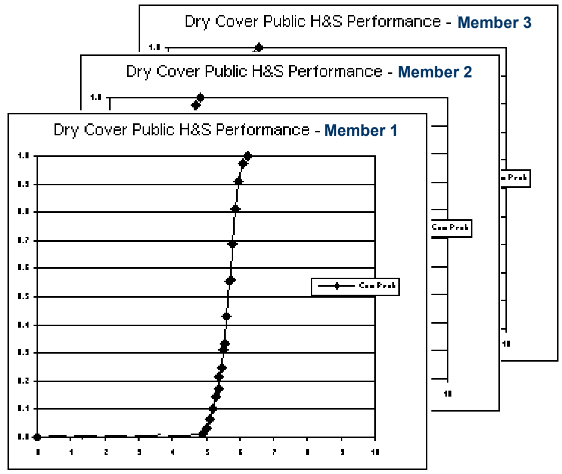


Figure 8.2. Risk curves for each individual assessment. The risk analysis consisted of generating probability curves indicating Team member uncertainty over performance.

8.6 Combining Team Member Performance Assessments

Because a single measure was desired that would summarize the Team's collective uncertainty regarding the performance of alternatives, the probability curves representing the assessments of the individual Team members were combined as follows. First, the 1% ("worst"), 10% ("min"), 50% (median), and 90% ("max") score values were read from each member's computed probability distribution. These scores were referred to as the Team member's "risk-adjusted scores."

Scoring ranges for the Team as a whole were then computed using a process similar to that used in the Olympics. For some events in the Olympics, multiple judges score the performance of each competitor using zero-to-10 scales. However, to avoid allowing any one judge to bias results, the extreme highest and lowest scores are omitted from averaging. A similar approach was used here. However, the process was modified slightly because, rather than assigning a single, point-estimate score, for each alternative, as explained above, Team members assigned ranges of scores intended to represent uncertainty.

The approach used to convert individual Team-member scoring ranges into scoring ranges for the Team was as follows. First, the lowest 1% ("worst" performance) and 10% ("min" performance) scores were dropped, as was the highest 90% ("max" performance) score. Then, a combined scoring range was computed using the remaining scores; the 1% ("worst") and 10% ("min") scores were taken to be the lowest of the remaining 1% and 10% scores, respectively, and the 90% ("max") score was taken to be the highest of the remaining 90% scores.

Figure 8.3 illustrates the form of the results. The scores for the alternatives provided by the Assessment Team (presented in the next chapter) are provided using this graphic format.

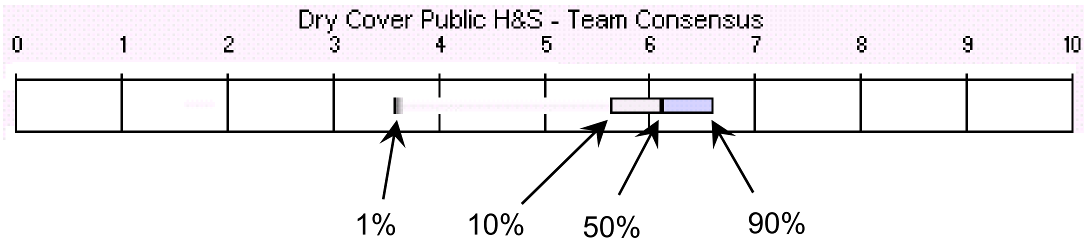


Figure 8.3. Graphic presentation of scoring results. Ranges were developed to indicate the uncertainty in performance score by combining the individual assessments provided by Team members. The notation "Public H&S" denotes that the scores are for the public health and safety objective.

The process described above produced a range of scores sufficiently wide to encompass the range of scores provided by every Team member, with the exception of the scores assigned by the one or two Team member who assigned the most extreme scores. The resulting range was viewed as indicative of the actual uncertainties because it captures both the uncertainties held by all but one Team member as well as the differences of opinion across Team members.

Note that, in subsequent chapters when results displayed similarly to Figure 8.3 are summarized, the 10% to 90% range is often referred to as indicating the "most likely" range of performance (according to the estimates provided by the Assessment Team). The term "downside risk" is used to refer to the 1% ("worst case") score. Alternatives with lower 1% scores, are said to present more "downside risk."

Chapter 9. Assessment Results by Objective

9.0 Introduction

The results of the Assessment Team's efforts are organized into three parts. The first part, presented in this chapter, contains the results of the Team's assessment of the various alternatives against each objective in each time period.

Performance Assessments – Terminology and Interpretation

In this chapter, and elsewhere, reported results are referred to as "performance assessments" (or "performance estimates"). This terminology is consistent with the common definition that a "performance assessment" is "an assessment against a set of predetermined criteria." In our case, the criteria are the decision objectives. In other words, we are presenting estimates, based on scores and other inputs provided by the Assessment Team, of the performance of alternatives against a set of specific objectives deemed important for making a choice about how to deal with the Faro site.

As explained in Chapter 8, the performance ranges that are reported in this Chapter were generated through risk analyses. The performance ranges are expressed on the same zero-to-ten scales introduced in Chapter 8. For example, for public health and safety, the performance ranges for an alternative might (hypothetically) be reported as an 80% confidence range between scores of 4.0 and 5.0, with a "worst case" score of 2.0. Because the scoring scales are defined in terms of consequences specific to the objective in question (in the case of the example, as specified by the scoring scale for health and safety), the above (hypothetical) scores would signal an estimate that, if the alternative is selected, there will most likely (with 80% probability) be between one and three public fatalities and between 30 and 100 serious injuries and illnesses (see the health and safety scoring scale, displayed in Table 8.1 and below in Table 9.1 for this correspondence). The (hypothetical) "worst case" estimate (1 chance in 100) is that there would be more than 30 fatalities and as many as a thousand serious injuries or illnesses.

Obviously, the precision of such statements of this type is limited by difficulty of the assessment task (imagine using a tape measure to measure the size of a cloud). Despite this limitation, the definitions provided in the scoring scales ensure that the estimates have absolute meanings; the scores are not simply relative, arbitrary measures of performance. Even though the precision of the absolute consequence estimates implied by the scoring definitions may be questionable, this does not mean that small differences in scores should be ignored (for example, if one cloud is estimated to have a diameter of 200 meters and another a diameter of 201 meters, there may still be high confidence that the second cloud is larger, so long as the same measurement rules were used in each case).

As discussed previously, the scoring scales are logarithmic—a reduction in score of two points corresponds to a situation roughly ten times as bad (similarly, a reduction in score of one point corresponds to a situation approximately 3.3 times as bad). Like other logarithmic scales, the scoring scales have the advantage of being capable of representing very large ranges of possible performance (since a zero on the scales represents roughly the worst conditions that could be conceived), while, at the same time, being sensitive to small degradations in performance (at the upper end of the scale). A disadvantage of using log scales is that making comparisons using such scales requires care. Specifically, what may appear to be a small difference in the performance of alternatives at the middle or low end of the scale can actually represent a very large and important difference. For example, the difference between a score of 3.0 and 3.1, which would appear very close on plots based on scores, represents a difference in performance roughly equal to the difference in performance between a score of 5 and a score of 10.[1] Thus, it is important not to interpret small differences in scores as necessarily implying essentially the same level of performance.

Reliance on Previously Developed Information

The assessments required incorporating a very large foundation of data and information that has accumulated over the life of the mine. On the order of $6 million has been spent on technical studies in the last decade alone (Michael Nahir, 2008, personal communication). Topics addressed cover the full range of issues spanned by the eight closure objectives. Significant effort has gone into identifying the risks that are associated with closure alternatives.

The Assessment Team made every effort to draw from this foundation of information. Undertaking such a synthesis presented a major challenge. As indicated in Chapter 8, to address this task, individual members of the Assessment Team developed briefing packages for each of the eight objectives in which the information base was summarized (often drawing from earlier topic-specific syntheses), key issues and effects identified, and risk scenarios described. References to the briefing packages are provided at the end of this chapter. The briefing packages served as an information resource for Team members' assessments.

[1] For example, in the case of the health and safety scales, an alternative that scores a 10 is estimated to result in one less fatality than an alternative that scores a 5. Similarly, as can be shown through interpolation, , and an alternative that scores a 3.1 is estimated to result in one less fatality than an alternative that scores a 3.0.

Organization of this Chapter

The subsections of this chapter are organized around the decision objectives. For each objective, the judgment process used by Team members is described, the risk scenarios of concern are summarized, the factors influencing performance are outlined, and the scoring results are provided. No aggregation is attempted here; that is the topic of Chapter 10.

9.1 Maximize Public Health and Safety

Judgment Process

The data and information available for assessing the performance against the public health and safety objective are summarized in Knapp, 27 August 2007.

The primary issues that were identified as needing consideration under this objective relate to:

1. Chemical hazards including those from breathing Potential Contaminants of Concern (PCOC), drinking water contaminated from site discharges; and eating fish, berries, animals, etc., that carry contaminants from the site;
2. On-site physical hazards including pits, pit walls, dams, diversions, structures etc leading to accidents; and
3. Off-site physical hazards related to the closure project, in particular traffic accidents occurring as people and supplies move to and from the site.

Each Team member assessed for each alternative, the potential severity of these hazards: (1) over the short and long term, and (2) for normal operating conditions and risk scenarios.

The scoring scale used for public health and safety is shown below in Table 9.1.

Table 9.1 Scale used for scoring public health and safety

Score	Definition
10	Ideal performance. No health or safety problems. Although some might experience "psychological" effects, Western science and traditional knowledge will agree that there are no known physical mechanisms by which people could be harmed.
9	Very good performance. No exceedences of any health/safety-related standards will occur. Any illnesses that plausibly relate to the site will be minor and will not require medical treatment. Any injuries will be attributable to very poor judgment on the part of those harmed.
8	Good performance. Some minor violations of applicable health/safety-related standards. At worse, only a very few moderate, temporary non-life-threatening illnesses and/or injuries will occur—extreme lifestyle or habits will be a factor. Effects will be temporary and hospitalization will not be required..
7	Fair performance. The alternative will produce a few serious exceedences of applicable health/safety-related standards. There will be no deaths, but some non-life-threatening, moderately serious illnesses and/or injuries will occur. Only a small fraction of those exposed will be affected.
6	Mediocre performance. The alternative will produce moderate illnesses and injuries and a few serious injuries and/or long-term illnesses (effects lasting 5 years or more). Small (30%) chance of a fatality, but most likely not for anyone with average lifestyles and exercising reasonable judgment.
5	Poor performance. Significant problems. There will be numerous violations, and on the order of 30 serious injuries and/or illnesses. There will probably be one fatality to a member of the public.
4	Very poor performance. Serious problems. The alternative will result in a few (e.g., 3) fatalities and roughly 100 serious injuries or illnesses will occur. Not attributable to bad judgment.
3	Bad performance. Very serious problems. Ten or more fatalities and hundreds of serious illnesses and/or injuries.
2	Very bad performance. Major problems. The alternative will result in a 30 or more fatalities to the public and as many as a thousand serious illnesses or injuries.
1	Terrible performance. Critical problem. One hundred or more fatalities and thousands of serious illnesses and injuries.
0	Abominable performance. A public health and safety disaster. The alternative will result in 300 or more fatalities to the public.

Risk Scenarios

Short Term

The following risk scenarios were identified by Team members as potentially significant for public health and safety in the short term:

1. Traffic accidents (this risk scenario is dominant);
2. Tailings dam breach, tailings move down stream;
3. Loss of water treatment capacity for whatever reason.

Estimates by Team members of the probability that these risk scenarios would occur in this time period generally ranged around 1% - 2%, although both lower (to) 0.1% and higher estimates (to) 10% were given in a few cases.

Long Term

For the long term, the following risk scenarios were considered:

1. Traffic accidents (this risk scenario is dominant);
2. Tailings dam breach, tailings move down stream;
3. Loss of water treatment capacity for whatever reason.

Estimates of the probability that these risk scenarios would occur in this time period ranged from 0.1% to 10%.

Factors Influencing Performance

Figure 9.1 shows graphically the factors that the Assessment Team considered important to public health and safety performance.

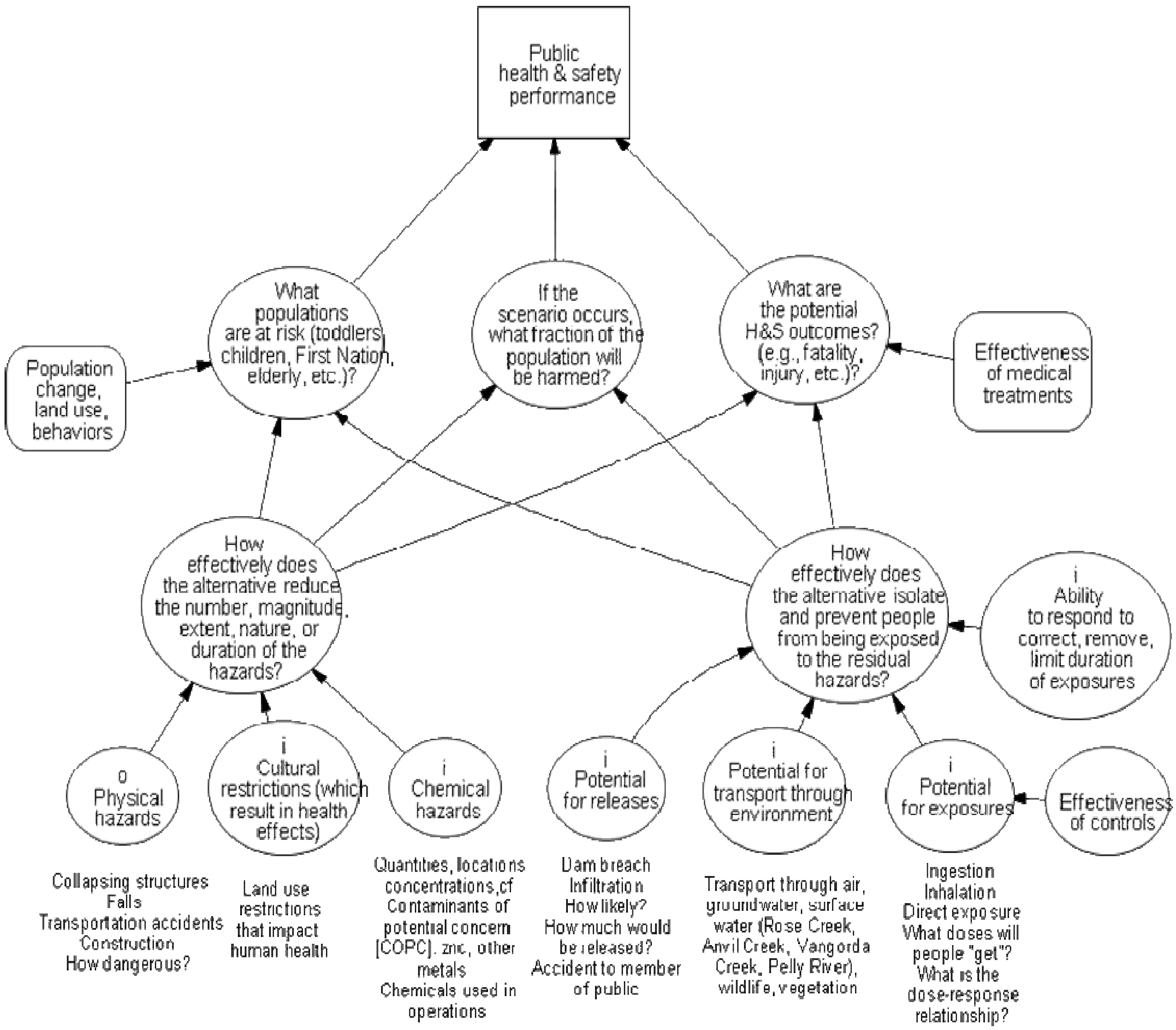


Figure 9.1. Factors influencing performance on public health and safety.

Scoring Results and Logic Summary

Figure 9.2 shows the public health and safety performance estimates for the component alternatives, expressed against the scoring scale, for the short- and long-term time periods. As described in Chapter 8, these estimates were derived from scores and risk scenario probabilities assigned by Team members.

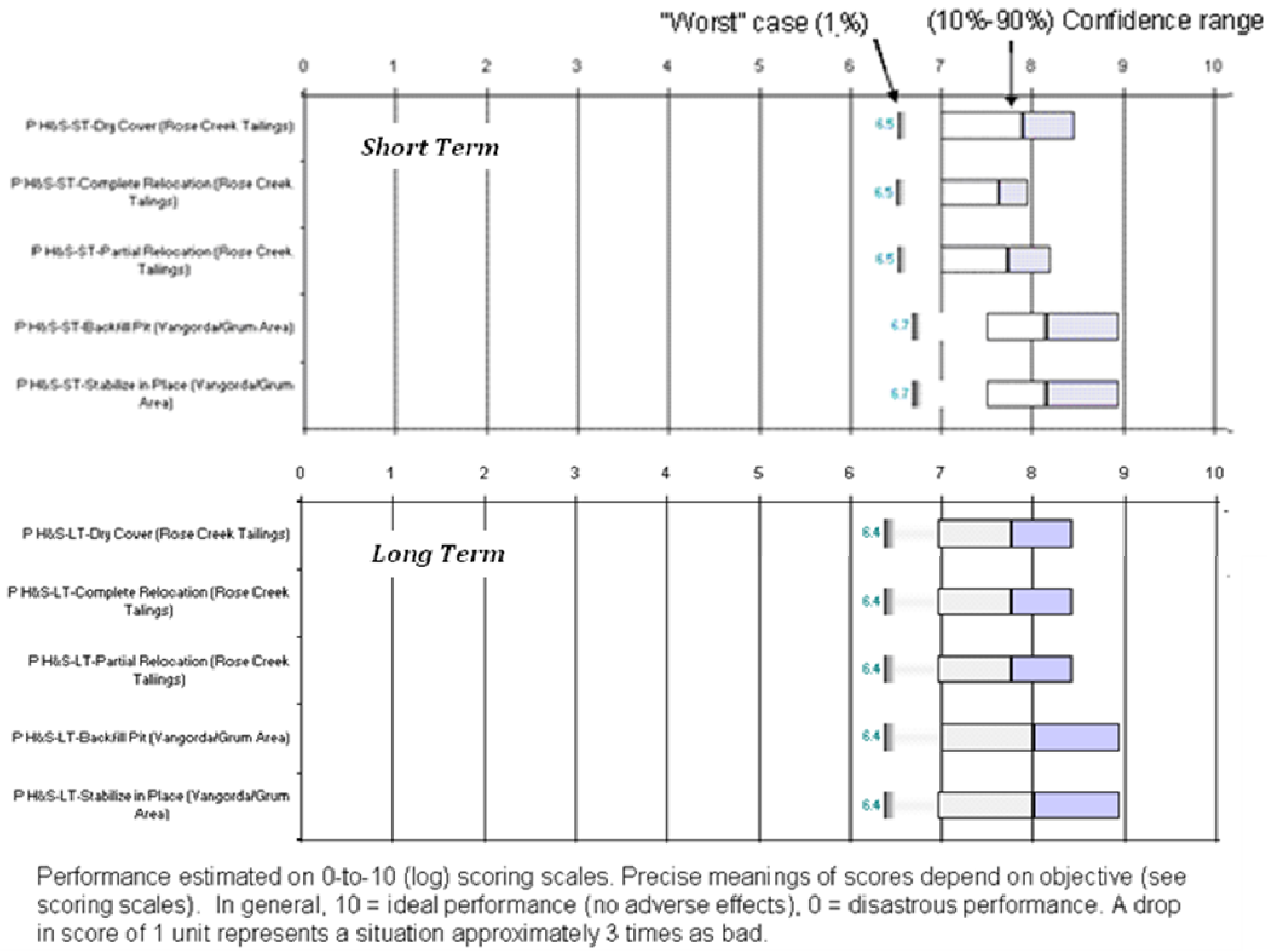


Figure 9.2. Performance estimated for the public health and safety objective over the short and long terms

Assessment Results, General

The Assessment Team results indicate a fairly high degree of confidence that any of the alternatives will do a fairly good job of protecting public health and safety.

Assessment Results, Short Term

Faro Mine/Rose Creek area

1. Performance scores for short term public health and safety for the Faro Mine/Rose Creek area range between fair (7) and good/very good (8.5). This range reflects a belief that some serious exceedences of health and safety standards (particularly traffic accidents) will occur. The most likely health effects, should they occur, are seen to be temporary, non life-threatening illnesses or injuries. No deaths are expected.

2. Overall, the "Dry cover" alternative scores slightly better than "Partial" and "Complete relocation" but the breadth of the bar for "Dry cover" signals greater uncertainty. The slight differences in performance that arose are linked to an estimated higher probability that risk scenarios will occur for the relocation options.

Vangorda/Grum Area.

1. Performance scores on public health and safety for the Vangorda/Grum side are somewhat higher than on the Faro/Rose Creek side suggesting a lower public health and safety risk. Scores signal fair/good (7.5) to very good (8) performance for both alternatives

Assessment Results, Long Term

Both sides:

1. Assessment team scores suggest fair (7) to good/very good (8.5) performance in the Faro/Rose Creek area and fair (7) to very good (9) on the Vangorda/Grum side, signalling a belief that the various alternatives will all do a fairly good job of protecting Public Health and Safety .

9.2 Maximize Worker Health and Safety

Judgment Process

The data and information available to serve as a basis for assessing the performance of each alternative on the worker health and safety objective are summarized in Knapp, 27 August 2007, who in turn, drew heavily on SRK, August 1, 2007.

The primary issues that were identified as needing consideration for worker health and safety for the short term (during the 15 year construction period and 25 year period of monitoring and adjustment) were: (1) on-site lost-time injuries and fatalities; and (2) traffic fatalities and injury risks related to the hauling of major deliverables to the site including lime and fuel. In the short term, risks are primarily related to construction activities. Therefore, options with lower person-hour requirements have lower worker health and safety risks. Over the long-term, the primary worker health and safety risks at the site relate to ongoing care and maintenance activities and operation of the water management system.

The task of the assessors involved estimating for each alternative the potential for and severity of the above hazards: (1) over the short and long term, and (2) for normal operating conditions and risk scenarios. The Scoring Scale used by the Assessment Team is shown below in Table 9.2.

Table 9.2 Scale used for scoring worker health and safety

Score	Definition
10	Ideal performance. No worker fatalities, injuries, occupational exposures, or illnesses.
9	Very good performance. Insignificant problems. Minor effects only. No loss of work or hospital care needed. Between a score of 8 and 10.
8	Good performance. Minor problems. No fatalities. One serious, non-fatal, injury-causing accident.
7	Fair performance. Smallish problems. Several serious, non-fatal, injury-causing accidents.
6	Mediocre performance. Moderate problems. Small (30%) chance of a fatality. Ten or more serious, non-fatal, injury-causing accidents.
5	Poor performance. Significant problems. One fatality, arguably due to bad judgment. More than thirty serious, injury-causing accidents.
4	Very poor performance. Serious problems. 3 fatalities. One hundred or more serious accidents.
3	Bad performance. Very serious problems. 10 fatalities. Hundreds of serious accidents.
2	Very bad performance. Major problems. Roughly 30 fatalities. Roughly a 1000 serious accidents.
1	Terrible performance. Critical problem. Roughly 100 fatalities and several thousands of serious accidents.
0	Abominable performance. A worker health and safety disaster. Exposures will result in 300 or more worker fatalities and ten thousand or so serious worker injuries.

Risk Scenarios

During the short term (0 to 40 years), the primary risk scenario that could result in harm to workers was judged to be slope failure initiated by extreme rainfall or earthquakes. The likelihood of such scenarios was judged to be low given the worker health and safety programs assumed to be in place. Estimates provided by Team members of the probability of occurrence ranged from 0.5% - 4%, with the risk scenarios for “Complete relocation” being judged slightly more likely to occur than for “Dry-cover” on the Faro side and similarly, the “Backfill pit” option for the Vangorda/Grum side being slightly more vulnerable during the process of moving the waste rock.

Over the long term, risk scenarios relate again to extreme initiating events (high rainfall, earthquake) coupled with worksite slope instabilities. Estimates of the probabilities of occurrence ranged from 0.1% to 10%.

Factors Influencing Performance

Figure 9.3 shows graphically the factors that the Assessment Team considered to be most important to worker health and safety performance.

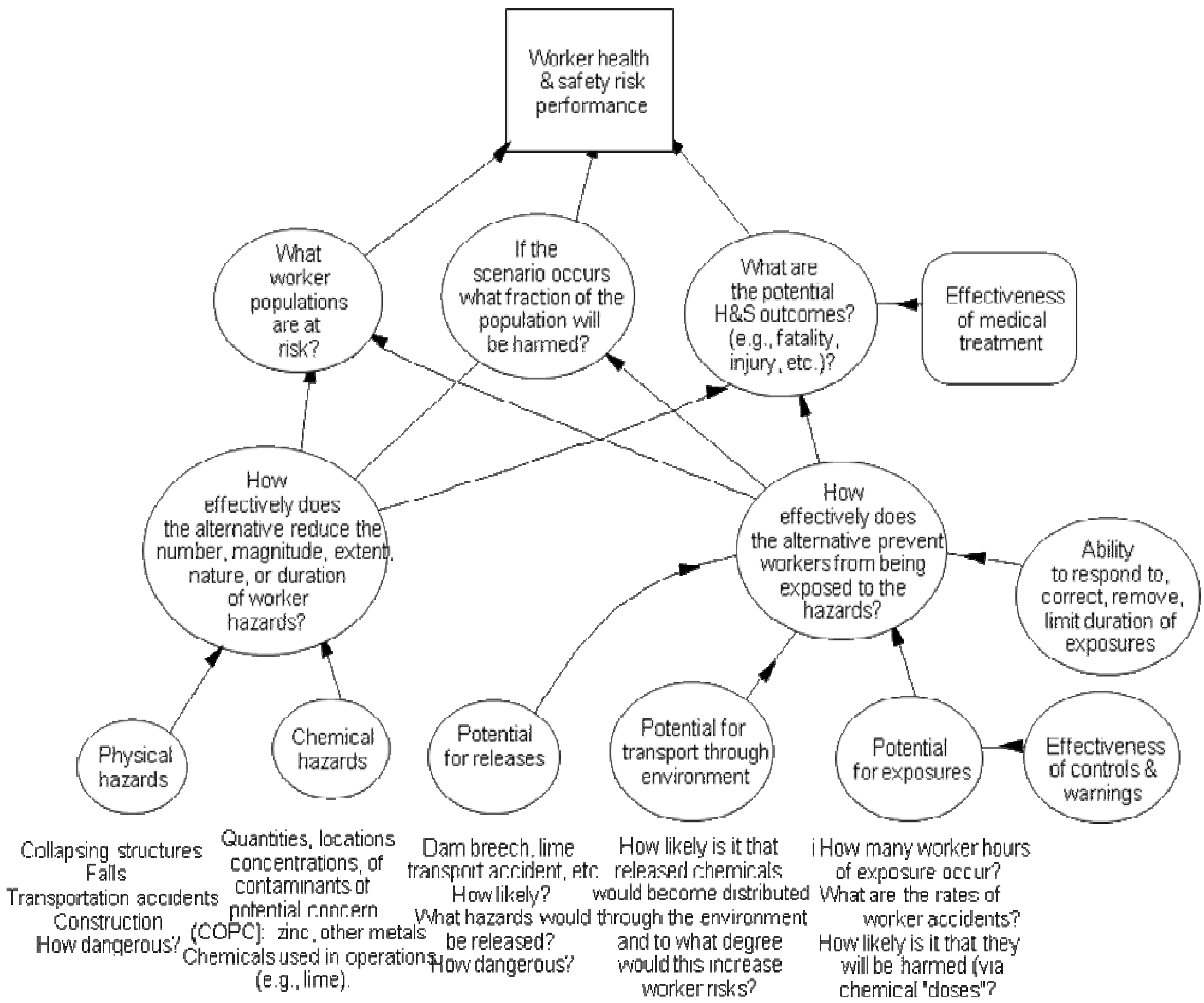


Figure 9.3. Factors influencing performance on worker health and safety

Scoring Results and Logic Summary

Figure 9.4 shows the worker health and safety performance estimates for the component alternatives, expressed against the scoring scale, for the short- and long-term time periods.

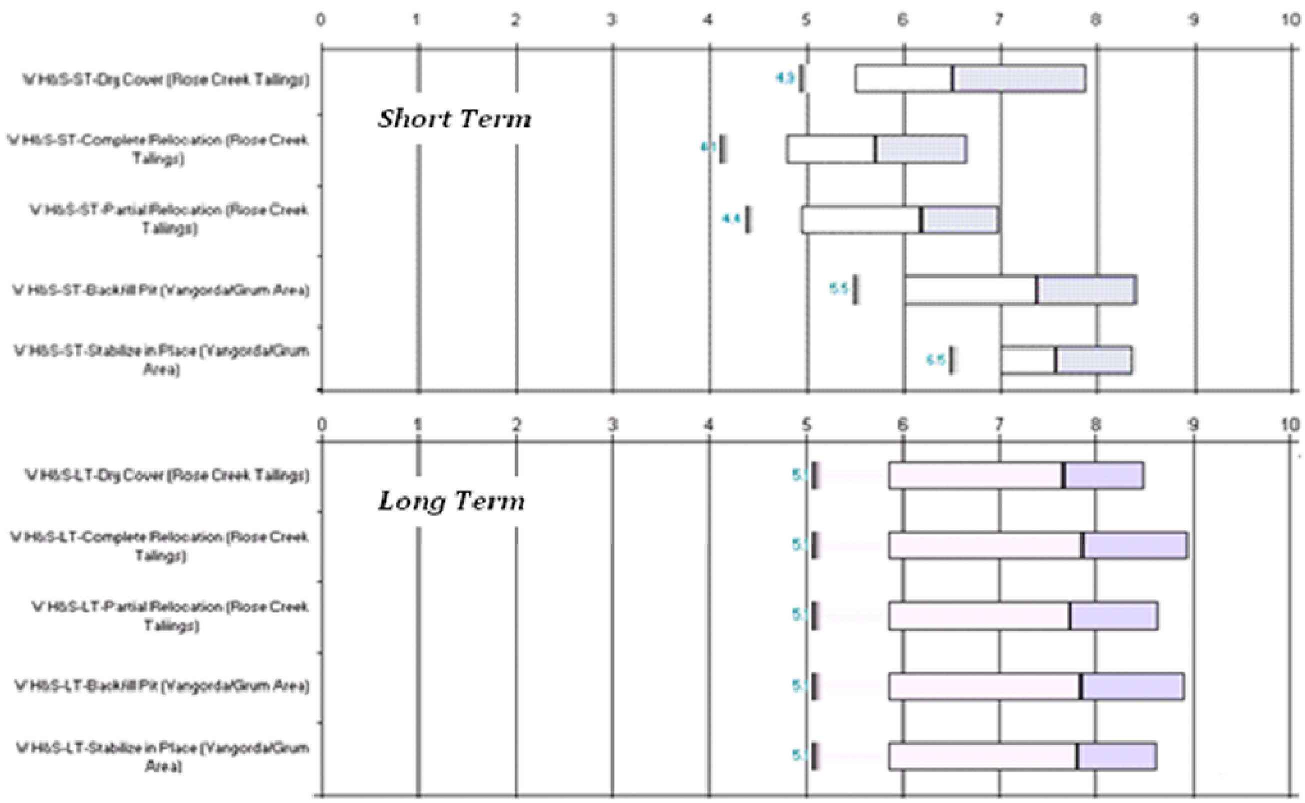
Assessment Results, Short Term

1. For the short term, “Dry cover” on the Faro side and stabilize in place on the Vangorda/Grum side are estimated to produce the least worker risk in the short-term time period compared to other alternatives. “Dry cover” performance ranged from poor/mediocre (5.5) to good (7.9) with a median of mediocre/fair (6.5); in comparison, “Complete relocation” performance estimates ranged from very poor/poor (4.8) to mediocre/fair (6.7) with a median of poor/mediocre (5.7). This result derives from estimates of the lower worker hours involved and the higher risks associated with moving materials.

Assessment Results, Long Term

1. For the long term, performance estimates range between mediocre (6) and good/very good (8.5 – 8.9) with medians clustered in the upper 7’s (fair/good). All alternatives involve the same water collection and treatment risks and many site features that would be subject to monitoring and inspection are common including the surface water and groundwater management systems. Not surprisingly, the spread indicates a higher degree of uncertainty in long term performance.

2. Long term performance estimates are very similar, although on the Faro side performance scores suggest a slight advantage for “Complete relocation” likely due to a slightly lower level of worker-hours required for maintenance and monitoring. On the Vangorda/Grum side there is little appreciable difference between options for worker health and safety over the long term.



Performance estimated on 0-to-10 (log) scoring scales. Precise meanings of scores depend on objective (see scoring scales). In general, 10 = ideal performance (no adverse effects), 0 = disastrous performance. A drop in score of 1 unit represents a situation approximately 3 times as bad.

Figure 9.4. Performance estimates for the worker health and safety objective over the short and long terms

9.3 Maximize Restoration, Protection and the Enhancement of the Environment

Judgment Process

Table 9.3 summarizes the key environmental factors that were identified as requiring consideration for assessing the alternatives (Slater, September 2007).

Table 9.3. Possible discriminating environmental interactions

Time frame	Normal Scenario	Risk Scenario
Faro Mine Area		
Short-Term, (0-40 years)	Air quality, surface water chemistry, sediment quality, fish habitat, fish health and populations	Surface water chemistry, sediment quality, fish habitat, fish health and populations
Long-Term (40 years plus)	Air quality, climate conditions, surface water chemistry, sediment quality, fish habitat, fish health and populations, land area, vegetation abundance, wildlife habitat.	Surface water chemistry, sediment quality, fish habitat, fish health and populations
Vangorda Mine Area		
Short-Term (0-40 years)	Surface water chemistry, sediment quality, fish habitat, fish health and populations	Surface water chemistry, sediment quality, fish habitat, fish health and populations
Long-Term (40 years plus)	Surface water chemistry, sediment quality, fish habitat, fish health and populations, land area, vegetation abundance, wildlife habitat and aesthetics.	Surface water chemistry, surface water sediment concentrations, sediment quality, fish habitat, fish health and populations

For each of these factors, information was gathered regarding the nature of anticipated effects; (2) the extent of effects including areas, ecology, structure and facilities affected; (3) magnitude of effects; (4) frequency of effect occurrence; (5) duration/reversibility of effect; and (6) ecological context. This information base was then used by each Assessment Team member as the foundation for their judgments of the environmental performance of each alternative over the short and long terms.

The Scale used for scoring alternatives is shown below in Table 9.4.

Table 9.4 Scale used for scoring environment

Score	Definition
10	Ideal performance. No adverse impact to any aspect of the environment, including aesthetics. The alternative fully restores and protects all water, land, air, fish and wildlife to conditions that are equal to or exceed that which existed prior to the mine. Comprehensive monitoring provides assurance.
9	Very good performance. Impacts are insignificant. No violations to environmental standards will occur. Although some minimal aesthetic affects may remain, the alternative fully restores and protects all high-value resources. Cleanup and monitoring is best-practice.
8	Good performance. Some minor, localized, temporary impacts to environmental resources. Any violations to standards are minor; exceedences will self-correct within the year. Monitoring is adequate to allow problems to be identified and addressed in a timely fashion.
7	Fair performance. Some exceedences of applicable standards and/or localized, short-term impacts to environmental resources will occur. Effects on plants, fish, and wildlife will be mild and self-correcting within about 3 years.
6	Mediocre performance. There will be a few serious violations of applicable environmental standards. Effects on environmental resources will be significant, but localized and correctable. Regional abundance of the important species will not be seriously affected. Self-correcting in about 10 years.
5	Poor performance. Significant violations and significant problems. There will be serious but correctable damage to some highly valued ecosystem components. Regional abundance of some important species will be affected, and adverse effects will not persist for more than a generation.
4	Very poor performance. Serious problems. Moderate-scale, long-term, ecosystem damage. Regional abundance of important species impacted over multiple generations. Not entirely correctable.
3	Bad performance. Very serious, moderate-scale problems with irreversible (permanent) damage to some of the most highly-valued ecosystem components. Between scores of 2 and 4.
2	Very bad performance. Major problems. Permanent, large-scale, ecosystem damage. Regional loss of some key resources.
1	Terrible performance. Critical problem. Loss of some ecosystem functions. Between scores of 0 and 2.
0	Abominable performance. An environmental disaster. Permanent, large-scale loss of many key species and irreparable damage to ecosystem function.

Factors Influencing Performance

Figure 9.5 shows graphically the factors that the Assessment Team considered important to environmental performance.

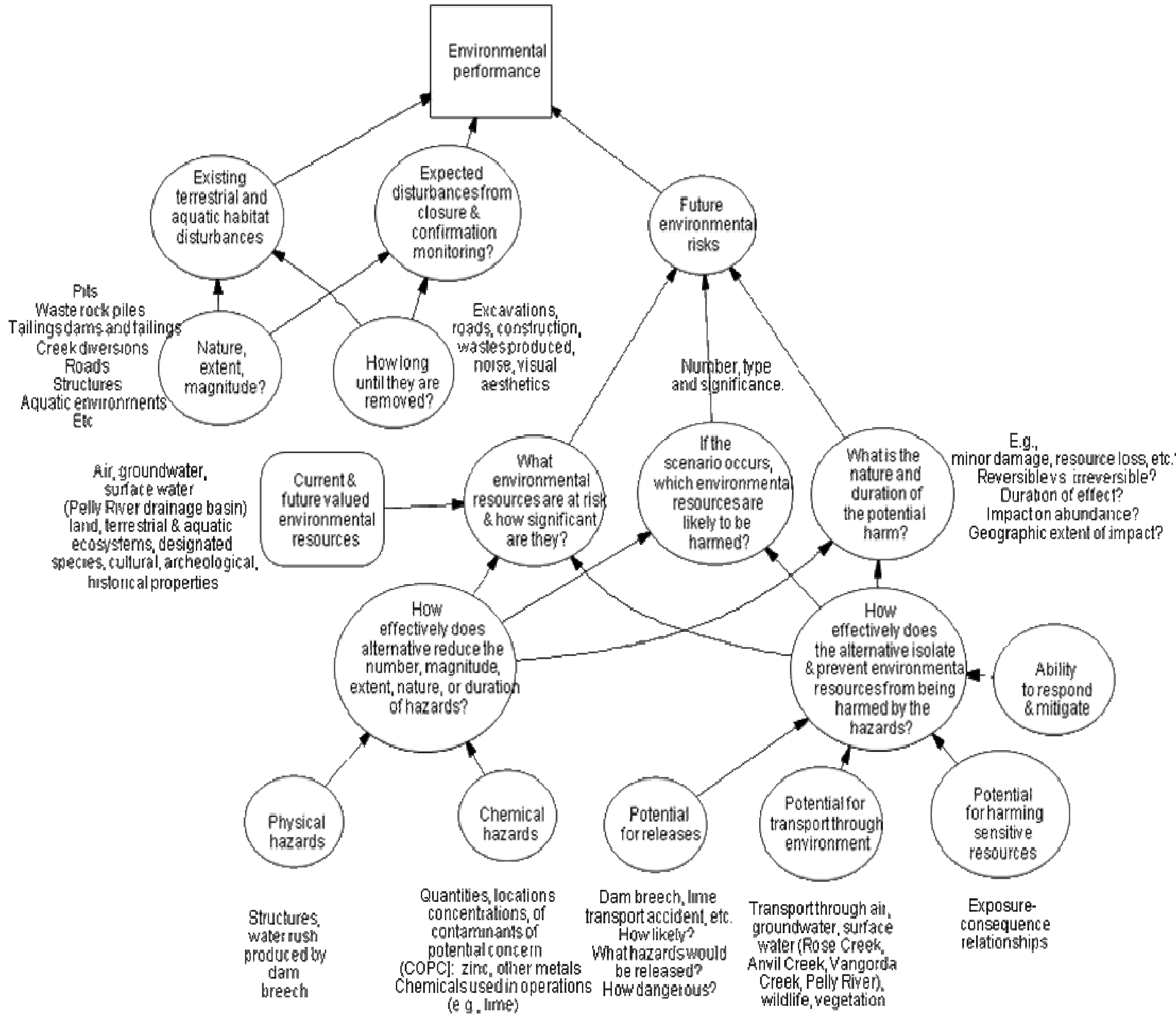


Figure 9.5. Factors influencing performance on the environmental objective

Risk Scenarios

Table 9.5 below lists the risk scenarios for the Faro side that were presented for consideration by the Assessment Team, and Table 9.6 lists those for the Vangorda/Grum side (Slater, 2007).

Table 9.5. Environmental risk scenarios for the Faro side

Risk Scenario		2006-2007 Risk Ratings – Environmental Risks						Notes
		Alternative 1:		Alternative 2:		Alternative 3:		
		Stabilize Tailings In Place with Dry Cover		Complete relocation of Tailings		Partial Relocation of Tailings		
		Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence	
Structural Risks	Flood exceeding design flood causes failure of Intermediate dam leading to tailings release.	Very Unlikely	Critical	Very Unlikely	Critical	Very Unlikely	Critical	All options - very unlikely/critical, but there may be some difference within this category, especially re: relocation where dam is only in place for short time.
	Rainfall induced upstream slope movement and rainfall event leads to breach of the Intermediate dam.	Unlikely	Major	Very Unlikely	Major	Very Unlikely	Major	Assume no release of tailings - only water. If tailings released, consequences are similar to above risk.
	Dam stabilization ineffective leading to a breach of the Intermediate or secondary dam during an earthquake.	Very Unlikely	Critical	Very Unlikely	Critical	Very Unlikely	Critical	All options - very unlikely/critical, but there may be some difference within this category, especially re: relocation where dam is only in place for short time.
	Partial blockage of Rose Creek channel causing overtopping of diversion causing erosion and release of tailings, and/or affecting relocation operations.	Unlikely	Major	Very Unlikely	Major	Very Unlikely	Major	
Operational Risks	While government commits the initial capital subsequent changes in government or other circumstances curtail or reduce the availability of the required long term funding for operation and maintenance, leading to permanent discontinuation of O&M activities, reduction in level of O&M activities or failure to complete some project components. Time period is several hundred years (500-1000).	Unlikely	Critical	Unlikely	Critical	Unlikely	Critical	Non Discriminator Ratings reflect worst case condition of curtailed funding leading to discontinuation of project activities - assumption that reduced funding would have lower risks.
	Shutdown or systematic failure of groundwater collection system in tailings area for approximately 2 weeks leads to periodic exceedance of site specific criterion	Likely	Moderate	Unlikely	Moderate	Likely	Moderate	Likelihood for relocation considers failure - possibly during valley clean-up, but risk is considered over 500-1000 years - therefore likelihood less for this option.

Table 9.5. Environmental risk scenarios for the Faro side

Risk Scenario		2006-2007 Risk Ratings – Environmental Risks						Notes
		Alternative 1:		Alternative 2:		Alternative 3:		
	2 weeks shutdown or systematic failure of groundwater collection system in the Mine area leads to exceedence of site specific criteria	Likely	Moderate	Likely	Moderate	Likely	Moderate	Non Discriminator
	Water collection/conveyance and treatment system fails due to technical constraint to operate for approximately 1 year leading to contaminant release	Unlikely	Critical	Very Unlikely	Critical	Unlikely	Critical	Non Discriminator
	Hydraulic mining leads to significant release of tailings or contaminated water	N/A	N/A	Very Unlikely	Major	Very Unlikely	Major	
Performance Risks	Risk of long-term groundwater contamination from tailings, leading to exceedence of water quality guidelines in receiving waters. Possible causes related to performance of gw collection system, performance of covers, performance of cut-off walls, geochemistry predictions, tailings relocation.	Unlikely	Major	Unlikely	Moderate	Unlikely	Major	Short-term/long-term differences in risk may be important and need further consideration.
Performance Risks	Risk of groundwater contamination from mine area, leading to exceedence of water quality guidelines in receiving waters. Possible causes related to performance of gw collection system, performance of covers, performance of cut-off walls, geochemistry predictions, hydrogeology predictions.	Unlikely	Major	Possible	Major	Possible	Major	Non Discriminator
Performance Risks	Risk of direct surface water contamination resulting from performance failures on stream diversion facilities. (North Wall Interceptor, Rose Creek Diversion, North Fork Channel, Faro Creek Diversion, Vangorda Creek Diversion).	Possible	Major	Possible	Moderate	Possible	Moderate	

Table 9.6. Environmental risk scenarios for the Vangorda/Grum side (Slater, 2007)

Risk Scenario		2006-2007 Risk Ratings – Environmental Risks				Notes
		Alternative 1		Alternative 2		
		Backfill Vangorda Pit		Stabilize Waste Rock in Place		
		Likelihood	Consequence	Likelihood	Consequence	
Structural Risks	Geotechnical failure of pit wall below Vangorda Creek diversion leading to release of pit water	Very Unlikely	Major	Unlikely	Major	
Structural Risks	Failure of Vangorda Creek channel over pit leading to increased leakage into pit	Possible	Moderate			Refers only to new channel over pit. Leakage into pit not likely to cause significant public concern, health effects or land use effects.
Structural Risks	Vangorda Diversion fails in 1:100 year flood leading to discharge of contaminated water after 16 days.	Unlikely	Major	Unlikely	Major	Backfill option considers failure during implementation
Operational Risks	While government commits the initial capital subsequent changes in government or other circumstances curtail or reduce the availability of the required long term funding for operation and maintenance, leading to permanent discontinuation of O&M activities, reduction in level of O&M activities or failure to complete some project components. Time period is several hundred years (500-1000).	Unlikely	Moderate	Unlikely	Major	Non Discriminator Ratings reflect worst case condition of curtailed funding leading to discontinuation of project activities - assumption that reduced funding would have lower risks.
Operational Risks	2 weeks shutdown or systematic failure of groundwater collection system in the Mine area leads to exceedence of site specific criteria	Likely	Moderate	Likely	Moderate	Non Discriminator
Operational Risks	Water collection/conveyance and treatment system fails due to technical constraint to operate for approximately 1 year leading to contaminant release	Unlikely	Major	Unlikely	Major	Non Discriminator Environmental consequences assumed to be less for VG since the load is expected to be smaller and valuable ecosystem components are located in a small portion of Vangorda Creek that is several km downstream
Performance Risks	Risk of groundwater contamination from mine area, leading to exceedence of water quality guidelines in receiving waters. Possible causes related to performance of gw collection system, performance of covers, performance of cut-off walls, geochemistry predictions, hydrogeology predictions.	Unlikely	Major	Unlikely	Major	

Risk Scenario	2006-2007 Risk Ratings – Environmental Risks				Notes
	Alternative 1		Alternative 2		
Risk of direct surface water contamination resulting from performance failures on Vangorda Creek Diversion.	Unlikely	Major	Unlikely	Major	Stabilize option considers release of contaminated water from Vangorda Pit following failure. Relocate option considers release of solids and water during relocation. Likelihoods are not consistent as one could occur for long period while the other only has a short-term potential (upgraded diversion in long-term though).

The risk scenarios that Assessment Team members identified as most important are as follows.

Short Term

Faro Side

1. Failure of the Rose Creek Diversion in high flow period during the cover placement or during relocation of tailings. The worst implications would probably occur under the "Dry cover" option, the least under the total relocation option because there would be a better chance to collect and treat water during the relocation option (1% - 10% probability of occurrence). Another perspective views "Dry cover" as least dependent on current diversions over the short term (they have been up-graded) and therefore would score a bit better.
2. Failure of the collection system for the "Dry cover" option on the Faro side (1% – 10%); for the relocation options, uncontrolled release of tailings from a spill (25% - 75% probability of occurrence).
3. Poor management of construction work leading to environmental problems. For the "Complete relocation" option, poor management leads to significant tailings or solution release (0.1% – 1% probability of occurrence)
4. Failure of funding during remediation leading to system breakdown. Probability of occurrence estimated at 10 – 45%.

Vangorda/Grum Side

1. Geotechnical failure of the Vangorda diversion channel, in the case of the backfill option, before the relocation of the Vangorda diversion channel. (Assessment team members estimated various estimates of occurrence probability ranging from 2% - 10%).
2. Failure of funding during remediation leading to failure. Probability of occurrence estimated at 10 – 45%.

Long Term

<u>Faro Side</u>

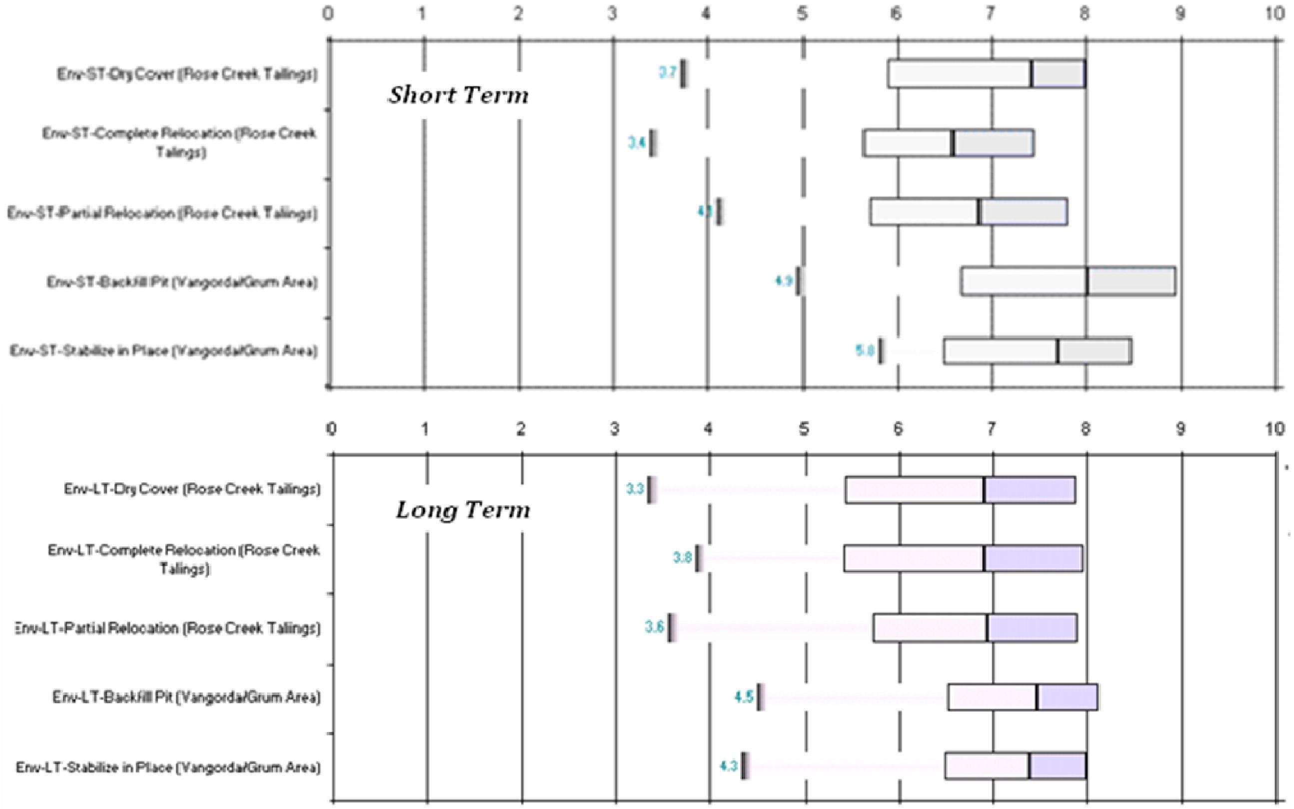
1. For all alternatives, extended shutdown or systematic failure of the groundwater and surface water collection and treatment system in the mine area leading to contaminant releases. This scenario could arise from several situations including operational failure (poor management, loss of funding) or performance failures (water collection system breakdown, cover performance breakdown, unexpected geochemical deterioration). Probabilities of occurrence were generally estimated at 1- 10% but one team member estimated at 95% - 100% probability.
2. For the "Dry cover" and "Partial relocation" options, ineffective dam stabilization leading to breach of intermediate or secondary dams (1% - 10 % probability).

<u>Vangorda/Grum Side</u>

1. For all alternatives, extended shutdown or systematic failure of the groundwater and surface water collection and treatment system in the mine area. This scenario could arise from several situations including operational failure (poor management, loss of funding) or performance failures (water collection system breakdown, cover performance breakdown, unexpected geochemical deterioration). Probabilities of occurrence were generally estimated at 1- 10% but one team member estimated at 95% - 100% probability
2. Failure of the Vangorda Creek Diversion leading to surface water contamination (90% - 100% probability of occurrence). Note that the Vangorda diversion has failed twice in the last five years.
3. For the stabilize in place option, the failures will likely occur more frequently and be more difficult to correct than the backfill option but the implications of failure of the diversion channel in the backfill option are likely to be greater because the storage in the Vangorda Pit allows time to correct the option before there are downstream effects.

Scoring Results and Logic Summary

Figure 9.6 shows the environmental performance estimates for the component alternatives, expressed against the scoring scale, for the short- and long-term time periods.



Performance estimated on 0-to-10 (log) scoring scales. Precise meanings of scores depend on objective (see scoring scales). In general, 10 = ideal performance (no adverse effects), 0 = disastrous performance. A drop in score of 1 unit represents a situation approximately 3 times as bad.

Figure 9.6. Performance estimates for the environment over the short and long terms

Assessment Results, Short Term

<u>For the Faro/Rose Creek areas</u>

1. There is some risk to the environment regardless of which alternative is selected. "Dry cover" scores range from mediocre (6) to good (8) with a median of fair/good (7.4) while "Complete relocation" comes in lower ranging from poor/mediocre (5.7) to fair/good (7.4) with a median of mediocre/fair (6.6). These scores suggest that the Team would not be surprised to see a few serious violations of applicable environmental standards and some serious but correctable damage to some environmental resources. The higher score for "Dry cover" reflects a sense that the construction process will bring least disturbance to the environment. However, while "Dry cover" is estimated to perform best, even in this case that there will be some localized, correctable minor-to-moderate impacts to some sensitive resources.
2. "Complete relocation" was estimated to pose slightly more risk, with the potential seen for more serious violations of standards. This assessment stems from the elevated risk of contaminant

discharge related to hydraulic monitoring activities and the higher level of activity operating over a longer duration. The relocation options are vulnerable during construction with the "Complete relocation" option scoring the least well as a result even though after construction it is the most robust.

3. As shown by the worst-case scores, the Team is concerned about down side risk for all alternatives - the low-probability (1 chance in 100) possibility of moderate-scale, serious to very-serious damage to the environment that is not entirely correctable. This risk is seen as slightly higher for "Complete relocation" (lower score).

<u>For the Vangorda/Grum areas</u>

1. Scores vary from mediocre/fair (6.5) to very good (9) reflecting an less concern overall on this side compared to the Faro side. In other words, less environmental risk is foreseen, with the most likely outcome being the potential for some exceedences of applicable standards and localized, correctable damage to some sensitive environmental resources.
2. On the Vangorda side, the backfill option performs slightly better because the Vangorda diversion channel will be relocated to a more stable location across the backfilled pit and because a slightly greater area will have been re-vegetated.
3. Although "Backfill pit" is estimated to most likely pose less risk than "Stabilize in place," this alternative was seen as carrying greater down side risk, i.e. a higher probability existed for a low-probability but high-consequence event leading to the possibility of serious, but correctable, damage that might affect the regional abundance of some valued species.

Assessment Results, Long Term

<u>For the Faro/Rose Creek areas</u>

1. Performance scores vary from poor/mediocre (5.5) to good (8) with a median of fair (just under 7) indicating that the most likely outcome being the potential for some exceedences of applicable standards and localized, correctable damage to some sensitive environmental resources.
2. The wide spread of the scoring range indicates considerable uncertainty over performance for all of the alternatives.
3. All alternatives were viewed as posing serious down-side risk, with "Dry cover," and, to a lesser degree, "Partial relocation," being seen as somewhat more risky. Team scores indicate a belief that there is a small chance of serious, irreversible damage occurring that would affect the regional abundance of some important species.
4. The "Dry cover" is estimated to have a somewhat greater down-side risk because of the dependence on containment in the valley. Some argued that "Complete relocation" would perform slightly better for several reasons: (1) less chance of a dam failure; and (2) does not require as high contaminant collection efficiency

For the Vangorda/Grum areas

1. Scores vary from mediocre/fair (6.5) to good (8) with a median of fair/good (7.5). This assessment is better than the the Faro/Rose Creek side. Vangorda/Grum is also scored as having less down side risk and greater certainty. In other words, the likely environmental impact is viewed as milder than the Faro side regardless of the alternative selected.
2. The backfill pit option may perform marginally better, reducing water treatment needs and allowing re-vegetation of a slightly greater area.

9.4 Maximize Local Socio-Economic Benefits

Judgment Process

To Yukoners living in the local area and throughout the Yukon, socio-economic effects will be felt as a result of the combined set of activities occurring at any point of time within the project boundaries. As a result, the socio-economic assessments – local and Yukon – focused on the six combinations of alternatives, as shown below in Table 9.7, rather than the individual project components as is the case for the assessments against other objectives.

Table 9.7. The six composite alternatives

Alternative	***Faro Mine***	***Rose Creek Tailings***	***Vangorda/Grum***
Dry Cover plus Backfill	Upgrade Faro Creek Diversion	Stabilize Tailings in Place, Dry Cover	Backfill Vangorda Pit with Waste Rock
Complete relocation plus Backfill	Upgrade Faro Creek Diversion	Complete relocation	Backfill Vangorda Pit with Waste Rock
Partial Relocation plus Backfill	Upgrade Faro Creek Diversion	Partial relocation	Backfill Vangorda Pit with Waste Rock
Dry Cover plus Stabilize Waste Rock in place	Upgrade Faro Creek Diversion	Stabilize Tailings in Place, Dry Cover	Stabilize waste rock in Place
Complete relocation plus Stabilize Waste Rock in place	Upgrade Faro Creek Diversion	Complete relocation	Stabilize waste rock in Place
Partial Relocation plus Stabilize Waste Rock in place	Upgrade Faro Creek Diversion	Partial relocation	Stabilize waste rock in Place

More than any of the other assessments, the degree of success at achieving socio-economic objectives is linked to the assumptions embedded in the implementation strategy (summarized in Chapter 7) particularly the key assumptions summarized in Table 9.8.

Table 9.8. Implementation strategy assumptions important for assessing socio-economic implications

Topic	Assumption
Financial Surety	For normal operating scenarios, it is assumed that the resources for the project will be available from the federal government as needed.
Construction phase timing	15 years, regardless of alternative chosen
Employment phasing; pace of development	Smoothed to greatest extent possible to reduce peaks and valleys in employment
Numbers of employed during 15 year construction period	About 60 labourers and 10 professional, annual average. There will be higher seasonal peaks – 10 more for stabilize tailings in place and 25 more for Complete tailings relocation.
Source of these 70 workers, for all alternatives	• 20 from Ross River (10 permanent, 5 seasonal, 5 working on reclamation and traditional knowledge research) • 15 from Faro (10 permanent, 5 seasonal) • 15 from outside and move to Faro, 10 commute from elsewhere in the Yukon;10 commute from outside Yukon

Socio-economic foundation material for the assessment was compiled by Assessment Team member, Dan Cornett, Access Consulting Group (Cornett, 2007). Potential socio-economic effects arising from the project were identified in the Assessment Team generated influence diagram (see below) as well as the report *Preliminary Socio-economic Evaluation of the Sample Alternatives for the Faro Mine Closure Final Report* (Zanasi et al, March 31, 2007).

Potential local social effects that were used in the assessment are summarized in Table 9.8, and potential local economic effects that were considered are summarized in Table 9.9.

Table 9.9. Potential local social effects considered in the assessment

Direct	Indirect
Demographics	
increase in population and/or composition (Faro/Ross River/Pelly Crossing)	
disruption of current composition (youth and elders, men and women) due to employment labour requirements	
Community Wellness	
increased risk of substance abuse and therefore family violence	increased demand for health and social services may lead to enhanced services. May also lead to lower levels of services due to high demand and no capacity.
inappropriate expenditure of income	
strengthening local social structure and network. Newcomers diversifying community skills and spending	
effects on workers mental, physical and cultural health (+/-). Positive aspects of healthy work environment. Negative aspect of poor working environment.	
newcomers create social disruption in community - drugs & alcohol, male workers seeking female partners	
a-cultural forces effect FN individuals (culture, language, traditional lifestyle)	
effects on family mental, physical and cultural health	
Justice	
possible change in local crime rate	increased demand for law enforcement/justice services due to population growth. May also lead to enhancement of services
Education and Training	
change in individuals' skill and education levels through training	increased demand for educational services may lead to enhancement of services due to population growth. May also lead to lower levels of services
incentive for youth to stay in school	
lasting life long skills	

Table 9.10. Potential local economic effects considered in the assessment

Direct	Indirect
Employment	
project activities generate economic benefits and growth for individual, families and community. Creates local employment near local community. Opportunity for greater income.	economic benefits will reduce community unemployment, and/or create financial inequality in community
project generates job uncertainty due to lack of stability and predictable employment community	lasting life-long skills
lack of success of marginally employed people keeping jobs	
Business Opportunities	
increased business opportunities and business growth potential locally	
increased business diversification potential locally and regionally	
Infrastructure and Community Services	
increased demand on services and infrastructure - local communities	
greater utilization and cost effectiveness on existing infrastructure, locally and regionally	

The above factors were evaluated for each alternative using the assessment criteria of the Yukon Environment and Socio-economic Assessment Board (YESAB). Assessment Team members were provided with this material as a foundation for their assessment.

The scale used for scoring local socio-economic performance is provided below in Table 9.11.

Table 9.11. Scale used for scoring Local Socio-economic performance

Score	Definition
10	Ideal. All agree substantial benefits are provided in all 4 benefit areas to Kaska & Selkirk First Nations and to Faro. No problems occur in any of the 6 indicators. There are no concerns regarding the distribution of benefits and no-one experiences difficulties associated with any eventual decline or discontinuation of benefits.
9	Very good. Nearly everyone agrees that local socio-economic benefits are substantial in all 4 areas. There are no significant problems in any of the 6 indicators. A few are dissatisfied either because they hoped for more benefits or because they feel there are inequities in the way benefits are distributed.
8	Good. Nearly all agree that substantial benefits are provided in at least 3 of the 4 areas. Some are not satisfied, but there are no significant problems in any of the 6 indicators..
7	Fair. Most believe that significant benefits are provided, but many are not completely satisfied. Minor problems occur in in at least one of the 6 indicators.
6	Mediocre. The majority agree significant benefits are proved, and most are better off, but the majority are not satisfied and believe more should have been done. A moderate problem occurs in at least one of the 6 indicators.
5	Poor. Significant benefits occur in only one of the 4 areas. Some are better off and some are worse off. On balance, there is no real improvement. A serious problem exists in at least one of the 6 indicators.
4	Very poor. Nearly everyone is dissatisfied with benefits and many believe they are worse off. Some serious problems in several of the 6 components.
3	Bad. Some benefits are provided but they are inadequate. Serious problems result in several of the 6 indicators and most believes they are worse off.
2	Very bad. No significant local social-economic benefits are provided and major problems occur in several of the 6 indicators. Nearly everyone believes they are worse off.
1	Terrible. No significant local socio-economic benefits are provided in any of the 4 areas and critical problems occur in at least half of the 6 indicators. Everyone is worse off.
0	Abominable. No local socio-economic benefits are provided in any of the 4 areas. Disastrous problems occur in the 6 indicators.

The four benefit areas referenced in the scale are: (1) training and skill development; (2) job & business opportunities; (3) tourism & educational opportunities; and (4) other. The six indicators of socio-economic quality referred to in the scale are: (1) sense of well being; (2) infrastructure & services; (3) trust in government; (4) costs & income to government; (5) local economy; (6) income and family economics

Table 9.12 provides a summary of considerations used by the Team when scoring socio-economics.

Table 9.12. Considerations used to assess socio-economic quality

Component	No Problems	Problems
Sense of well-being	People confident in future, no fears, youth inspired, sense of self-worth, people happy; belief in cultural integrity & strength.	People pessimistic about future, have fears, no sense of self-worth, unhappy; loss of cultural integrity.
Infrastructure & services	Adequate infrastructure for water, sewage, energy, housing, communications, recreation, & education. Excellent health & social services, education & training, recreation, day care, seniors' support, food availability, and retail services.	Inadequate infrastructure for water, sewage, recreation, & education. Poor health and social services, inadequate education and training, recreation, day care, seniors' support, food availability, and retail services.
Trust in government	People trust government	People distrust government
Costs & income to government	Government income sufficient to fund needs, taking into account pace and scale of costs.	Government income insufficient to fund needs, taking into account pace and scale of costs.
Local economy	Growing, diverse economy. Strong small business, Stable, resilient economy. Opportunities. No boom/bust.	Declining economy becoming less diverse. Weak small business. Unstable, less resilient. economy. Few opportunities. Boom/bust.
Economics for individuals and families	High-quality jobs, healthy individual and family incomes, entrepreneurial opportunities, low taxes, increasing but affordable property values.	Few quality jobs, individual and family incomes decline, few entrepreneurial opportunities, high taxes, declining property values.

Risk Scenarios

The dominant risk scenarios identified by the Team as most important for the local socio-economic assessment were as follows.

Short Term

1. Significant environmental incident from failure of treatment and water collection systems; creek diversion breach; dam failure and tailings release.
2. Institutional failure leading to system breakdown – reduction in government funding, bankruptcy of operating contractor.
3. Major political problem leading to system breakdown – significant disagreement between affected communities.
4. Significant labour unrest leading to system breakdown – long-lived and violent wildcat strike.
5. Poor site management and poor communication leading to .system breakdown.

Estimates of the probability of risk scenarios occurring on the short term ranged from 0.1% - 5%.

Long Term

1. Significant environmental incident from failure of treatment and water collection systems; creek diversion breach; dam failure and tailings release (0.1% - 5% probability of occurrence). Within the Assessment Team there was a divergence of opinion as to the dominant implication of such an environmental incident. For some, the devastation would out weigh any short term local economic benefits brought by the clean-up activity. For others, the increase in economic activity brought by the system failure would bring net positive benefits to the local communities.
2. Institutional failure leading to system breakdown – reduction in government funding, bankruptcy of operating contractor.

3. Major political problem leading to system breakdown – significant disagreement between affected communities.

Estimates of the probability of risk scenarios occurring on the long term ranged from 0.1% - 60%. The higher end of probabilities relates to the long time frame and the inevitability of failure sometime during that long time period.

Factors Influencing Performance

Figure 9.7 shows graphically the factors that the Assessment Team considered important to local socio-economic performance.

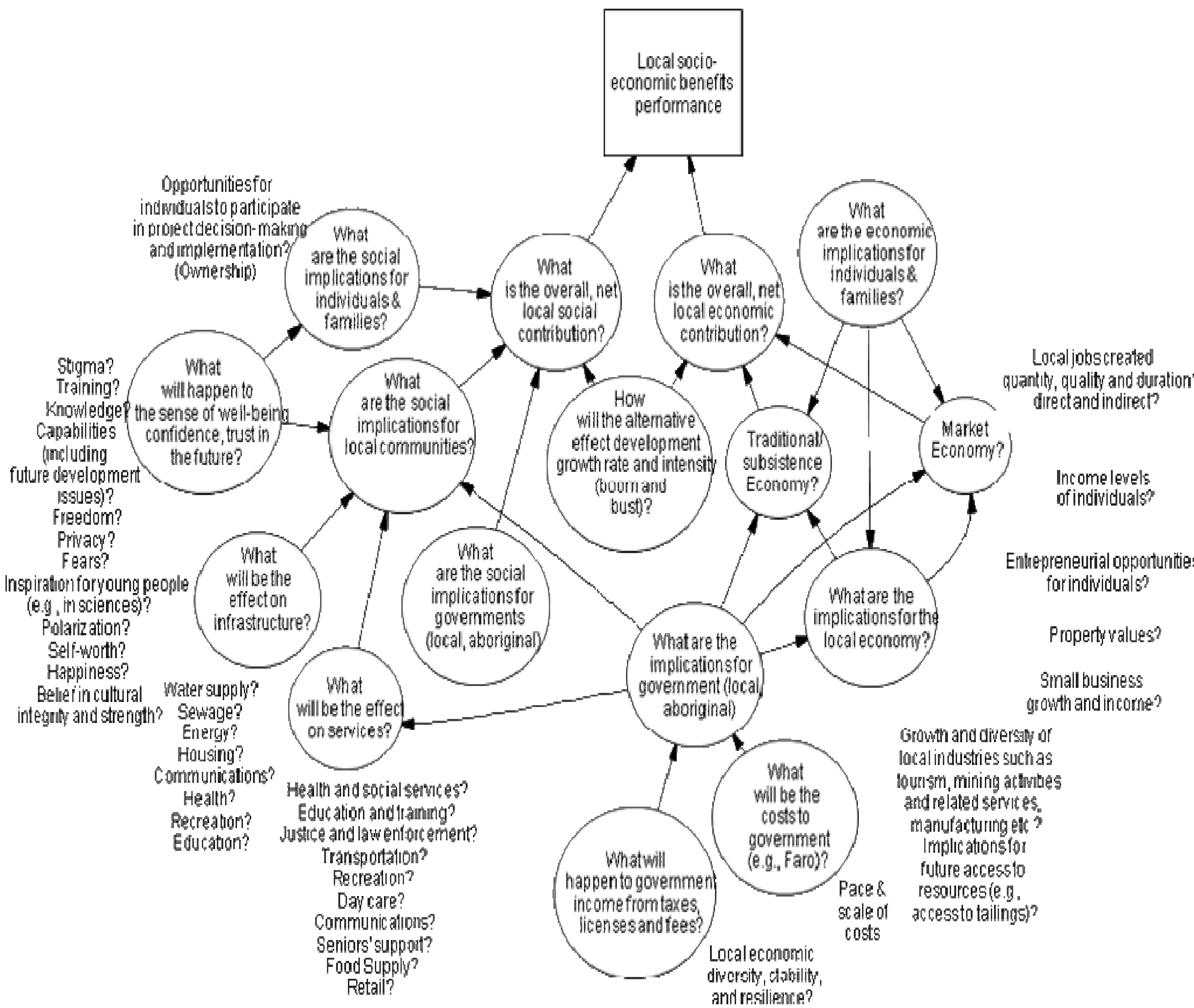


Figure 9.7. Factors influencing performance on the local socio-economic objective

Scoring Results and Logic Summary

Figure 9.8 shows the local socio-economic performance estimates for the composite alternatives, expressed against the scoring scale, for the short- and long-term time periods.

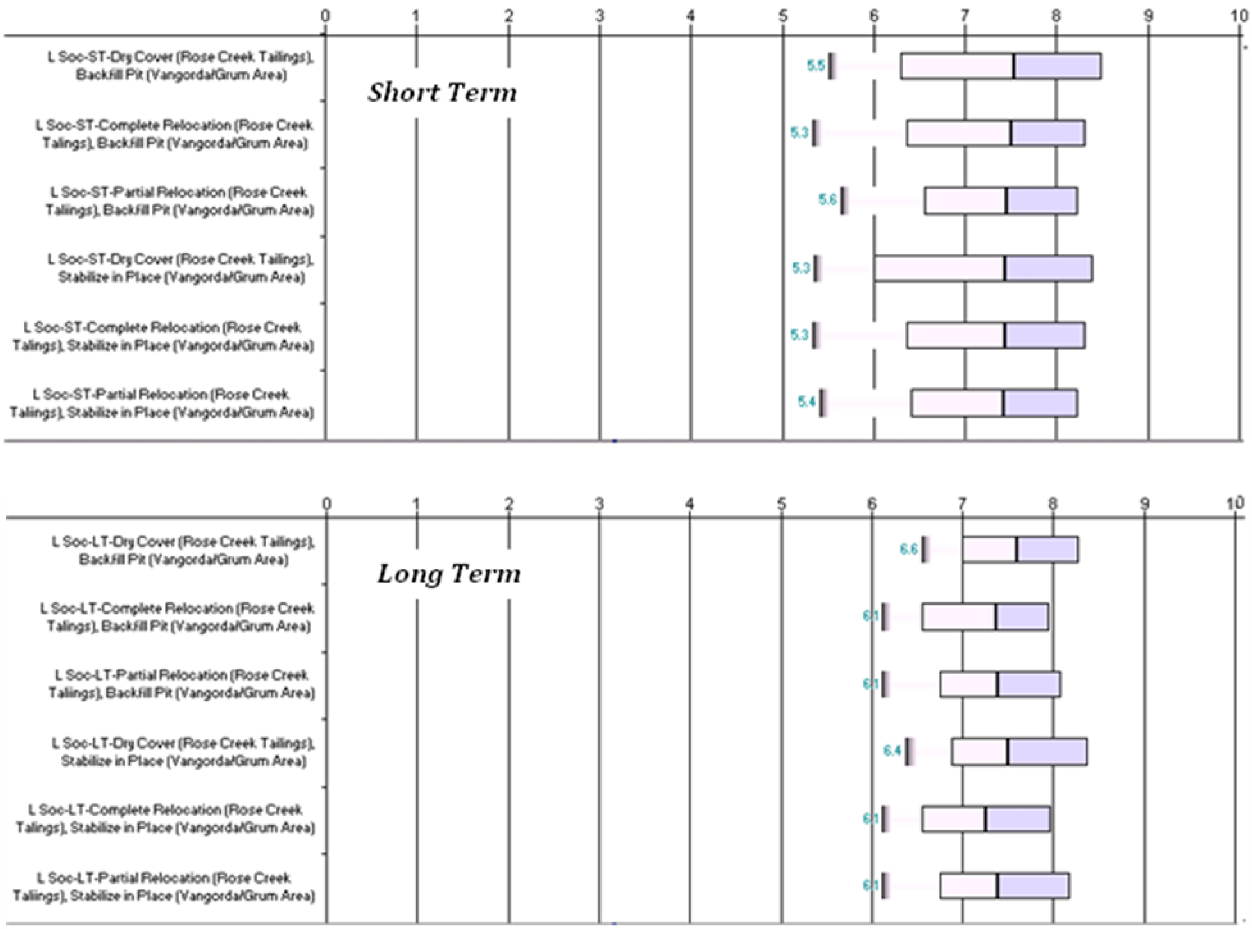


Figure 9.8. Performance estimates for local socio-economics over the short and long terms

Assessment Results, Short Term

1. In the short term, all six combinations are estimated to perform similarly and fairly well with nearly equal median scores. Scores ranged from mediocre (6) to good/very good (8.4) with a relatively close median between fair and good (7.4 – 7.5). The result indicates a sense that all alternatives will provide significant to substantial benefits, though not all Yukoners will be satisfied**.**

2. The slightly more narrow width for the range of scores estimated for "Partial relocation" with "Backfill pit" may indicate that the Team perceives slightly less uncertainty regarding short-term socio-economic performance for this combination. However, the results for "Partial relocation" alternative may also simply reflect a tendency on the part of members of the Assessment Team to score this alternative in the middle between the other two, generating a result that is not a true reflection of estimating uncertainty about this alternative.

3. The slightly wider range of scores for "Dry cover" with "Stabilize in place" may indicate slightly more uncertainty regarding short-term, local socio-economic performance.

4. The closeness of these results is directly related to the decision of the Implementation Team to spread construction activities over 15 years regardless of the combination chosen and to pace the combined set of construction activities on the Faro and Vangorda/Grum sides in a way that smooths peaks and valleys in employment. The team recognized that there are positives and negatives linked to having more money in the community and that success at making it positive depended more on the implementation strategy than on the particular alternative chosen.

Assessment Results, Long Term

1. All alternatives were again estimated to most likely perform fairly well and roughly the same. The scores are similar to those for the short term, but with a narrower spread and less downside risk. Together this suggests more confidence that alternatives will perform fairly well in the long term.

2. The more narrow ranges for long-term performance indicate more confidence that the alternatives would all perform fairly well in the long-term period.

3. Combinations that involve "Dry cover" for Rose Creek Tailings scored slightly better indicating better local socio-economic performance. This reflects the larger expenditure for materials related to ongoing site management.

9.5 Maximize Yukon Socio-Economic Benefits

Judgment Process

As with the assessment for the Local Socio-economic objective, this assessment focused on the six combinations of alternatives as shown in Table 9.6 (previous section) rather than the individual project components as is the case for the assessments against other objectives. Again, the degree of success at achieving Yukon-wide socio-economic benefits is more controlled by the implementation assumptions described in Chapter 7 than by the variations in the "technical" closure alternatives currently being considered.

The foundation material for this element of the assessment is compiled in Hodge (11 October 07). Three sets of factors important to assessing the potential success for achieving the Yukon socio-economic objective were summarized for consideration by the Assessment Team: (1) factors influencing the relative social contribution to the Yukon of each alternative; (2) factors indicating the relative effect of alternatives on Yukon development growth rate and intensity; and (3) factors influencing the relative economic contribution to the Yukon of each alternative. Each of these three sets is summarized below in Table 9.13.

Table 9.13. Influencing Factors considered in the Assessment of Yukon-wide socio-economic benefits

Factor	Comment
1. Factors Influencing the Relative Social Contribution to the Yukon of Each Alternative	
Yukon in General	
Overall sense of well-being, confidence in the future *(elements not covered in Objective 1, Public H & S)*	Participatory decision-making process and engagement of Yukoners in the design, construction, and longer term management of the facility, would re-enforce confidence, choice of alternative likely doesn't matter if community and Yukon values are reflected in the result. Not a discriminator.
Fairness in the Distribution of Costs, Benefits, Risks, and Responsibilities	Depends on the details of the implementation strategy. Not a discriminator.
Crime and Justice	Depends on the details of the implementation strategy. Not a discriminator.
Maintenance and nourishment of cultural integrity and traditional knowledge	Depends on the details of the implementation strategy. Not a discriminator.
Education and Training, Knowledge development, management and transfer (research, scientific and traditional knowledge, innovation, future opportunities	Depends on the details of the implementation strategy. Not a discriminator.

Government of Yukon	
Respect for Government	Depends on the details of the implementation strategy and how it was developed. Not a discriminator.
2. Relative Effect of Alternatives on Yukon Development Growth Rate and Intensity	
Pace of Development, Growth rate and intensity during the construction period, as implied by the workforce profiles provided by SRK	Small variations across alternatives
Pace of Development, Growth rate and intensity during the construction period, as implied by the cash-flow profiles provided by SRK,	Small variations across alternatives
Overall Long term implications	Over the long term, the steady employment of a small workforce will contribute in a small way to overall Yukon economic strength, diversity, and stability. Not a discriminator.
3. Factors Influencing the Relative Economic Contribution to the Yukon of Each Alternative	
Yukon in General (non-local)	
Order-of-magnitude total cost estimate, 0-40 years, cumulative costs in current dollars (not all of this will accrue to the Yukon)	Variations allow ranking of alternatives
Rough estimate of annual average expenditures required over the long term; (most of this, if not all will accrue to the Yukon)	Variations allow ranking of alternatives
Average Workforce during construction in person-years[1] (ratio)	Variations allow ranking of alternatives
Peak Workforce during construction In person years	Variations allow ranking of alternatives
Direct Yukon non-local employment during construction	SRK estimate that for all alternatives, employment will be about 60 workers directly employed annually during construction over 15 years with another 10 professional – technical - management. Peak employment is expected to reach 70 to 85 workers depending on the alternative selected. Of these, the implementation strategy is targeting 20 from Ross River, 15 from Faro, 15 from outside the Yukon and move to Faro to become local, 10 will commute from elsewhere in the Yukon and 10 will commute from outside the Yukon. The post construction workforce is estimated at about 10 permanent and 5 seasonal, all living in local communities In sum, direct, non-local employment is targeted to involve about 10 from elsewhere in the Yukon and 10 from outside the Yukon. This is not a definable differentiator at this time.
Indirect employment during construction (based on cost profile	very small differences across alternatives
Average Income levels	Not a definable discriminator for non-local Yukoners
Yukon small business growth, income, strength and diversity	based on cost profile, very small differences

Government of Yukon	
Cost of Services (health, education and training, policing, justice, social services, social assistance)	Not a discriminator.
Cost of Infrastructure (energy, housing, transportation, water and sewer, health, communications, emergency response)	Not a discriminator.
Cost of project oversight	Not a discriminator.
Income to government from taxes, licenses and fees (based on cost estimate profile)	Variations allow ranking of alternatives
Overall contribution to Yukon GDP (based on cost estimate profile)	Variations allow ranking of alternatives

Assessment Team members drew on the above information base to make their assessments.

The same scoring scale was used to score Yukon socio-economic performance as was used to score local socio-economic performance. It is shown in Table 9-11.

Risk Scenarios

The dominant risk scenarios that Assessment Team members identified as most important for Yukon socio-economic assessment were as follows.

Short and Long Terms

1. Failure of treatment /collection systems, creek diversion breach, dam failure and tailings release, leading to some kind of performance failure.
2. Economic pulse from some sort of disaster. Assessment team members varied in seeing the resulting increase in economic activity as a positive or a negative.
3. Project delay or termination as a result of institutional failures and loss of funding.

Estimates of the probability of such risk scenarios ranged from 0.1% to 5%.

Factors Influencing Performance

Figure 9.9 shows graphically the factors that the Assessment Team considered important to Yukon-wide socio-economic performance.

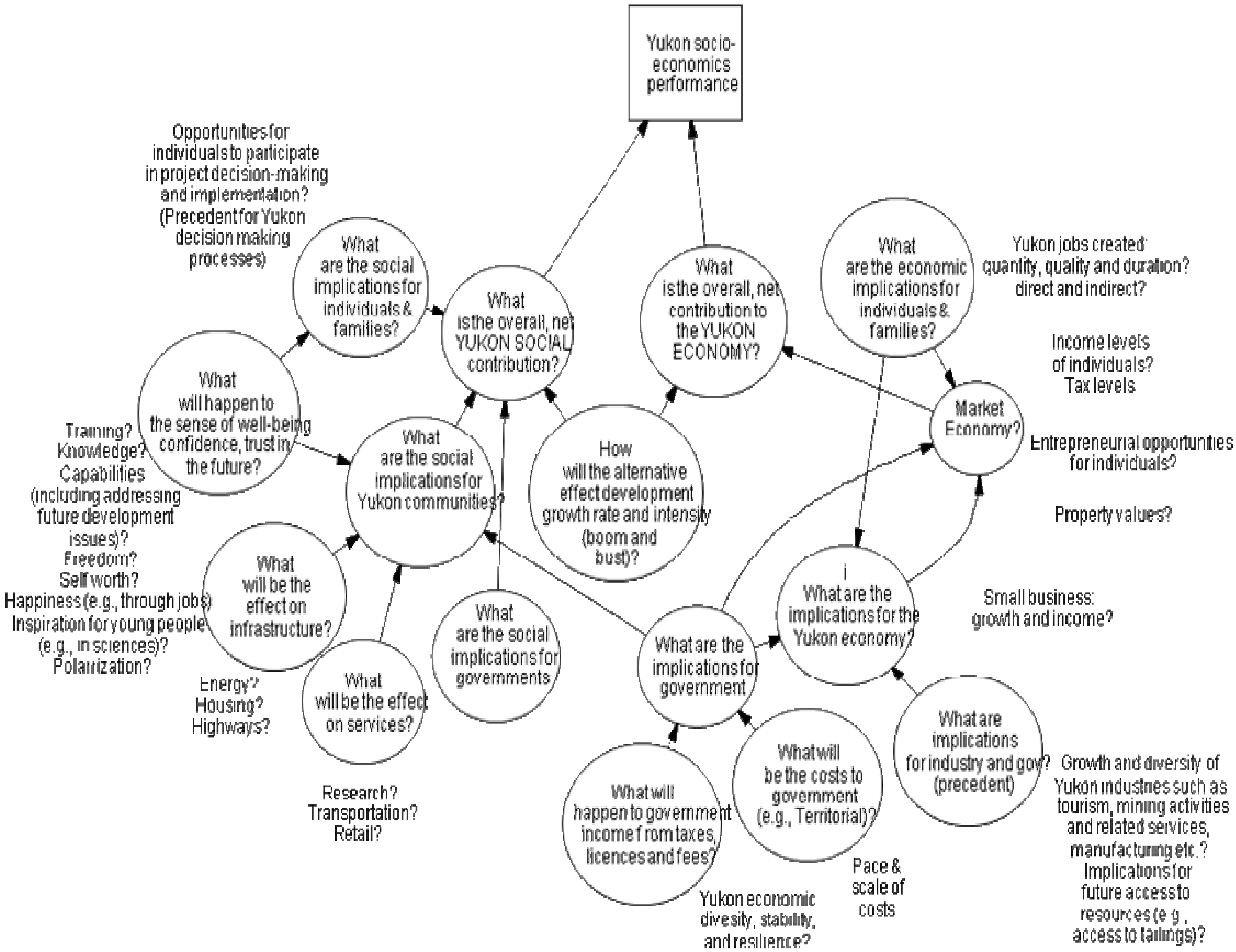


Figure 9.9. Factors influencing performance on the Yukon Socio-economic benefits objective.

Scoring Results and Logic Summary

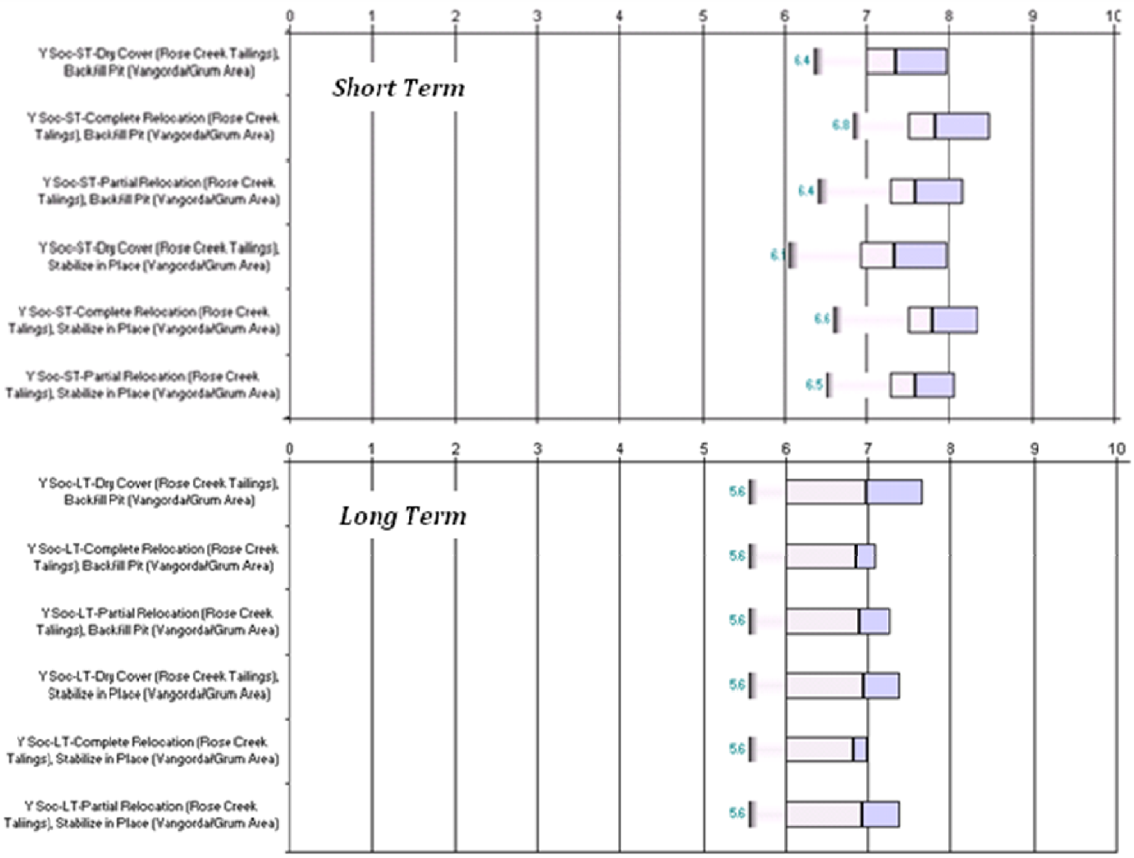
Figure 9.10 shows the Yukon socio-economic performance estimates for the composite alternatives, expressed against the scoring scale, for the short- and long-term time periods.

Assessment Results, Short Term

1. Estimates of performance for the alternatives are between fair (7) and good/very good (8.5), with relatively tight and similar confidence range. “Complete relocation” was estimated to

perform slightly better regardless of which Vangorda/Grum area alternative it was combined with. The two "Dry cover" options are the weakest and carry the greatest downside risk. The "Partial relocation" options lie in an intermediate position.

2. The dominant factor affecting the assessment is the higher level of expenditures and the employment numbers that come with the "Complete relocation" alternatives.



Performance estimated on 0-to-10 (log) scoring scales. Precise meanings of scores depend on objective (see scoring scales). In general, 10 = ideal performance (no adverse effects), 0 = disastrous performance. A drop in score of 1 unit represents a situation approximately 3 times as bad.

Figure 9.10. Performance estimates for Yukon socio-economics over the short and long terms

Assessment Results, Long Term

1. The alternatives were all estimated to perform between fair (6) and fair/good (7.7) (median of fair (7) , indicating the same fair performance over the long term. The two "Dry cover" options score slightly better over the long term, but the greater spread in the scoring range indicates a higher degree of uncertainty. The slightly higher score is related to the higher level of annual expenditures for maintenance activities.

2. All of the alternatives were judged to have the same downside risk.

9.6 Minimize Cost Over the Short and Long Terms

Cost Metrics Used to Compare Alternatives

Over the Short Term. The Assessment Team agreed that the best metric to use in scoring over the short term time horizon would be a present value of the time stream of costs occurring from years 0 through 40. However, the short-term cost estimates that were available at the time (from SRK Consulting) were only expressed as cumulative values over the 15 year construction phase followed by a 25 year period of monitoring and adjustment. Accordingly, the metric for short-term costs was chosen to be cumulative costs over the short-term time period.

Over the Long Term. Over the long term, the Assessment Team used the metric of annual average costs expressed in current dollars. This metric provides an effective way to compare the burden of the financial obligations to future generations.

As discussed in Chapter 8, for purposes of calculating relative performance, a somewhat arbitrary 175 year time frame was used, based on the concept of a "rolling seven generation" responsibility (assumes 25 years/generation) that emerged during the work of Canada's Nuclear Waste Management Organization (NWMO, 2003. Background Paper 8-5). This number could have been 200 years or 500 years; its use did not affect the relative results in terms of cost performance (the same multiplying factor applied to all annual average cost estimates and does not affect the relative size of each in the set).

Note that the Faro Closure Implementation Strategy (Chapter 6) assumes that resources will be provided by the federal government to cover costs as they are needed. Under this assumption, future maintenance costs will be covered by the government of the day and therefore represents an obligation to future generations.

There has been discussion of the concept of developing a permanent trust fund to cover all project costs. Doing so would mean that in theory, the current generation of people (those who create the trust) would pay the full cost of closure thus eliminating all financial obligations to future generations. Under these conditions, the long-term cost objective would disappear from the analysis as all alternatives would score the ideal score (no cost) and long term costs would no longer be a differentiator. However, since in that case all costs would be paid in the short-term, short-term costs would be increased by the amount needed to establish the trust fund.

Judgment Process

Assessing performance on the cost objective is unique amongst the eight objectives being considered in that, as described above, a foundation for the assessment has been provided by the detailed SRK cost estimates. The figures provided by SRK Consulting (Canada) Inc. for the cumulative costs for years 0 – 40 are listed in Table 9-14 below, and those for the annual average costs over the long term are listed in Table 9-15.

Table 9.14. Cost estimate, 0 – 40 years, cumulative dollars, $2007 from SRK Consulting (Canada) Inc. Version 33 (September 2007).

Faro Mine plus Rose Creek Tailings	***Vangorda/Grum***
Upgrade Faro Creek Diversion Dry Cover, Stabilize Tailings in Place $ 439.5 m	Backfill Vangorda Pit with Waste Rock $ 122.0 m
Upgrade Faro Creek Diversion Complete relocation of Rose Creek Tailings $ 681.5 m	Stabilize Waste Rock in Place $ 75.0 m
Upgrade Faro Creek Diversion Partial relocation of Rose Creek Tailings $ 542.5 m	

Table 9.15. Cost estimate, 40 – 500/1000 Years, annual average cost, current dollars from SRK Consulting (Canada) Inc. Version 33 (September 2007)

Faro Mine plus Rose Creek Tailings	***Vangorda/Grum***
Upgrade Faro Creek Diversion Dry Cover, Stabilize Tailings in Place $ 3.57 m	Backfill Vangorda Pit with Waste Rock $0 .69 m
Upgrade Faro Creek Diversion Complete relocation of Rose Creek Tailings $ 2.06 m	Stabilize Waste Rock in Place $ 0.98 m
Upgrade Faro Creek Diversion Partial relocation of Rose Creek Tailings $ 2.91 m	

The cost estimates provided the major input to the Assessment Team's cost estimates. To provide cost estimates for the assessment, Team members focused on (1) for the normal operating scenario – the potential for and extent of variation that might occur from the SRK-provided cost estimates; and (2) the nature of, cost impact, and probability of various cost risk scenarios.

Thus, assessing the performance on the cost objective for the short- and long-term periods involved the following steps:

1. The cost estimates developed by the project engineers (SRK Consulting) were used as a starting point for estimating costs for the normal operating scenario. Using this starting point, each scorer estimated a "minimum" and "maximum" that they felt reflected the range over which these estimates could reasonably vary as a result of the broad range of issues that could arise

under normal operating conditions: maintenance problems, other technical issues, labour shortages etc. The kinds of factors that were considered are summarized below.

2. Each scorer then developed a risk scenario description that represented the most significant concerns for cost increases. They then recorded the minimum and maximum cost estimates they expected for these risk scenarios (as in the normal scenario) as well as estimates of the probabilities that these risk scenarios would occur.

Factors Influencing Performance

The Assessment Team's notional map of factors influencing the performance on cost is provided below in Figure 9-11.

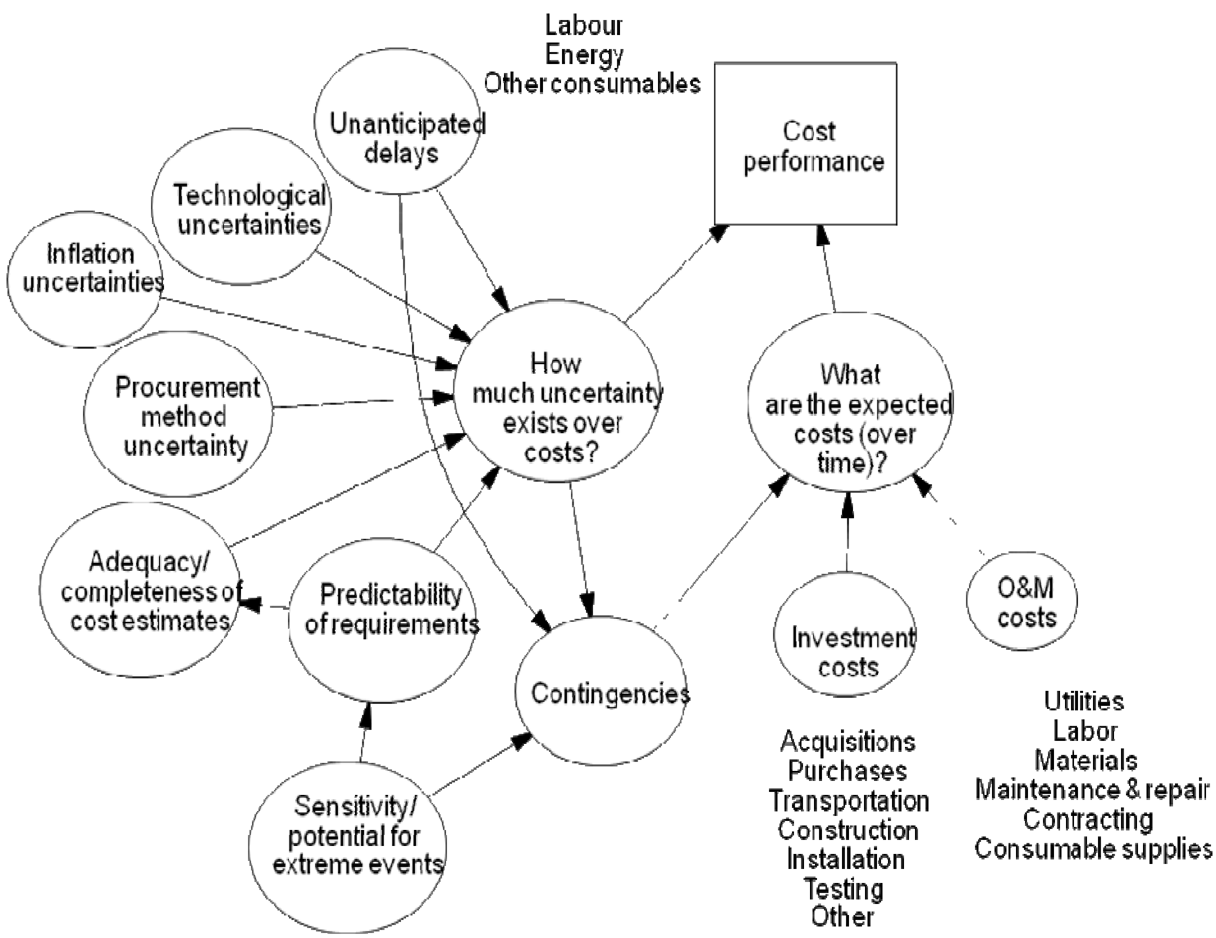


Figure 9.11. Factors influencing cost performance

Risk Scenarios

The following risk scenarios were identified as most significant possibilities for increasing costs.

Short Term

1. Poor management of construction leading to significant issues; in the case of "Complete relocation" on the Faro side, leads to significant tailings or solution release (0.1% – 1% probability of occurrence).
2. Tailings dam failure, diversion failure, unexpected geochemical rise to future 3 conditions (0.5% to 5% risk of occurring).
3. On the Faro side, all options, failure of the collection system to higher contaminant loads and increased costs for collection, even with adaptive management plans in place (1 – 10 % risk of occurring).
4. On the Vangorda/Grum side, for "Stabilize in place," failure of the Vangorda diversion and increased need for water treatment.

Long Term

1. Failure of collection systems (50% - 100% likelihood of occurrence).
2. Failure of collection systems combined with unexpected geochemical rise to future 3 conditions (1% - 10% probability of occurrence)
3. On the Faro side, dam failure for the "Dry cover" and "Partial relocation" options (.5% - 2% risk of occurring).
4. For the Vangorda/Grum side, future 3 geochemistry linked with failure of the collection system (2% - 10% chance of occurring).
5. For the relocation option, also diversion failure (could be higher than expected leakage or blockage leading to flooding and seepage into the pit) leading to flushing of acid products from the backfilled pit (5% - 25% risk of occurring)

Scoring Results and Logic Summary

Figure 9.12 shows the range of costs estimated for each component alternative in the short- and long terms.

Assessment Results, Short Term

<u>Faro/Rose Creek Tailings (all figures in current dollars):</u>

1. "Dry cover" was estimated to have the lowest short-term costs, and the most cost certainty – a confidence range between about $380 million and $500 million, median estimate of $440 million, and a worst case estimate of $622 million.

2. **"**Partial relocation**"** was identified as next least costly, with a confidence range between about $490 million and $630 million. The median estimate was $564 million, and the worst case estimate was $699 million.

3. **"**Complete relocation**"** was assessed as the most costly and the most uncertain, with a confidence range between about $620 million and $745 million. This result stems from a sense that the short-term performance of the "Complete relocation" option is less certain for both normal and risk scenarios. The median estimate was $696 million, and the worst case estimate was just below $1 billion**.**

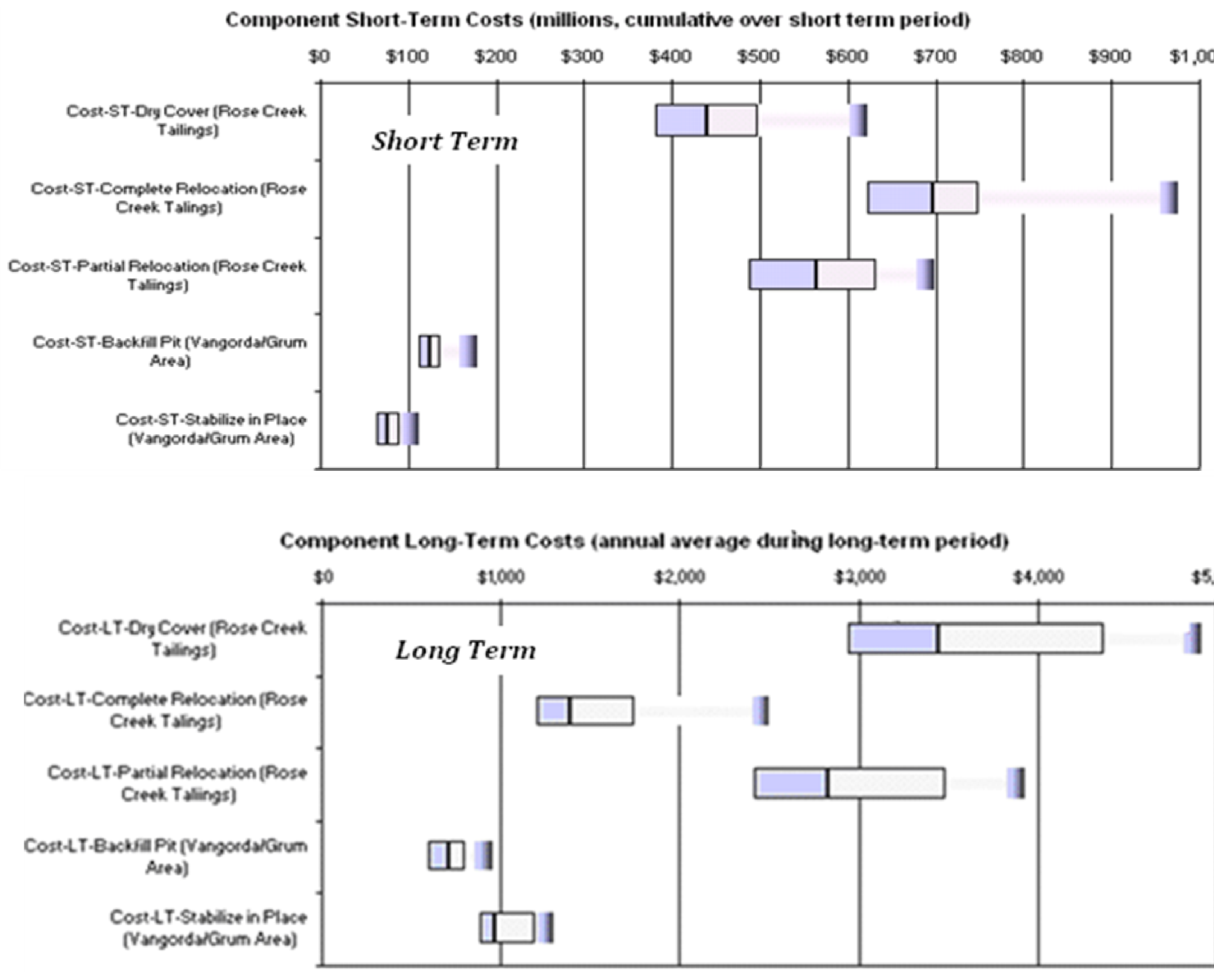


Figure 9.12. Short- and long-term cost estimates. The scale is linear in dollars in both cases. For the short term, the metric is cumulative costs from years 0 to 40, expressed in current dollars. For the long term, the metric is average costs in the long-term time period (averaged over the first 175 years or seven generations), expressed in current dollars

Vangorda/Grum

1. **"**Stabilize in place**"** was estimated to have the lowest short-term costs, with a confidence range between about $60 million and $90 million. The median estimate was $77 million, and the worst case estimate was $113 million.

2. "Backfill pit" was estimated as more costly, with a confidence range between about $110 million and $140 million. The median estimate was $125 million, and the worst case estimate was $179 million.

Assessment Results, Long Term

Faro/Rose Creek Tailings:

1. "Complete relocation" was estimated to have the lowest long-term, annual average cost, with a confidence range between about $1.2 million and 1.75 million. The median estimate was $1.39 million, and the worst-case cost estimate was $2.5 million.
2. "Partial relocation" was estimated next least costly, with a confidence range between about $2.4 million and $3.5 million. The median estimate was $2.83 million, and the worst-case cost estimate was $3.93 million.
3. "Dry cover" was estimated to have the highest long-term costs, with a confidence range between about $2.94 million and $4.38 million annual average per year. The median estimate was $4.38 million, and the worst-case cost estimate was $4.92 million.

Vangorda/Grum

1. "Backfill pit" was estimated to have lower long-term, annual average cost, with a confidence range between about $600 and $800 thousand. The median estimate was $706 thousand, and the worst-case cost estimate was $952 thousand
2. "Stabilize in place" was estimated to be more costly, with a confidence range between about $880 thousand and $1.2 million. The median estimate was $964 thousand, and the worst-case cost estimate was $1.3 million.

Observation: Long- and Short-Term Comparison

Comparison of the two parts of Figure 9.12 shows how short- and long-term performance was estimated to vary among the alternatives. On the Faro side, "Dry cover" is estimated least expensive in the short term but most expensive in the long term. The range of uncertainty and the downside risk increases significantly for the long term. In contrast, "Complete relocation" is most expensive and most uncertain, with greatest downside risk over the short term, and least expensive and least uncertain with less downside risk over the long term.

9. 7 Minimize Restrictions on Traditional Land Use

Assessment Process

Information on the capacity of alternatives to minimize limitations on traditional land use was compiled by Foy (20 September 2007). The concept of traditional land use considered by the Assessment Team included food and cultural activities both on-site as well as down-drainage.

Two influencing factors rose as dominant over others. First, changes to the spirit of the land will lead to voluntary restrictions to traditional land use. These are mostly perceptions of risk and risk impacts which will be driven by confidence in the management, monitoring and overall performance of the site. A second factor is the involuntary restrictions that will be imposed by physical or legal measures initiated at the site by the management system itself and related regulatory system.

The scale used for scoring traditional land use performance is provided below in Table 9.16.

Table 9.16. Scale used for scoring traditional land use performance

Score	Definition
10	Ideal performance. No adverse impact to traditional land use. Site fully restored to natural state.
9	Very good performance. Some remaining aesthetic affects, but only insignificant and impacts on traditional land use. Necessary aquatic resources fully restored. Site allows hunting, trapping trails, trap lines essentially as existed prior to mine. Unimpeded access available at traditional trails.
8	Good performance. Some minor, localized impacts to traditional land use. Few people are effected and for only a limited amount of time.
7	Fair performance. Some moderate, highly localized, short-term limitations to traditional land use. Affects utilization of some, but not all traditional resources.
6	Mediocre performance. Some significant limitations over a small area on traditional land use remain. Between 5 and 7.
5	Poor performance. Significant problems (e.g., reduction in habitat productivity) limit but do not eliminate uses essential for tradition. The impact is over a moderately sized area. Between scores of 4 and 6.
4	Very poor performance. Serious problems result in significant and persistent limitations on traditional land use over a relatively large area. Affects usage of many important traditional resources. Seriously adversely affects traditions for some peoples.
3	Bad performance. Very serious problems. Impacts large area. Between scores of 2 and 4.
2	Very bad performance. Major problems. Key traditional resources lost. Permanent and major limitations on traditional land use over a very large area. Affects usage of nearly all important traditional resources for many people. Traditions lost for many peoples.
1	Terrible performance. Critical problem. Between scores of 0 and 2.
0	Abominable performance. An disaster for traditional land use. Permanent loss of traditional land use opportunities over an extensive area and for nearly all people resulting in irreparable break with traditions.

Risk Scenarios

The dominant risk scenarios that Assessment Team members identified as most important for the traditional land use were as follows.

Short Term

1. Loss of funding from the federal government leading to failure to complete the closure plan.
2. Poor management practices leading to system failure and loss of confidence in the closure regime.
3. On the Faro side, dam breach and tailings release leading to downstream contamination and significant impacts on downstream fishing activities.
4. On the Faro side, dam breach or severe dusting leading to the need for an advisory for food or environmental safety.
5. On the Vangorda/Grum side, diversion failures leading to release of contaminants at severe levels (slilghtly greater concern for the backfill pit option with diminished pit voume to serve as storage after divesion failure).
6. Failure of the Vangorda Diversion Channel (impacts related to perception of risk and loss of confidence in management).
7. Failure of communication of risks to users.

Estimates of the probability of occurrence of risk scenario generally ranged from 0.1% - 10% with one assessment ranging up to 45%.

Long Term

1. Institutional failure from several years to decades leading to permanent cessation of water collection and treatment, loss of maintenance of diversion channels, dams, etc.
2. Societal collapse and loss of water treatment capacity combined with Future 3 geochemistry.
3. Dam failure leading to increase in perception of risk, loss of confidence in management systems, and greater voluntary reductions in traditional land uses.
4. Failure of communication of risks to users.

Estimates of the probability of occurrence of risk scenario ranged broadly from 0.1% to 100%. The higher estimates of risk occurrence relate to institutional failures and the loss of funding.

Factors Influencing Performance

Figure 9-13 shows graphically the factors that the Assessment Team considered important to traditional land-use performance.

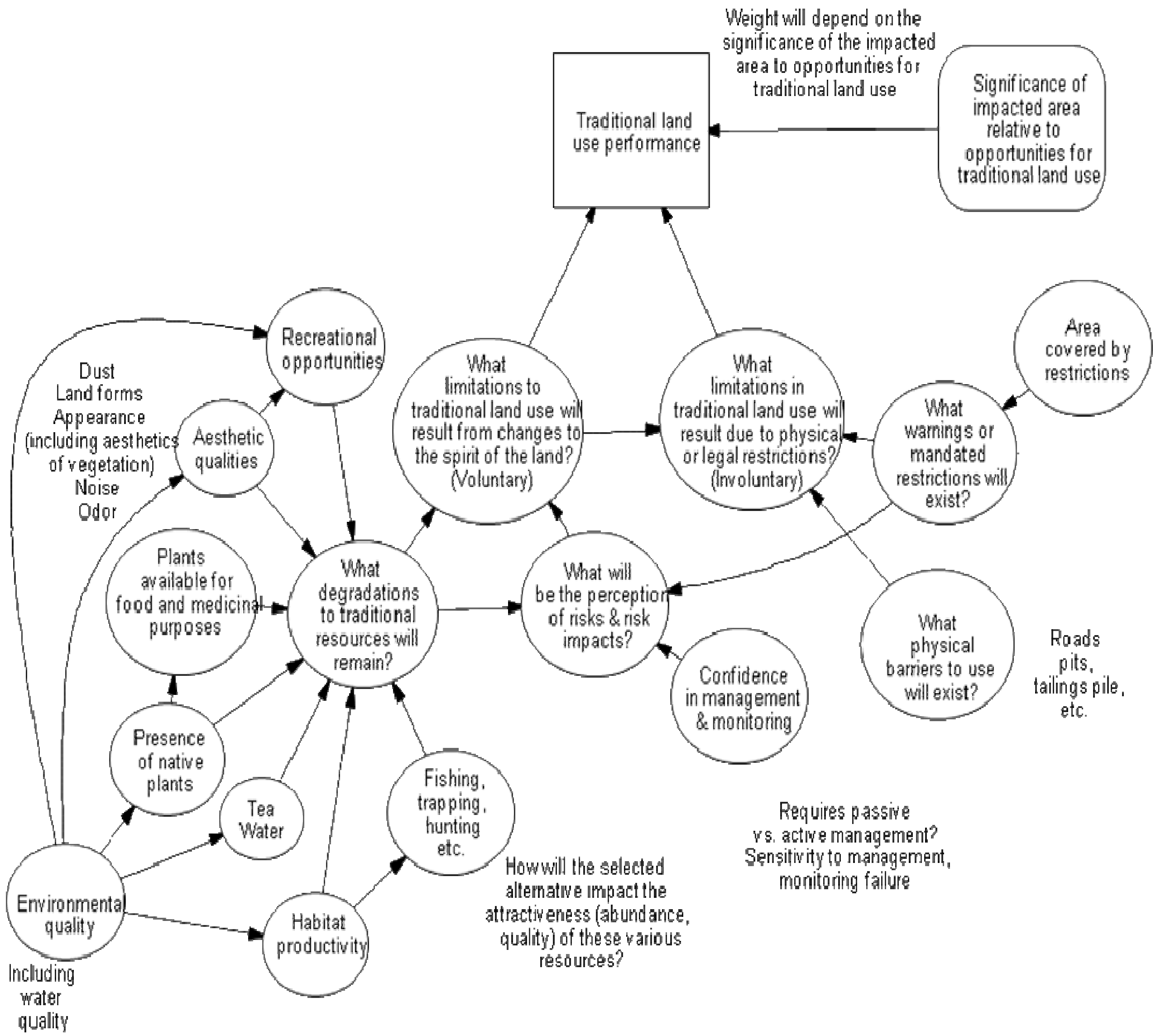
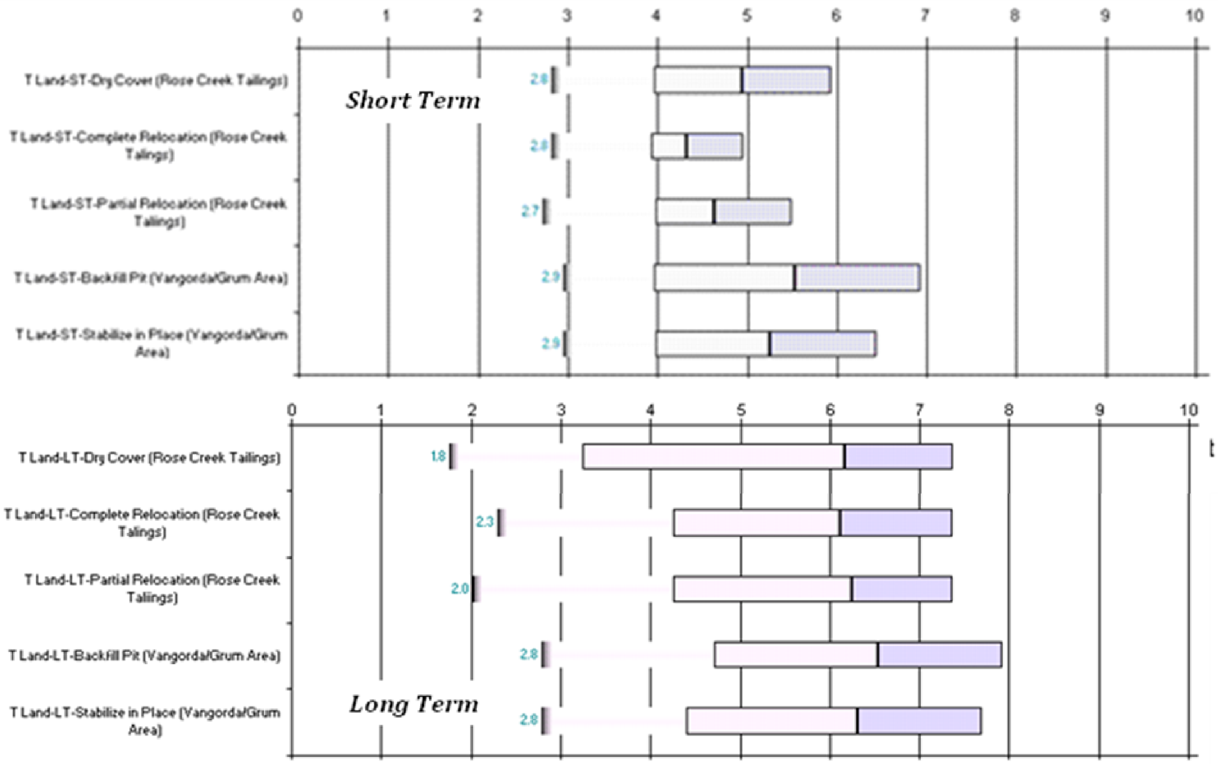


Figure 9.13. Factors influencing performance on the traditional land use objective

Scoring Results and Logic Summary

Figure 9.14 shows the traditional land use performance estimates for the component alternatives, expressed against the scoring scale, for the short- and long-term time periods.



Performance estimated on 0-to-10 (log) scoring scales. Precise meanings of scores depend on objective (see scoring scales). In general, 10 = ideal performance (no adverse effects), 0 = disastrous performance. A drop in score of 1 unit represents a situation approximately 3 times as bad.

Figure 9.14. Performance estimates for traditional land use over the short and long terms

Assessment Results, Short Term

<u>Faro/Rose Creek Tailings</u>

Performance estimates for alternatives ranged between very poor (4) and mediocre (6) on traditional land use, all with similar downside risk. “Dry cover” performance was estimated somewhat better than the others due to the lower disturbance during construction, the faster construction period and more time for traditional activities to be re-established. For the relocation options, the likelihood of continued site disturbance for the entire 40 year short-term time along with higher extent and duration of land use controls accounts for their lower scores. All of the alternatives are seen as posing similar, serious down-side risk; namely, the potential for moderate to large-scale serious and persistent limitations on traditional land use that affect many important resources.

<u>Vangorda/Grum</u>

Performance estimates for the Vangorda/Grum side ranged between very poor (4) and fair (7) with the “Backfill pit” alternative estimated to have slightly better performance but with more uncertainty.

Assessment Results, Long Term

Estimates indicate better performance over the long term but more uncertainty (greater spread in the scoring bars). The issue of generation-to-generation transfer of knowledge was seen as very important with any breakdown of communication leading to high possibility of long term or permanent harm. Under any scenario, the team considered it a high possibility of large scale, serious and persistent limitations on traditional land use

Faro/Rose Creek Tailings

Estimates range between bad (3.2) and fair (7.3) with a median of mediocre (6.2). The median estimates for all options were very close. “Dry cover” options were assessed as having greater downside risk – because of the potential of dam failure and release of tailings.

“Partial relocation” performance was estimated very slightly better because it has the lowest physical risk – the potential for a catastrophe from a dam failure is removed because there is no water behind the dam that remains.

The performance estimates suggest that, under any alternative, the Team would not be surprised to see large-scale, serious and persistent limitations on land use that affect many important resources and adversely affect traditions for many people.

Vangorda/Grum

Scores for both alternatives on the Vangorda/Grum side ranged between very poor/poor (4.5) and fair/good (7.9) with a median of mediocre/fair (6.4). “Backfill pit” was assessed to perform slightly better because of slightly greater security provided by the pit containment

9.8 Minimize Restrictions on Local Land Use

Assessment Process

A background document discussing local land use was prepared by Pitt (7 September 2007).

Potential local land uses on the Faro site included recreation, tourism, education and research, fishing, trapping, hunting, fuel wood harvesting, and mineral exploration. This perspective is limited to a consideration of the nature of the land as it currently is in the region – essentially “undeveloped.”

The Assessment Team did not undertake a long-term scenarios exercise that may have pushed out the boundaries of the thinking process to consider major demographic, ecological, and land use shifts that could occur over the next several centuries.

Members of the assessment team undertook this part of the assessment based on their best judgment as to the potential implications to local land use of each alternative.

Table 9.17 indicates the definitions of the scores assigned for impacts to local land use.

Table 9.17. Scale used for scoring local land use performance.

Score	Definition
10	Ideal performance. No observable adverse impact to local land use. Equal to or better than prior to the mine. Site fully restored to natural state.
9	Very good performance. Insignificant impacts. Between a score of 8 and 10.
8	Good performance. Some minor, localized impacts to local land use. Few people are effected and for only a limited amount of time.
7	Fair performance. Between a score of 6 and 8.
6	Mediocre performance. Some moderate, fairly localized, short-term limitations to local land use. Affects utilization of some, but not all relevant resources.
5	Poor performance. Significant problems. Between scores of 4 and 6.
4	Very poor performance. Serious problems. Significant and persistent limitations on local land use over relatively large area. Affects usage of many important local resources. Seriously adversely affects ability to enjoy the impacted land.
3	Bad performance. Very serious problems. Between scores of 2 and 4.
2	Very bad performance. Major problems. Permanent and major limitations on local land use over a very large area. Affects usage of nearly all important local resources for many people.
1	Terrible performance. Critical problem. Between scores of 0 and 2.
0	Abominable performance. An disaster for local land use. Permanent loss of local land use opportunities across an extensive area.

Risk Scenarios

The dominant risk scenarios that Assessment Team members identified as most important for local land use were as follows.

Short and Long Term

1. Loss of institutions, failure of funding to complete remediation
2. Poor site management and poor community relations
3. Failure of dams and diversions, loss of water treatment capacity.

All of these risk scenarios lead to a loss of faith in the closure system and a perception that the site should be avoided thus creating enhanced voluntary land use restrictions.

Estimates of the probability that these risk scenarios ranged from 1% to 45% in the short term and from 0.1% to 60% in the long term. The higher probabilities are associated with the risk of institutional and funding failures.

Factors Influencing Performance

Figure 15 shows graphically the factors that the Assessment Team considered important to local land-use performance.

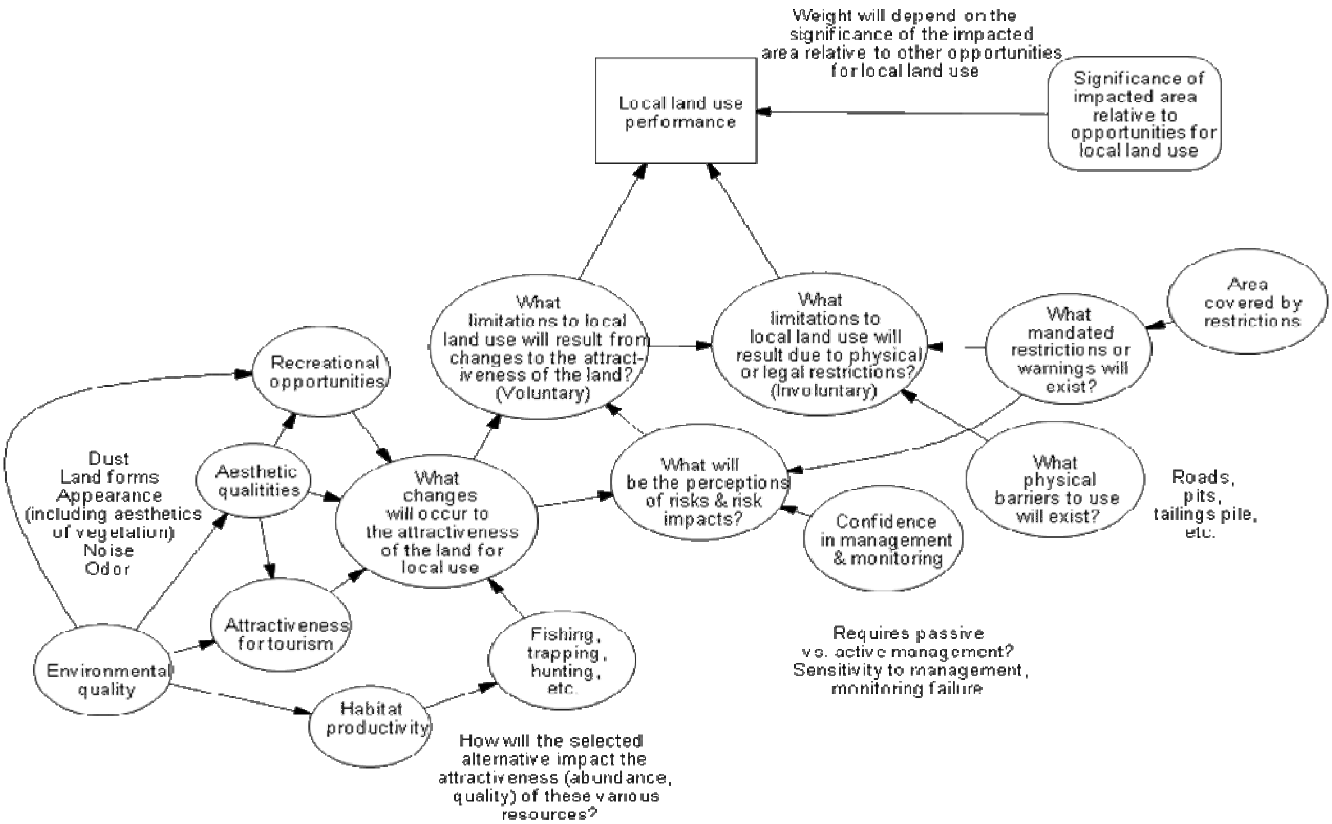
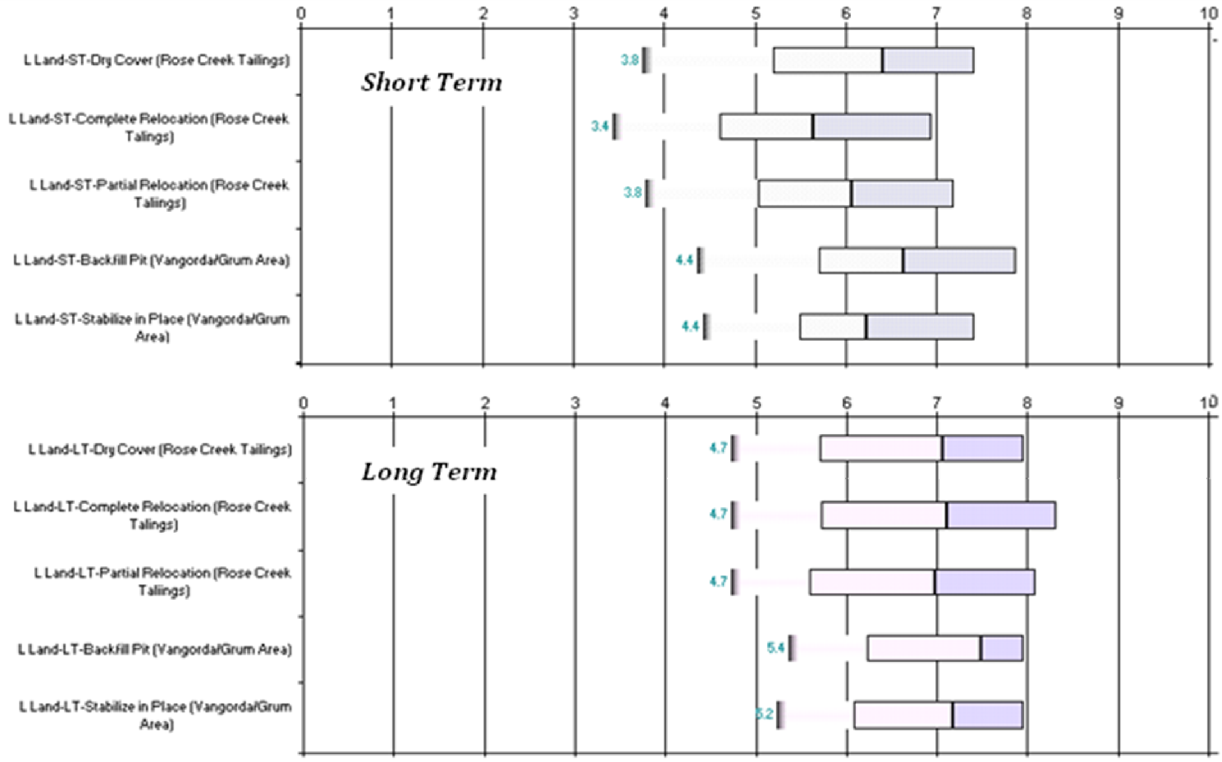


Figure 9.15. Factors influencing performance on the local land use objective.

Scoring Results and Logic Summary

Figure 9.16 shows the local land use performance estimates for the component alternatives, expressed against the scoring scale, for the short- and long-term time periods.



Performance estimated on 0-to-10 (log) scoring scales. Precise meanings of scores depend on objective (see scoring scales). In general, 10 = ideal performance (no adverse effects), 0 = disastrous performance. A drop in score of 1 unit represents a situation approximately 3 times as bad.

Figure 9.16. Performance estimates for local land use over the short and long terms

Assessment Results, Short Term

As indicated, all alternatives were estimated to perform fairly poorly with respect to local land use (scoring close to mediocre), although not so badly as with respect to traditional land use.

<u>Faro/Rose Creek Tailings</u>

Performance estimates ranged from very poor/poor (4.6) to fair (7.3) with a median of mediocre (around 6). The spread was fairly high indicating significant uncertainty. "Dry cover" was estimated to most likely perform the best, with the anticipation of some moderate, fairly localized, short-term limitations affecting some but not all relevant resources. The construction period would be shorter and less disruptive giving more time for local land uses to re-establish.

"Complete relocation" was estimated to most likely perform least well, with the impacts being somewhat more serious and more persistent and linked to the extent of disruption of the construction process over a longer time period.

"Partial relocation" was estimated to have a level of performance between that of "Dry cover" and "Complete relocation."

Vangorda/Grum

The two alternatives are viewed as most likely to perform somewhat better (although still poorly). Performance estimates ranged from poor/mediocre (5.5) to almost good (7.8). The scores indicate a belief that there will probably be limited land use impacts that affect some, but not all resources. However, there is some chance that the limitations will seriously impact the ability of people to enjoy the land.

“Backfill pit” is viewed as most likely performing slightly better than Stabilize in place.

Assessment Results, Long Term

All alternatives were estimated to perform somewhat better during the long-term period compared to the short-term period.

Faro/Rose Creek Tailings

All three alternatives scored very closely with fair performance. Estimates on the Faro/Rose Creek Tailings side ranged from poor/mediocre (5.6) to good (8.3) with a median of fair (7). The results suggest that any limitations on local land use would most likely be quite localized and minor to moderate. There is a significant amount of uncertainty.

“Complete relocation” was estimated to perform ever so slightly better because the tailings having been removed from the valley.

Vangorda/Grum

Performance estimates ranged from mediocre (6.1) to good (8) with a median of fair (7.4). Median scores suggest the team viewed Backfill pit as most likely performing slightly better than Stabilize in place.

9.9 Summary and Conclusions

The objective-by-objective assessment of alternatives involved the following steps:

1. **Foundation of Data and Information.** Compilation of the existing and available data and information base for review by Assessment Team members as a basis for their assessment;
2. **Influencing Factors.** Building on earlier work, identification and review of all factors that could potentially influence performance on each objective;
3. **Risk Scenarios.** Building on earlier work, identification by each Assessment Team member of the most important risk scenarios that could influence performance over the short and long terms; plus estimation of probabilities of occurrence.
4. **Assessing Performance.** Estimation of performance through the application of the scoring process. For all but the local and Yukon socio-economic objectives, each Team member scored each component alternative for a subset of objectives (some did all) for both the normal operating conditions and the risk scenarios judged by the Team member as most significant, over the short and long terms. For the socio-economic objectives, the six composite alternatives were scored under each objective over the short and long terms and under normal operating conditions as well as under risk scenarios. Probabilities were estimated for risk scenarios. Scores and probabilities were combined using risk analysis to quantify uncertainty in performance for each alternative. The results were combined across Team members (using conservative assumptions the captured both the uncertainties reflected in the scores assigned by individual Team members and the differences of opinions held by Team members).
5. **Results.** Overall observations and conclusions were drawn be examining the results on an objective-by-objective basis, over the short- and long-terms.

Key risk scenarios identified for short term, 0 – 40 year time period included:

- Poor site management leading to significant incident
- Dam breach, tailings discharge, severe dusting leading to need for advisory for food or environmental safety (for whatever reason)
- Slope failures (could be pit wall, operating face of hydraulic mining etc.) from high rainfall event and/or earthquake
- Diversion failure for whatever reason
- Loss of surface water and groundwater collection and treatment capacity
- Institutional and/or political failure leading to loss of resources and termination of project
- Traffic accidents
- Labour unrest leading to system breakdown
- Economic pulse from some sort of disaster at the site
- Lack of communication of risks to users

Key risk scenarios identified for the long-term, post 40 year period (long-term) included:

- Institutional and/or political failure leading to loss of resources and termination of project
- Dam breach, tailings discharge
- Diversion failure for whatever reason

- Unexpected change in geochemical performance leading to Future 3 conditions
- Lack of communication of risks to users

The above risk scenarios applied differently and were assessed by Assessment Team members to have varying probabilities of occurrence depending on the alternative and objective being assessed.

Assessment Results, Short Term

Faro/Rose Creek Tailings

1. Based on an interpretation of the 10% - 90% confidence interval as well as median performance estimates, "Dry cover" was estimated to perform slightly or somewhat better than other alternatives on six of eight objectives (public health and safety, worker health and safety, environment, cost, traditional land use, local land use). With regard to the objective of maximizing Yukon socio-economic benefits, the "Dry cover" combinations were estimated to perform below the other alternatives.
2. "Dry cover" was estimated to pose the least downside risk or downside risk equal to the other alternatives on five of eight objectives: public health and safety, worker health and safety, cost, traditional land use and local land use. "Dry cover" combinations were estimated to have more downside risk than the others with regard to maximizing Yukon socio-economic benefits.
3. Based on the 10% - 90% confidence intervals as well as the median performance estimates, combinations involving "Complete relocation" were estimated to perform better on one objective: maximizing Yukon socio-economic benefits. This result is directly related to the higher cost and related Yukon expenditures for this alternative relative to the other alternatives. "Complete relocation" was estimated to perform as well as or very close to other alternatives on short-term local socio-economic benefits.
4. "Complete relocation" was estimated to have the most downside risk on five of eight objectives (worker health and safety, environment, local socio-economic, cost, and local land use.)
5. "Partial relocation" was generally estimated to provide levels of performance between that estimated for "Dry cover" and "Complete relocation".
6. For all three alternatives, scoring was the same or very close with regard to short-term local socio-economic benefits.

Vangorda/Grum

1. "Backfill pit" was estimated to most likely perform slightly better in the short term on environment, traditional land use, and local land use;
2. "Stabilize in place" was estimated to most likely perform slightly better in the short term on cost and worker health and safety.
3. The two alternatives were estimated to perform the same or nearly the same on public health and safety and local socio-economic benefits.

Assessment Results, Long Term

Faro/Rose Creek Tailings

1. Performance estimates were the same or very close in the long term: public health and safety, worker health and safety, environment, local socio-economic, and Yukon socio-economic benefits.
2. Based on the 10% - 90% confidence interval as well as the median estimates**, "Dry cover"** was estimated to perform better on: local and Yukon socio-economic objectives. However over the long term, "Dry cover" was estimated to pose more down-side risk in comparison to other alternatives with regard to the environment, restrictions on traditional land use, and long-term costs.
3. "Complete relocation" was assessed as performing better or slightly better on worker health and safety, cost, and local land use over the long term. Combinations involving "Complete relocation" were estimated to perform as well or slightly worse on both local and Yukon socio-economic benefits.
4. Over the long term, "Complete relocation" was estimated to have the least or equivalent downside risk with regard to public health and safety, worker health and safety, environment, Yukon socio-economic benefits, cost, traditional land use, and local land use. In contrast, it had the most downside risk with regard to the long-term local socio-economic objective.

Vangorda/Grum

1. The two alternatives were estimated to perform the same or closely on public health and safety and worker health and safety,
2. "Backfill Pit" was estimated to most likely perform better or slightly better during the long term on environment, cost, traditional land use, and local land use and combinations of dry-cover on the Faro side and backfill pit on the Vangorda/Grum side were estimated to perform well on the local and Yukon socio-economic objectives.
3. "Stabilize in Place" was not estimated to perform better on any long term objective, although combinations of dry-cover on the Faro/Rose Creek side and "Stabilize in place" on the Vangorda/Grum side were estimated to perform well on the local and Yukon socio-economic objectives.

Assessment Results, Overall

1. **Similarities and Differences.** For nine assessments (of 16 on both short and long term) performance estimates are very close for all alternatives. These include public health and safety short and long term, worker health and safety long term, environment long term, short and long term local socio-economic, Yukon socio-economic long term, traditional land use long term and local land use long term. More significant differences were estimated for seven objectives including worker health and safety short term, environment short term, Yukon socio-economic

short term, cost short and long term, traditional land use short term, and local land use short term.

2. **Confidence in Protecting Public Health and Safety.** The Team appears confident that any of the alternatives will produce fair to good performance in terms of protecting public health and safety.

3. **Concerns.** The Team is less optimistic about performance against worker health & safety, environment, traditional land use and local land use objectives. Here, assessments ranged down to scores suggesting poor and very poor performance.

4. **Risk.** A review of risk scenarios and risk scores (as indicated by the extent to which the confidence ranges extend down to low scores), shows that the alternatives are perceived by the Team as presenting different but sometimes significant levels of risk. The risk of poor or worse performance (especially with regard to the environment and the traditional and local land use objectives) appears to be a serious concern to the Assessment Team. The estimates of downside risk (1 chance in 100 possibilities) in some instances emerged as a significant factor in the Team's assessments.

5. **For the Faro Mine/Rose Creek Tailings area**, over the short term "Dry cover" was estimated to perform slightly or somewhat better on a majority of objectives but over the long term, it was estimated to pose more down-side risk on several key objectives including environment, restrictions on traditional land use, and long-term costs. These results suggest a preference for "Dry cover." However, such a preference might not exist if Team members were to assign little or no weight to short term costs, if they were highly averse to down-side risks in the long term, or if long-term performance was weighted more highly than short-term performance. Chapter 10 explores synthesized assessment results and the implications of applying different weights to the various objectives, including a sensitivity analysis of the ranking of the combined alternatives to various weights provided by Assessment Team members.

6. **For the Vangorda/Grum area**, performance estimates tended to be better for Vangorda/Grum alternatives than for Rose Creek tailings alternatives. "Backfill pit" was estimated to most likely perform slightly better in the short term on environment, traditional land use, and local land use; and, during the long term, on cost, traditional land use, and local land use. "Stabilize in place" was estimated to most likely perform slightly better in the short term on cost and worker risk. As a whole, Assessment Team scores do not show a strong preference between the alternatives considered for the Vangorda/Grum area.

References

9.0 Introduction

Michael Nahir, 2008, personal communication. Technical Advisor, Contminated Sites Program, Northern Affairs Program, Indian and Northern Affairs Canada, Ottawa.

9.1 Public Health and Safety

Knapp, R. A., 27 August 2007. Memorandum to File. Faro Alternatives – Public Health and Safety Write-up, Background for Ranking Options. Senes Consultants Inc.

SENES Consultants Ltd. Anvil Range Mine Tier 2 Ecological and Human Health Risk Assessment of Remediation Scenarios. April 2006. (SENES, 2006)

SRK Consulting (Canada) Inc. 2007. *Dam Failure Risks*. Memo from Daryl Hockley to the Faro Assessment Team, July 30, 2007.

9.2 Worker Health and Safety

Knapp, R. A., 27 August 2007. Memorandum to File. Faro Alternatives – Worker Health and Safety Write-up, Background for Ranking Options. Senes Consultants Inc.

SRK Conulting (Canada) Inc., 1 August 2007. Memorandum from Peter Mikes to Daryl Hockley. Traffic/Worker Fatality and Lost Time Injury Risks for the Faro Recommended Alternatives. August 1, 2007.

9.3 Environment

Bryan, Pat. Memo - Candidate Method for Selecting Design Flood Events for Faro Creek and Vangorda Creek Closure Diversions. 2005. (Bryan, 2005)

Faro Mine Closure Planning Office. Background Paper, Receiving Water Quality Guidelines for Zinc. December 2006. (FMCPO, 2006)

Gartner Lee Limited. Faro Closure, Preliminary Matrix. December 2006. (Prepared as part of environmental assessment for Faro Mine Closure Project) (GLL, 2006)

Gartner Lee Limited . Anvil Range Mine Complex – Terrestrial Effects Study: Investigation into Metal Concentration in Vegetation, Wildlife and Soils. March 2006. (GLL, 2006-2)

Independent Peer Review Panel. Review of Remediation Alternatives for the Anvil Range Mine Complex, Final Report. March 2007. (IPRP, 2007)

Minnow Environmental Inc. Ecological Impact Assessment, Faro Mine, Yukon. May 2007. (Minnow, 2007)

SENES Consultants Ltd. Anvil Range Mine Tier 2 Ecological and Human Health Risk Assessment of Remediation Scenarios. April 2006. (SENES, 2006)

SRK Consulting. Primary Alternatives for Closure of Anvil Range Mining Complex, Draft for Residual Risk Meetings. January 2006. (SRK, 2006-1)

SRK Consulting. Example Alternatives for Closure of Anvil Range Mining Complex, Draft for Peer Review. September 2006. (SRK, 2006-1)

SRK Consulting. Anvil Range Mining Complex: Site Water and Load Balance. September 2006. (SRK, 2006-2)

SRK Consulting. Anvil Range Mining Complex: Site Water and Load Balance. September 2006. (SRK, 2006-3)

SRK Consulting. Memo re: Dam Failure Risks. July 2007. (SRK, 2007)

9.4 Local Socio-Economic

Cornett, Dan, September 14, 2007. Local Socio-Economic Briefing Package. Prepared for the Faro Closure Assessment Team. Whitehorse: Access Consulting Group

SRK Consulting (Canada) Inc. Faro Closure Scenario Labour Requirements. Internal SRK Memo from Peter Mikes to Daryl Hockley, 11 September 07

SRK Consulting (Canada) Inc. September 2007. Faro Closure Scenario Labour Requirements. Scenario Workforce Graphs. Primary_Alternative_Cost_Estimates rev33Workforce Charts.

9.5 Yukon Socio Economic

Hodge, R. Anthony. 11 Oct 07. Briefing Package – Objective 5. Maximize Yukon Socio-economic Benefits. Note Prepared for the Faro Closure Assessment Team. Victoria: Anthony Hodge Consultants Inc.

Mead, Stephen, Mike Nahir, Daryl Hockley, Malcolm Foy, Dan Cornett, Tony Hodge, Luigi Zanasi. Draft Closure Implementation Strategy. Draft: 13 Sept 07

MMSD North America, 2004. ***Seven Questions to Sustainability – How to Assess the Contribution of Mining and Mineral Activities.*** Winnipeg: International Institute for Sustainable Development. (http://www.iisd.org/natres/mining/7qs.asp)

Zanasi, Luigi, Gaye Hanson, Ian Robertson, Deborah Pitt, Robert Lorimer, and Malcolm Taggart, 31 March 2007. Preliminary Socio-economic Evaluation of the Sample Alternatives for Faro Mine Closure – Final Report. Whitehorse: Faro Mine Closure Planning Office.

Hanson, Gaye, undated manuscript. Social Effects Assessment. Received September 2007 from Luigi Zanasi.

9.6 Cost

Hockley, Daryl, November 2007. Personal Communication.

SRK Consulting (Canada) Inc. Cost Summary Tables, "Appendix D Cost Estimates; Primary Alternatives Cost Estimates Rev33, Summary. Sent by Daryl Hockley to Tony Hodge by e-mail, September 18, 2007

SRK Consulting (Canada) Inc. e-mail from Daryl Hockley to Tony Hodge, September 21, 2007 entitled Summary Cost Estimates

SRK Consulting (Canada) Inc. e-mail from Daryl Hockley to Tony Hodge, September 21, 2007 entitled Cost Estimate Summaries.

SRK Consulting (Canada) Inc. Summary of Combined Alternatives. Primary_Alternative_Cost_Estimates rev31. Summary 2.

9.7 Traditional Land Use

Foy, Malcolm, 20 September 2007. Briefing Package re Traditional Land Use. Memo from Malcolm Foy to Tony Hodge (for the Assessment Team).

Foy, Malcolm, 3 August, 2007. Memo to the Assessment Team regarding Traditional Land use in the Faor Area.

Weinstein, Martin S., 1992. "Just Like People Get Lost: A Retrospective Assessment of the Impacts fo the Faro Mining Development on the Land Use of the Ross River Indian People." Report to the Ross River Dena Council.

9.8 Local Land Use

Pitt, Deborah, 7 September 2007. Local Land-use Briefing Package. Memo to Tony Hodge (on behalf of the Assessment Team).

Chapter 10. Synthesized Results and Sensitivity Analysis

10.0 Introduction

As documented in the previous chapter, the Assessment Team's objective-by-objective performance assessments found differences, but did not identify any "clear winners" among the alternatives for addressing the Faro site. With regard to the three alternatives for the Faro/Rose Creek areas, "Dry cover" was, according to Team scores, most often estimated likely to perform slightly or somewhat better against objectives. However, in the long-term time period, "Dry cover" was estimated to pose more downside risk for the environment, traditional land use, and long-term costs. On the Vangorda/Grum side, "Backfill pit" was estimated to perform slightly better on some objectives while "Stabilize in place" was estimated to perform slightly better on others.

In order to further analyze and compare the alternatives, a single measure of performance was developed that would aggregate the assessments across the various objectives. This required assigning weights to the objectives. This chapter describes the weighting schemes developed by the Assessment Team and explores the sensitivity of the rankings to different weighting sets.

10.1 A Single, Overall Measure of Performance

In order to combine the objective-by-objective assessments of the alternatives, it was necessary to first convert scores into a linear measure of performance and then to assign weights.

Conversion of Scores to a Linear Measure of Performance

As described in previous chapters, the scoring scales used by the Assessment Team to express judgments regarding performance against the objectives are, in each case, log scales—a decrease in score of 2 points represents a situation roughly ten times worse. The use of log scales allows the zero-to-ten scales a span a very wide range of possible performance levels (from "abominable" to "ideal"). Indeed, the zero-to-ten scoring scales span a performance range of roughly 5 orders of magnitude (a score of zero describes consequences roughly 30,000 times worse than a score of 9).

It is not possible to add measures that are expressed on log scales. For example, an earthquake of magnitude 2 plus an earthquake of magnitude 3 does not equal an earthquake having a magnitude 5. Thus, to permit aggregating the assessments against the various objectives, logarithmic scores were converted to a linear measure of performance. An exponential ("10 to the power of…") conversion was used. This conversion was defined so that a score of 10 corresponds to performance of 100 and a score of 3 corresponds to a performance of zero.[1]

The Swing Weight Method

As described below, weights were assigned by the Assessment Team to represent the relative value of obtaining specified amounts of improvement expressed against the various objectives. The method for assigning weights is known as the "swing weight method," often recommended in the literature on multi-attribute utility analysis. The concept is to judge how the value of a specified "swing," in performance on one objective compares with the value of a similarly specified swing in performance on another objective. Swing weights are assigned based not only on the relative importance of the objectives, but also on the value of specific difference in performance represented by the points on the

[1] The mathematical equation for converting scores to performance was Performance = (10/316127766)*(3162277660-10^(11-(Score/2))), which produces the following correspondence:

Score	Verbal descriptor	Performance	How does the score compare to a score of 9?
10	Ideal	100	Slightly better
9	Very good/insignificant problems	99.93	The same
8	Good/minor problems	99.72	3.16 times worse
7	Fair/smallish problems	99.03	10 times worse
6	Mediocre/moderate problems	96.87	31.6 times worse
5	Poor/significant problems	90.03	100 times worse
4	Very poor/serious problems	68.40	316 times worse
3	Bad/very serious problems	0.00	1000 times worse
2	Very bad/major problems	-216.3	316 times worse
1	Terrible/critical problems	-900.29	10,000 times worse
0	Abominable/disastrous	-3063.25	31,600 times worse

scale used for that objective. This is important, since there is a critical difference between how we value different objectives and how we value changes in performance in the specific context of a decision.[2]

To assign swing weights, participants assume that performance is, hypothetically, at some pre-specified level defined on each scale, for example, the level corresponding to zero (the specified level could correspond to any pre-specified value). They then identify the scale corresponding to the objective for which a swing from zero to 100 would be most desirable. This objective is then assigned the highest weight and becomes the standard against which all other swings are compared. Weights are assigned to the swings on the other objectives to indicate the relative value compared to the standard. For example, if a swing on another objective is judged to be half as valuable, it would be assigned half the weight. To ensure that the assigned weights add to a convenient number of 100, the participants can be given 100 poker chips and asked to distribute those chips in accordance with their preferences for the various swings. This was the process used by the Assessment Team to assign weights.

The goal of the weighting exercise was to create one set of weights more or less reflecting the average of the value judgments provided by Assessment Team members, plus some alternative "illustrative weights" intended to reflect different value judgments that might be expected within Canada's diverse society. Thus, as described below, alternative illustrative weighting sets were specified that place increased value on the environment, health and safety, land use, costs, and socio-economics.

10.2 Assessment Team Weights

Assessment Team members assigned swing weights to the objectives that, in each case, represented the judged relative value of a swing from a level of performance against the objective characterized by a score of 4 ("very poor performance") to a level of performance characterized by a score of 10 ("ideal" performance"). Figure 10.1 summarizes the objective-specific definitions (taken from the scoring scales) that were used by the Team for assigning the swing weights. A score of 4 on the log scoring scale corresponds to a level of performance on the linear, zero-to-100 scale of roughly 68.[3]

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[2] An example may help to explain the distinction made above. If you were to use a version of the assessment methodology to help decide what car to purchase, you might consider safety to be most important in some absolute sense. However, in making the choice of a particular car, you might already have narrowed your choice to a shortlist of cars all of which are relatively safe. Suppose, for example, that your scale for assessing safety assigned a score of 100 to a car if it has both a front and side airbags, but zero if it only has front airbags. If this was the only difference in the safety of the cars you were considering, you might care less about the safety differences than about differences in cost and styling. Thus, you would assign a low swing weight to safety because the difference between the highest and lowest safety scores is small. If the safety difference were greater (e.g., if one of the cars was top heavy and had a tendency to roll over in crashes) and if you had defined a 0 score to reflect a more serious safety risk, you might assign a higher weight to safety.

[3] A score of 4 was chosen to define the swings rather than a score of 3, which would have corresponded to a level of 0 on the linear scale. The reason for this was that it was rare for any alternative to score as low as 3 on any objective, meaning that scores of 3 were relatively extreme and, therefore, not very representative of the actual scores obtained.

Objective	Outcome - Short-term	Outcome - Long-term
Cost	$10 million (NPV) more than anticipated.	$57,000 per year more than anticipated.
Public health & safety	30% chance of a public fatality; 10 serious injuries or illnesses.	30% chance of a worker fatality; 10 serious injuries or illnesses.
Worker health & safety	30% chance of a worker fatality; 10 serious injuries.	30% chance of a worker fatality; 10 serious injuries.
Environment	Serious violations of environmental standards; some localized, serious, effects on environmental resources that are self correcting in 10 years.	Serious violations of environmental standards; some localized, serious, effects on environmental resources that are self correcting in 10 years.
Traditional land use	Some significant, lasting limitations over a small area. Affects utilization of some resources, but does not eliminate activities essential for tradition.	Some significant, lasting limitations over a small area. Affects utilization of some resources, but does not eliminate activities essential for tradition.
Local land use	Some moderate, fairly localized, short-term limitations; affects utilization of some, but not all relevant resources.	Some moderate, fairly localized, short-term limitations; affects utilization of some, but not all relevant resources.
Local socio-economics	Majority agrees significant benefits are provided, and most are better off, but majority is not satisfied and thinks more should have been done. A moderate problem occurs in at least one of the 6 indicators.	Majority agrees significant benefits are provided, and most are better off, but majority is not satisfied and thinks more should have been done. A moderate problem occurs in at least one of the 6 indicators.
Yukon socio-economics	Majority agrees significant benefits are provided, and most are better off, but majority is not satisfied and thinks more should have been done. A moderate problem occurs in at least one of the 6 indicators.	Majority agrees significant benefits are provided, and most are better off, but majority is not satisfied and thinks more should have been done. A moderate problem occurs in at least one of the 6 indicators.

Figure 10.1. Adverse outcomes used in the weighting process. Weights were obtained by asking the Assessment Team to judge the relative importance of eliminating each of the adverse outcomes identified above.

The Team weights obtained by averaging the weights from the individual Team members are shown in Figure 10.2.

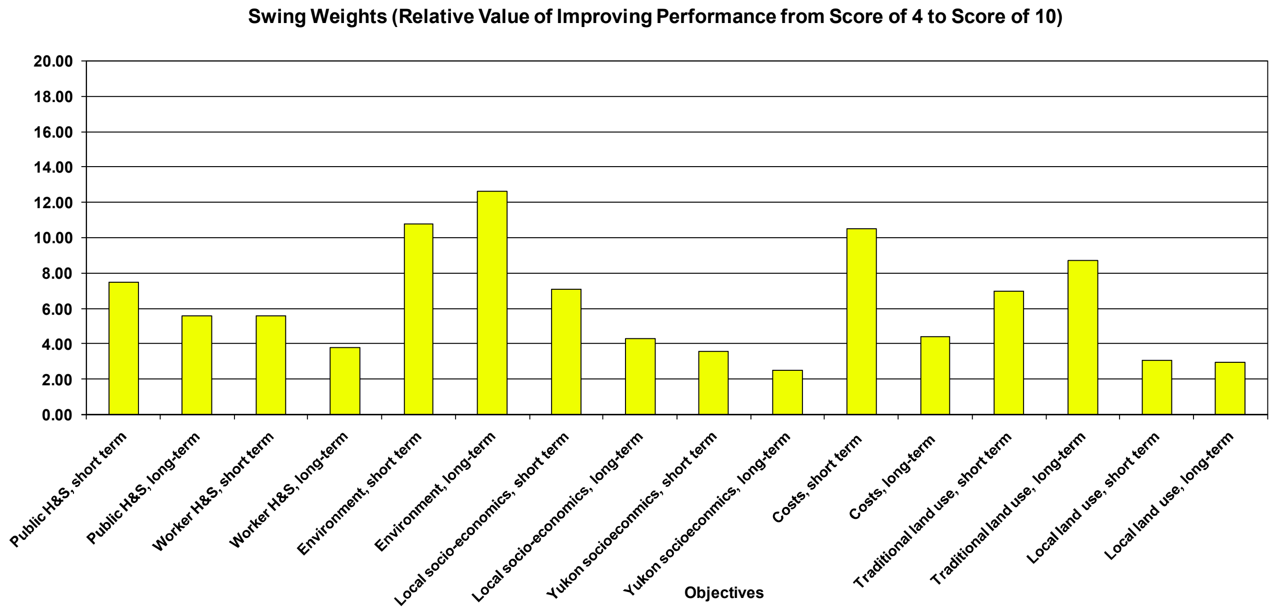


Figure 10.2. Illustrative "nominal" weights (averages of weights provided by Assessment Team members).

10.3 Aggregated Performance Estimates

The aggregation of performance estimates was conducted in steps. First, the performance estimates for the non-socio-economic measures were aggregated, using the nominal swing weights described above. As explained previously, the three alternatives for the Faro/Rose Creek areas and the two alternatives for the Vangorda/Grum areas were assessed separately for all objectives except for the socio-economic objectives. For socio-economics, instead of assessing and comparing the five component alternatives, the six composite alternatives (i.e., a choice for the Faro/Rose Creek area plus a choice for the Vangorda/Grum area) were compared.

The performance estimates for the various permutations of the 5 component alternatives were combined to obtain performance estimates (expressed on the linear performance scales) for the 6 composite alternatives. This allowed the performance estimates for the non-socio-economic objectives and the socio-economic objectives to be combined. When combining the estimates against the various objectives, total correlation was assumed for risk scenarios. In other words, to obtain the aggregated confidence ranges and the 1% worst-case performance estimates, the 1% and low and high-ends of the individual ranges were simply combined, using the weights. This approach effectively makes the conservative assumption that, should an alternative's performance turn out to be lower (or higher) than expected on one objective, then its performance on the other objectives would similarly be that same proportional amount lower (or higher) than expected. We refer to this as being a "conservative" assumption because its effect is to make the aggregated performance assessments within a time period as wide as possible (if, instead, it was assumed that how well an alternative does against one objective has no bearing on how well it does on other objectives the confidence ranges would be more narrow).

Figures 10.3 and 10.4 present the comparative results for the six composite alternatives for the short-term and long-term time periods, respectively. As explained above, the charts express performance in terms of a linear performance scale such that a performance value of 100 corresponds to scores of 10 (ideal) on all objectives and a performance value of 0 corresponds to scores of 3 (bad) on all objectives.

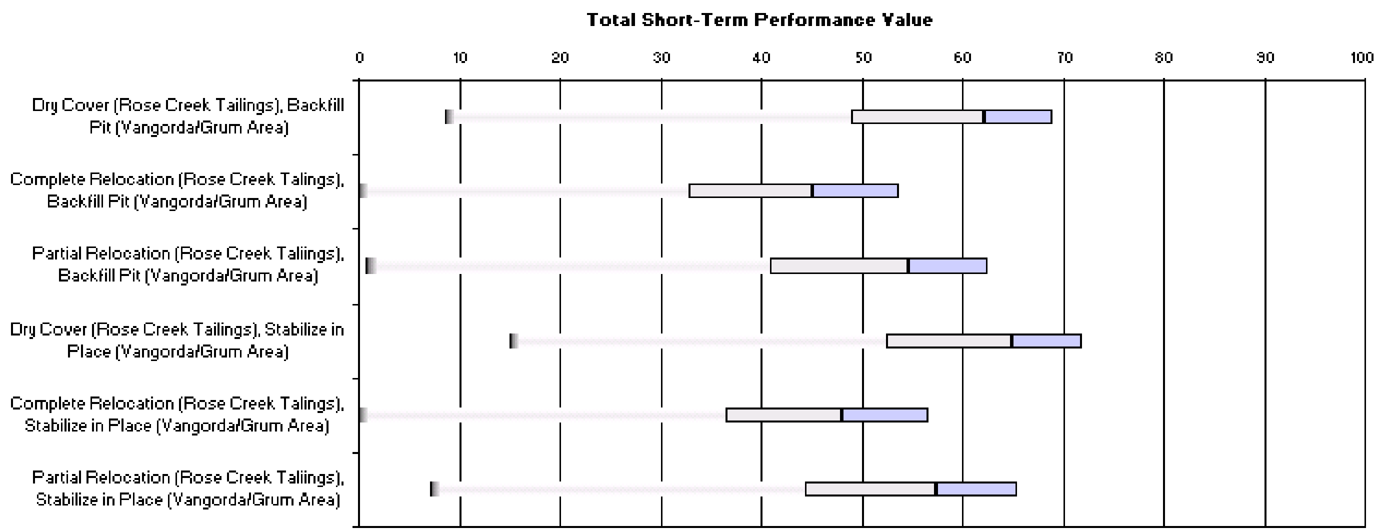


Figure 10.3. Aggregated short-term performance estimates.

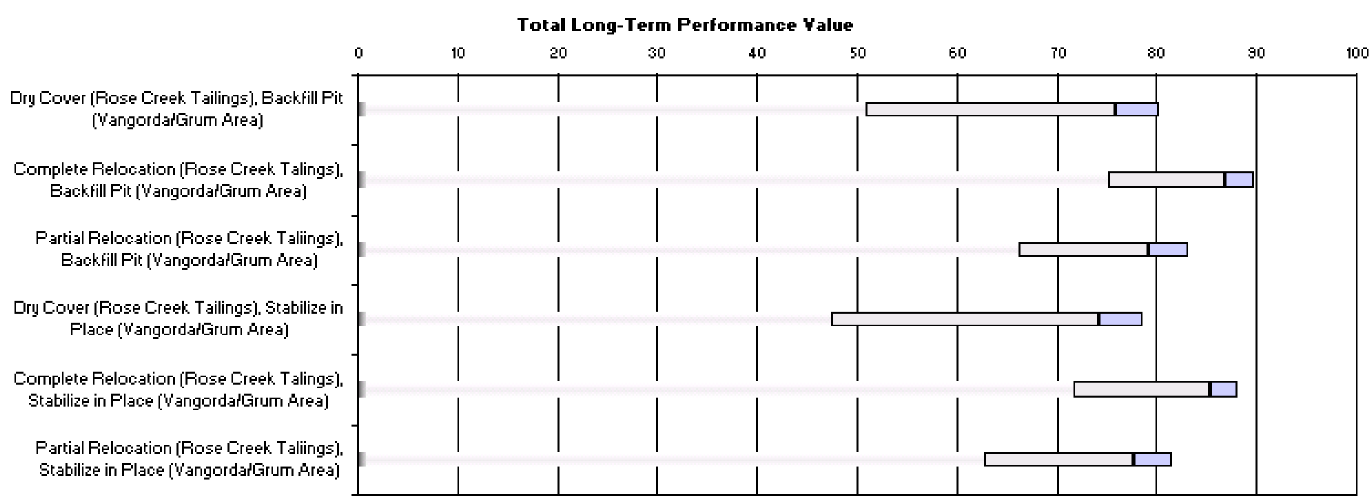


Figure 10.4. Aggregated long-term performance estimates.

The above figures make it clear that the various alternatives tend to tradeoff performance in the two time periods. The alternatives that include “Dry cover” are superior from the standpoint of aggregate short-term performance, but worse with respect to long-term performance. Note that expressing performance on the linear scale makes it clear how adverse the “worst case” assessments are (in the case of long-term performance, the “worst case” estimates all lie below the zero point on the linear scale, meaning that, “worst case,” performance is worst than a situation wherein performance on every objective was consistent with a score of 3).

The last step in the aggregation process was to combine the aggregated performance assessments for the short-term time period with the aggregated performance assessments for the long-term time period. In this case, complete independence, rather than total correlation, was assumed. In other words, the assumption made was that how well the alternative happens to perform in the short-term period has no bearing on how well it performs in the long-term time period. Short-term and long-term performance values were combined via simulation (using an event tree), to obtain probability distributions describing overall performance across the two time periods. Figure 10.5 shows the resulting confidence ranges for the alternatives, again plotted on the linear scale of performance value.

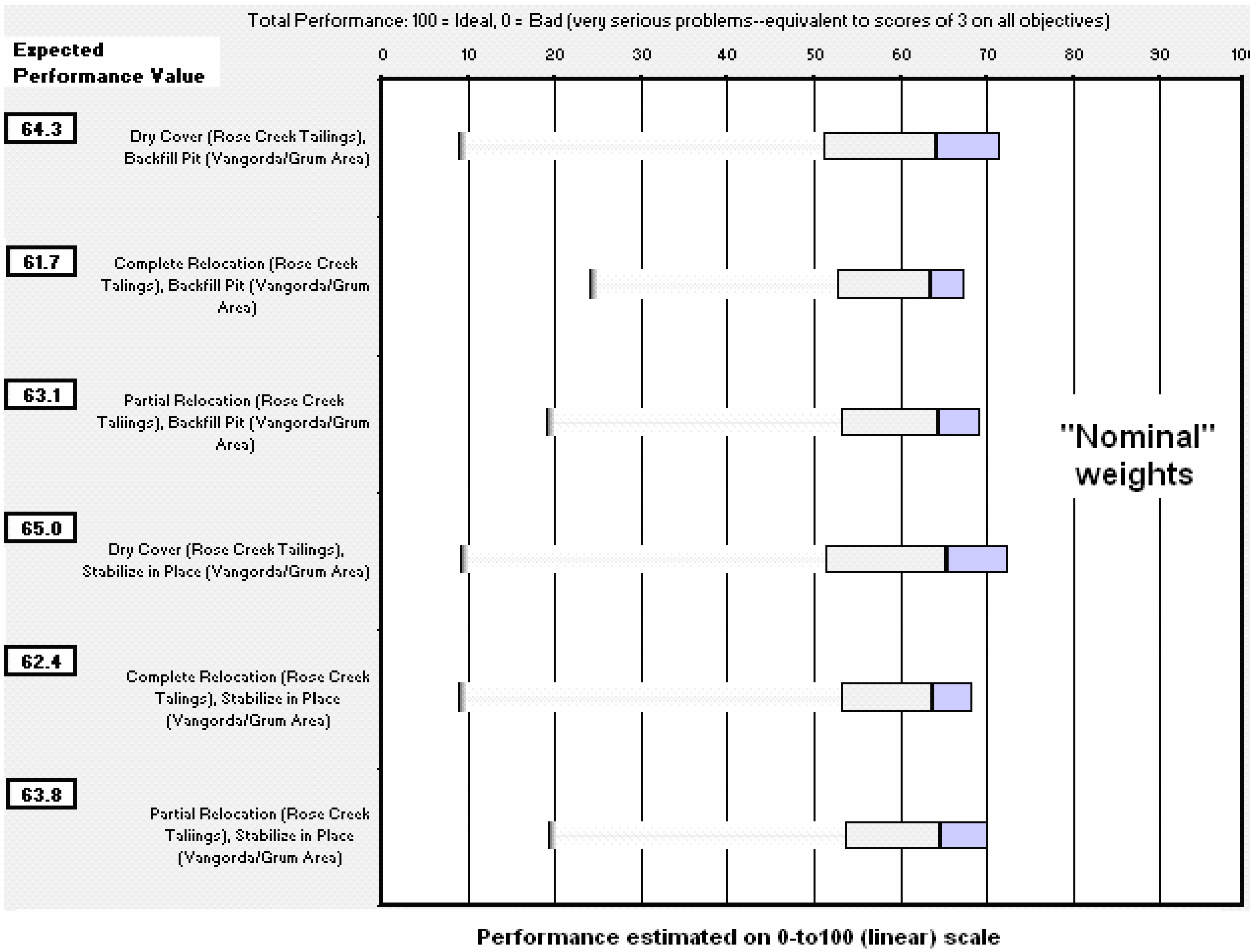


Figure 10.5. Aggregate performance estimates obtained using the illustrative "nominal" weights (averages of weights provided by Assessment Team members).

Also shown in Figure 10.5 are probability weighted values of performance for each combined alternative (the numbers to the left of the plots). These values were computed by weighting the possible levels of performance by their probabilities (i.e., the values shown to the left of the figure are "expected values"). This probability weighted value represents a single number that combines both the uncertain levels of performance (according to their probabilities) as well as the performance assessments against the various objectives.

In terms of most likely and expected performance (aggregated across all objectives based on the nominal weights), the differences among the alternatives is small. The component alternatives that include "Dry cover" were estimated, based on the weights, to have an overall expected performance slightly better than those composite alternatives that include either "Complete relocation" or "Partial relocation." However, "Complete relocation" was estimated to produce less down-side risk than "Dry cover." Likewise, choosing "Backfill pit" was generally estimated to produce somewhat less down-side risk than "Stabilize in place."

In view of the component assessments described in the previous chapter and the nominal weights illustrated in Figure 10.2, the above results should not be surprising. Notice in Figures 10.3 and 10.4 that the superiority of performance of alternatives including "Dry cover" over those containing "Complete relocation" is, in the short term, nearly twice the superiority of "Complete relocation" over "Dry cover" in the long term. The nominal weights are such that, in some cases, greater weight is assigned to long-term objectives than short-term objectives, but the reverse is true for other objectives. Any excess weighting implied by the nominal weights for the future time period is not sufficient to overcome the estimate that "Dry cover" is most likely to perform significantly better in the short-term.

10. 4 Sensitivity of Results to Alternative Weighting Sets

Different people will, obviously, assign different weights, so the Assessment Team explored the sensitivity of the overall ranking to alternative weighting judgments. Figures 10-6 through 10.10 show the five alternative weighting sets developed by the Assessment Team. Each alternative weighting set is intended to represent a viewpoint that places greater weight on a particular type or class of objective (environment, health and safety, land-use, cost, and socio economics). These alternative weighting sets were generated by using the maximum weights (for short-term and long term) assigned to the objective class (the similar objectives for the short- and long-term time periods) by any team member (with the remaining weights rescaled downward so the sum of the weights remains equal to 100). Note that the Assessment Team did not intend these alternative weighting sets to span the entire range of weights that might be assigned by reasonable people.

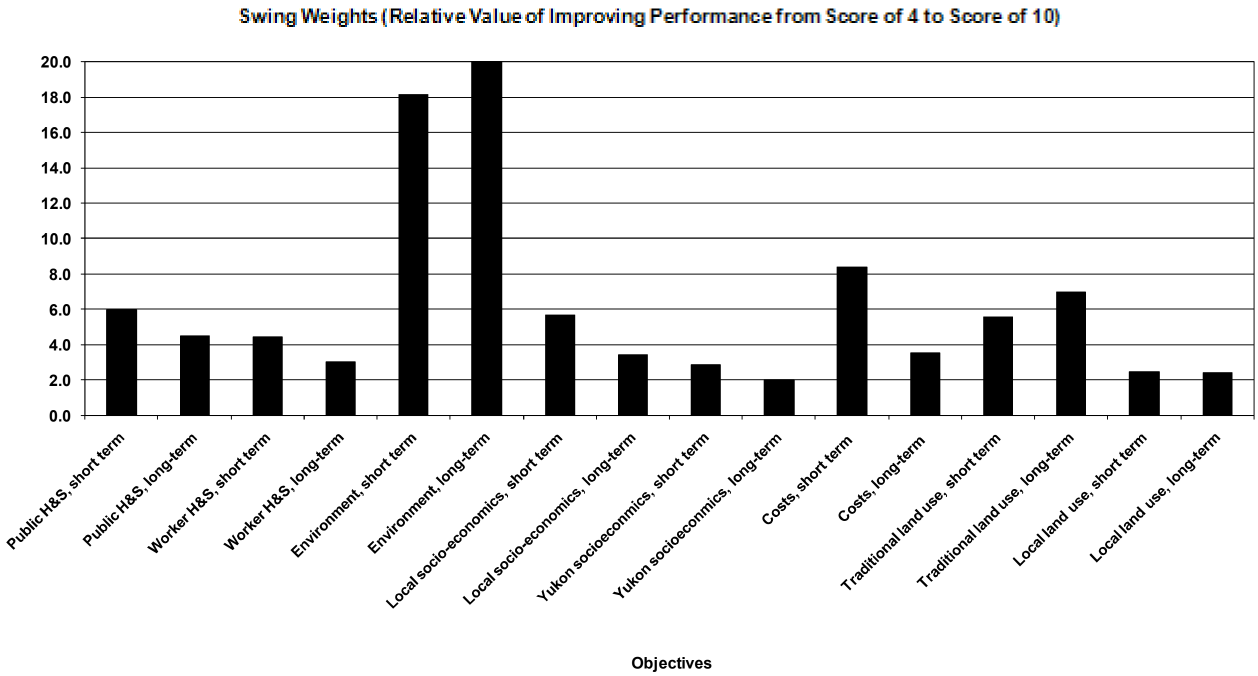


Figure 10.6. Illustrative "environmental" weights.

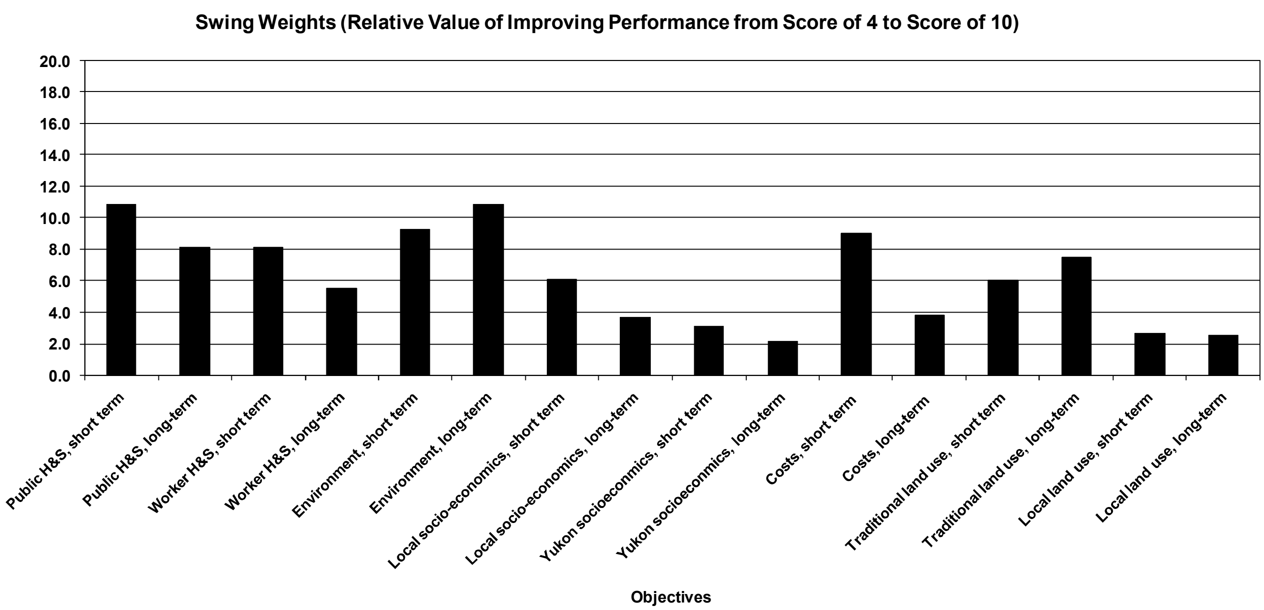


Figure 10.7. Illustrative "health & safety" weights.

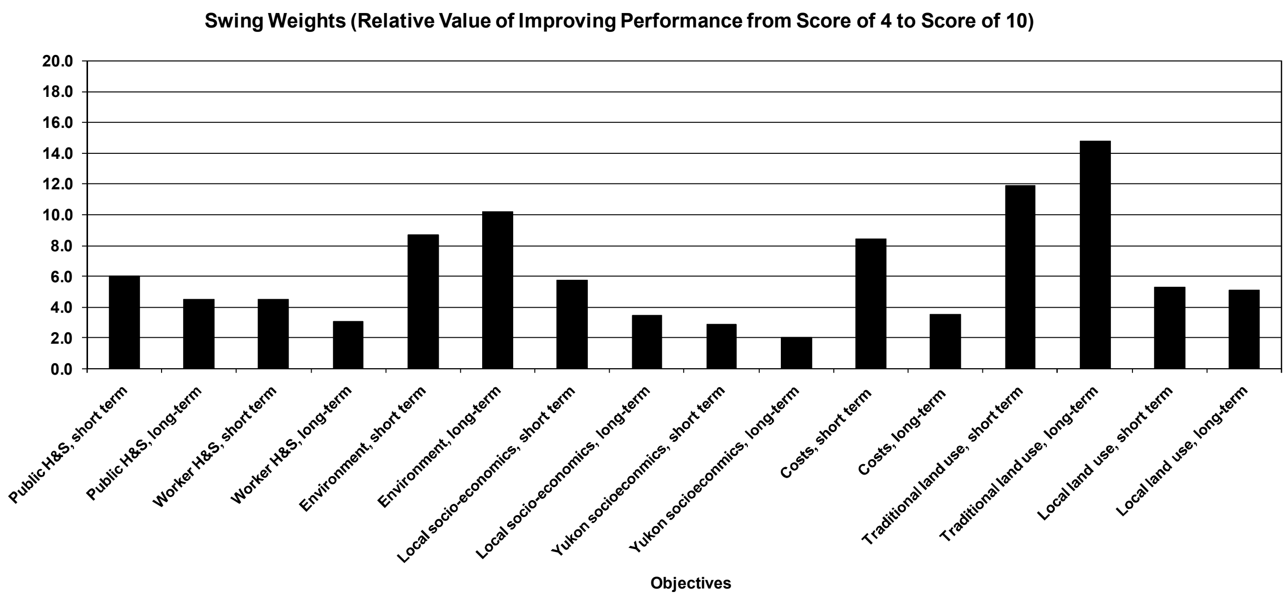


Figure 10.8 Illustrative "land-use" weights.

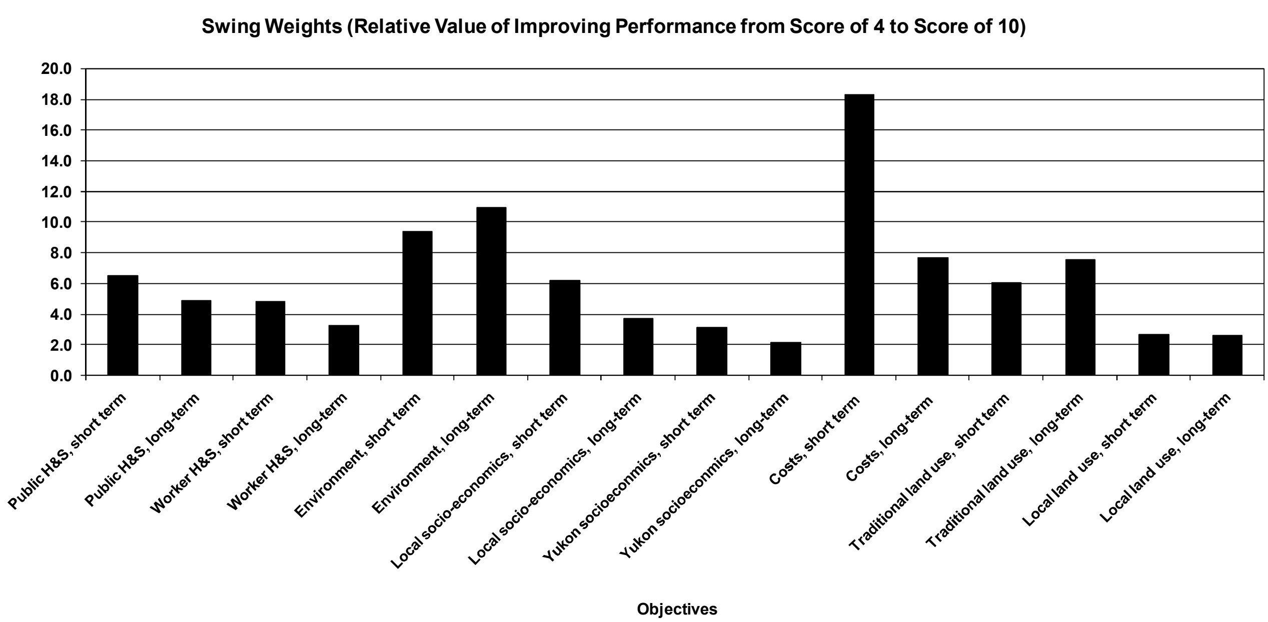


Figure 10.9 Illustrative "cost" weights.

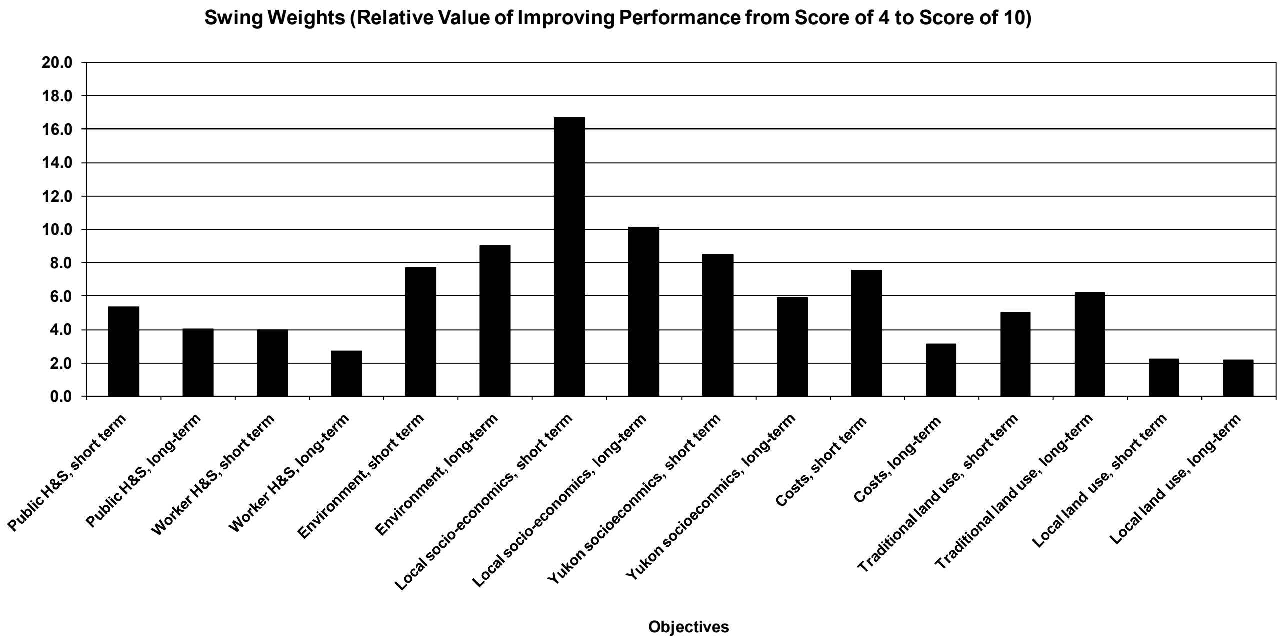


Figure 10.10 Illustrative "socio-economic" weights.

Figures 10.11 through 10.15 show the results of using these alternative weighting sets.

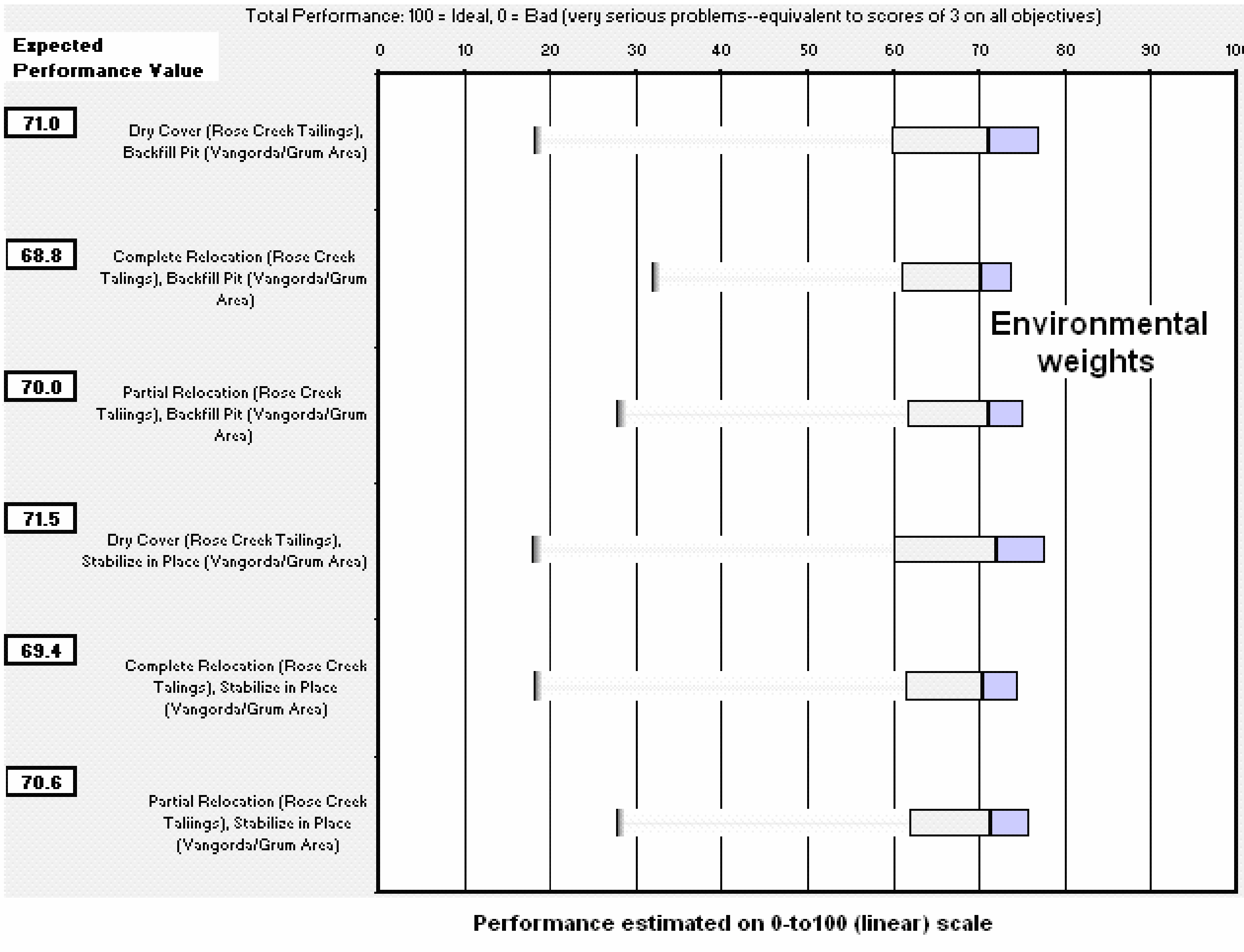


Figure 10.11. Aggregate performance estimates obtained using the illustrative "environmental" weights.

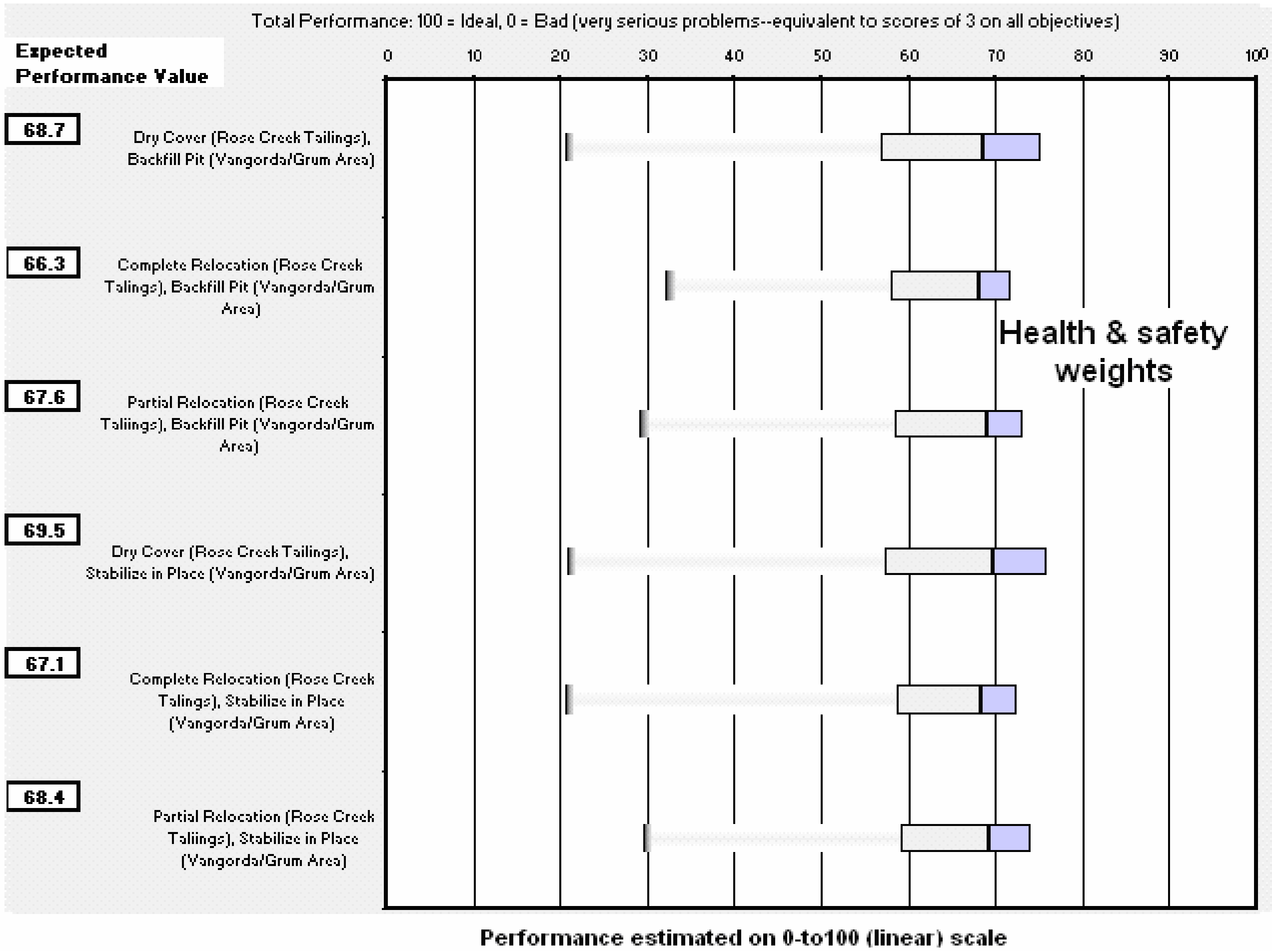


Figure 10.12. Aggregate performance estimates obtained using the illustrative "health & safety" weights.

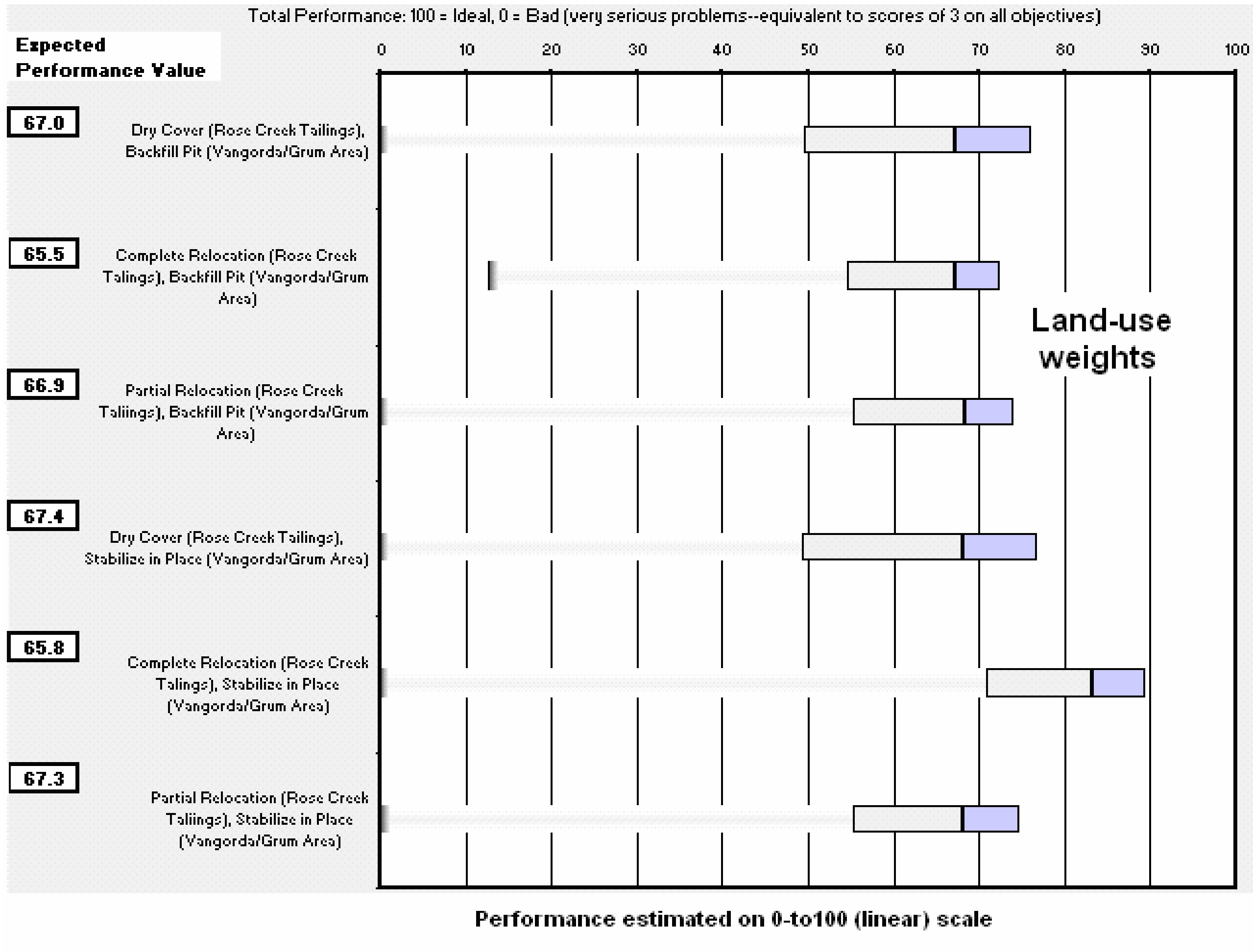


Figure 10.13. Aggregate performance estimates obtained using the illustrative "land use" weights.

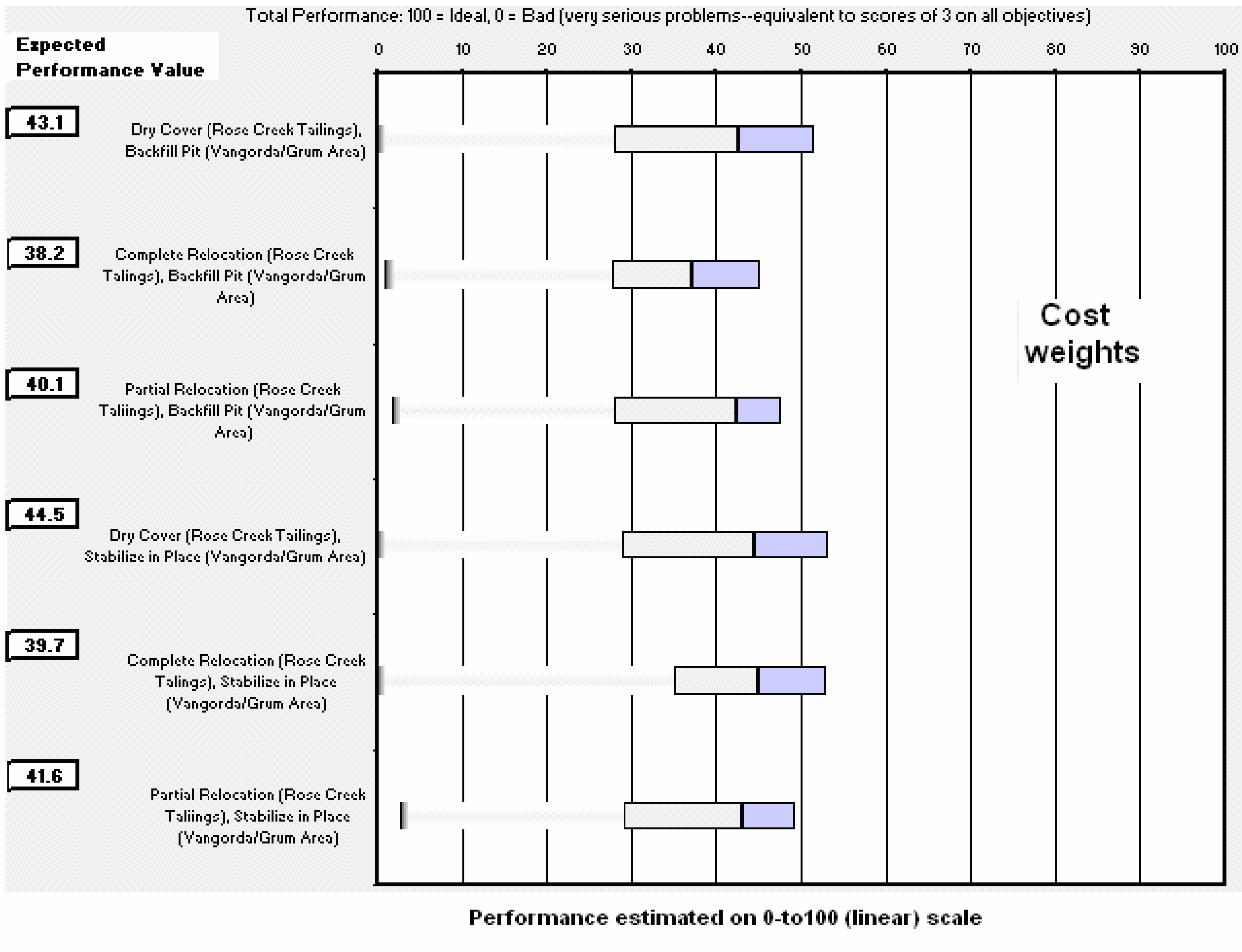


Figure 10.14. Aggregate performance estimates obtained using the illustrative "cost" weights.

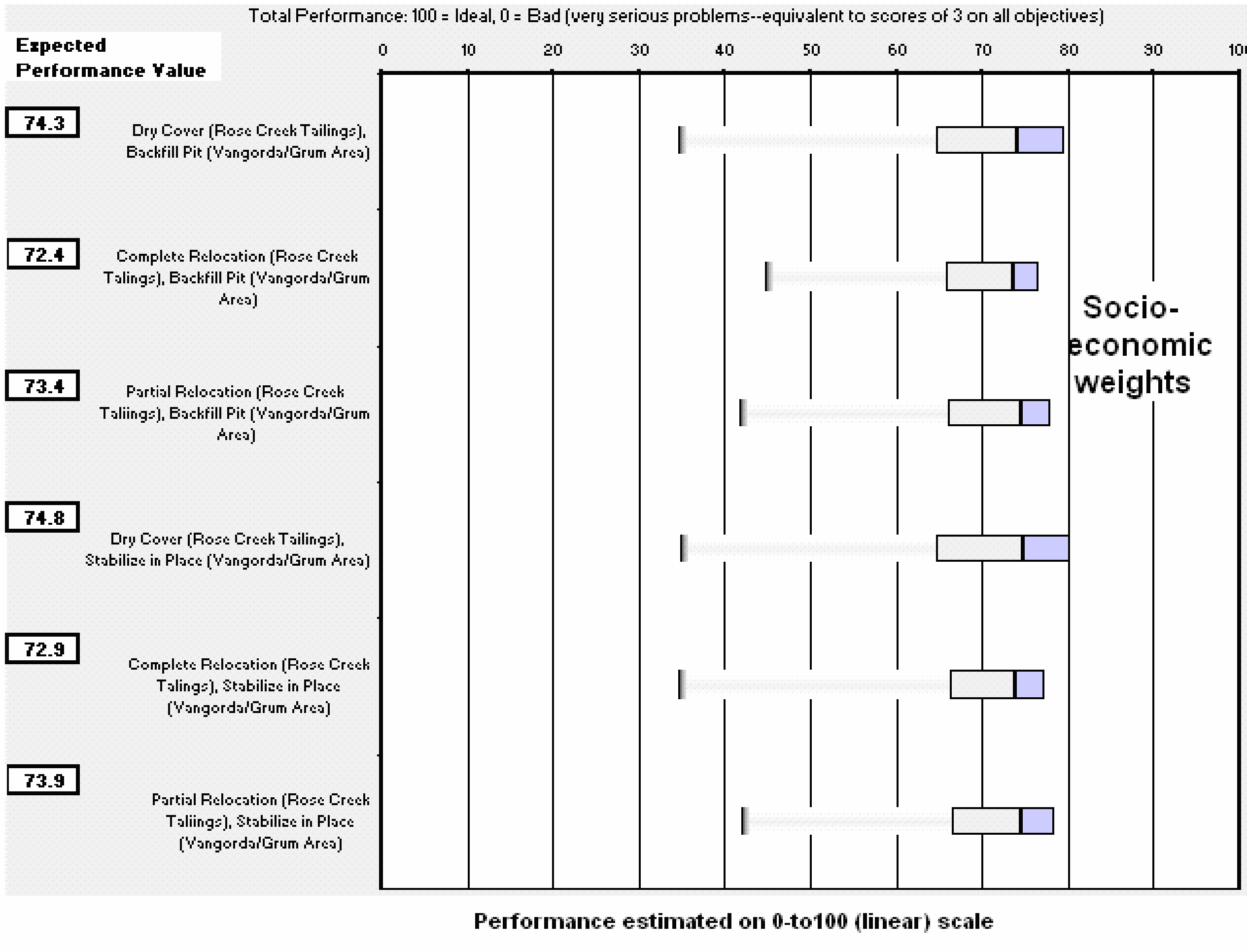


Figure 10.15 Aggregate performance estimates obtained using the illustrative "socio-economic" weights.

As indicated by the preceding figures, regardless of the weighting sets used, the alternative "Dry cover" plus "Stabilize in place" was estimated to have the highest median level of performance, highest probability weighted level of performance, and greatest down-side risk. However, the differences were relatively small.

10.5 Summary and Conclusions

The choice among alternatives involves tradeoffs between achieving short-term and long-term objectives, between maximizing expected performance and minimizing risk, and between achieving cost versus non-cost objectives. More specifically, the performance and value judgments provided by the Assessment Team appear to indicate:

- A conclusion that there is no clear "winner"—Overall performance is nearly the same for all combinations.
- A conclusion that there is significant downside risk that overall performance could be significantly worse than anticipated.
- A conclusion that "Partial relocation" would likely result in a level of performance between that of "Dry cover" and "Complete relocation."
- A conclusion that "Stabilize in place" presents somewhat more risk but (considering all objectives) would most likely perform just slightly better "Backfill pit."
- A general conclusion, independent of the range of weights provided by Team members, that "Dry cover" would most likely perform slightly better (when considering performance against all objectives) than "Complete relocation."
- A conclusion that "Dry cover" presents more downside risk.

The performance and value judgments provided collectively by the Assessment Team appear to possibly present a case for choosing "Dry cover" over "Complete relocation."

- For a wide range of weighting sets, "Dry cover" is consistently ranked (in terms of probability-weighted performance across all objectives based on the Assessment Team collective judgments) equal to or higher than "Complete relocation".
- Thus (ignoring risk aversion), the assessment results appear to indicate (based on the aggregate judgments of Assessment Team members) either indifference, or a slight preference toward "Dry cover" compared to "Complete relocation."
- To a decision maker who prefers lower short-term costs, the above might be interpreted as supporting the choice of "Dry cover." ("If the Assessment Team results indicate indifference, why not choose the cheapest alternative?").

However, because of risk aversion, the fact that (based on Assessment Team judgments) "Dry cover" presents more down-side risk, the choice of "Dry cover" versus "Complete relocation" logically depends on decision-maker willingness to accept the greater downside risk estimated for the "Dry cover" option. The case for selecting a combination that includes "Dry cover" over one that includes "Complete relocation" would be much stronger if the Assessment Team did not attribute significant risks to the selection of any of the alternatives.

Chapter 11. Benefit-Cost Analysis

11.0 Introduction

As noted in Chapter 4, the assessment included an application of benefit-cost analysis. Benefit-cost analysis is a form of analysis that involves comparing the total expected benefits to be derived from available actions with their expected costs.

11.1 The "Base Line" for Computing Benefits

For the purposes of the analysis, the benefits of implementing an alternative were defined in terms of the degree to which the alternative enables objectives to be achieved, relative to doing nothing. Thus, in order to estimate the benefits of conducting the various alternatives, it was first necessary to estimate what would happen under a "do-nothing" alternative. The "do-nothing" alternative is not an option actually being considered by decision makers. Rather, it is a hypothetical alternative defined to serve as a baseline for quantifying the benefits of doing something.

Tables 11.1 through 11.4 summarize the assumptions made by the Assessment Team for the purpose of estimating the consequences of a hypothetical, "do nothing" alternative.

Table 11.1. The "Do Nothing" Alternative for Common Elements

Common Element for all Alternative	Do Nothing Alternative
1. **Covering of Waste Materials**.	No covers; surface water channels abandoned. No maintenance
2. **Upgrade of Diversions.**	No upgrading of diversions; no long term maintenance.
3. **Long-term Groundwater Collection.**	No long-term groundwater collection; no attempt to clean water.
4. **Long-term Water Treatment.**	No short or long-term water treatment
5. **Long-term Site Presence.**	No long-term site presence.
6. **Adaptive Management.**	No adaptive management.
7. **Ancillary Facilities, and Roads.**	Some ancillary buildings removed (as in the current budget)
8. **Hydrocarbon Contaminated Soils**.	No action

Table 11.2 The "Do Nothing" Alternative for the Faro Mine Area

Component	Do-Nothing Alternative
Faro Creek	Abandon as is
North Fork Rose Creek	Abandon as is
South Fork Rose Creek	Abandon as is
Groundwater Collection	No collection
Water Treatment	No water treatment
Oxide Fines/ Low-Grade Ore	No cover, no relocation
Sulphide Cells	No cover, no consolidation
Faro Valley Dump	No cover
Other Waste Rock	No re-sloping, no covers, no swales, no ditches
Faro Pit	No berm, no use of pit for contaminated water
Emergency Tailings Area	Abandon as is, no relocation, no groundwater collection

Table 11.3. The "Do Nothing" Alternative for the Rose Creek Tailings Area

Component	Do-Nothing Alternative
Rose Creek Diversion	Abandon as is
North Wall Interceptor	Abandon as is
Lower Guardhouse Creek	Abandon as is
Groundwater Collection	No groundwater collection
Water Treatment	No water treatment
Intermediate Tailings	Abandon as is
Original & Secondary Tailings	Abandon as is
Cross-Valley Dam	Abandon as is
Intermediate Dams	Abandon as is
Secondary Dams	Abandon as is
Original Dams	Abandon as is

Table 11.4. The "Do Nothing" Alternative for the Vangorda/Grum Area

Component	Do-nothing Alternative
Vangorda Creek Diversion	Abandon as is
Grum Creek	Abandon as is
Groundwater Collection	No groundwater collection
Water Treatment	No water treatment
Vangorda Waste Rock	No covers, no compaction, no relocation
Grum Sulphide Cell	No covers
Other Grum Dump	No cover
Ore Transfer Pad	Abandon as is
Overburden Dump	Abandon as is
Haul Road	Abandon as is
Vangorda Pit	Abandon as is
Grum Pit	Abandon as is

11.2 Consequences of Doing Nothing

The Assessment Team estimated the consequences of "do nothing" using the same zero-to-10 scoring scales (described in Chapter 9) used for assigning performance scores to the alternatives. As explained in Chapter 8, the definitions of the various scores depend on the objective in question, however, in general, a score of 10 represents "ideal performance" while a score of zero corresponds to a situation (defined in terms of the specified objective) that could be characterized as "abominable performance." The scales are logarithmic, such that a drop in score of 2 points represents a situation approximately 10 times as bad.

Figure 11.1 shows the performance ranges obtained for the "do-nothing" alternative. As in the case of the real alternatives, the performance ranges were derived through risk analysis by combining scores provided by Team members under normal and risk scenarios, taking into account the estimated probabilities of risk scenarios. The bars and tick marks show the resulting 1% ("worst case") and 10%- to 90% (low-to-high) confidence ranges, with the 50% median performance indicated on the ranges.

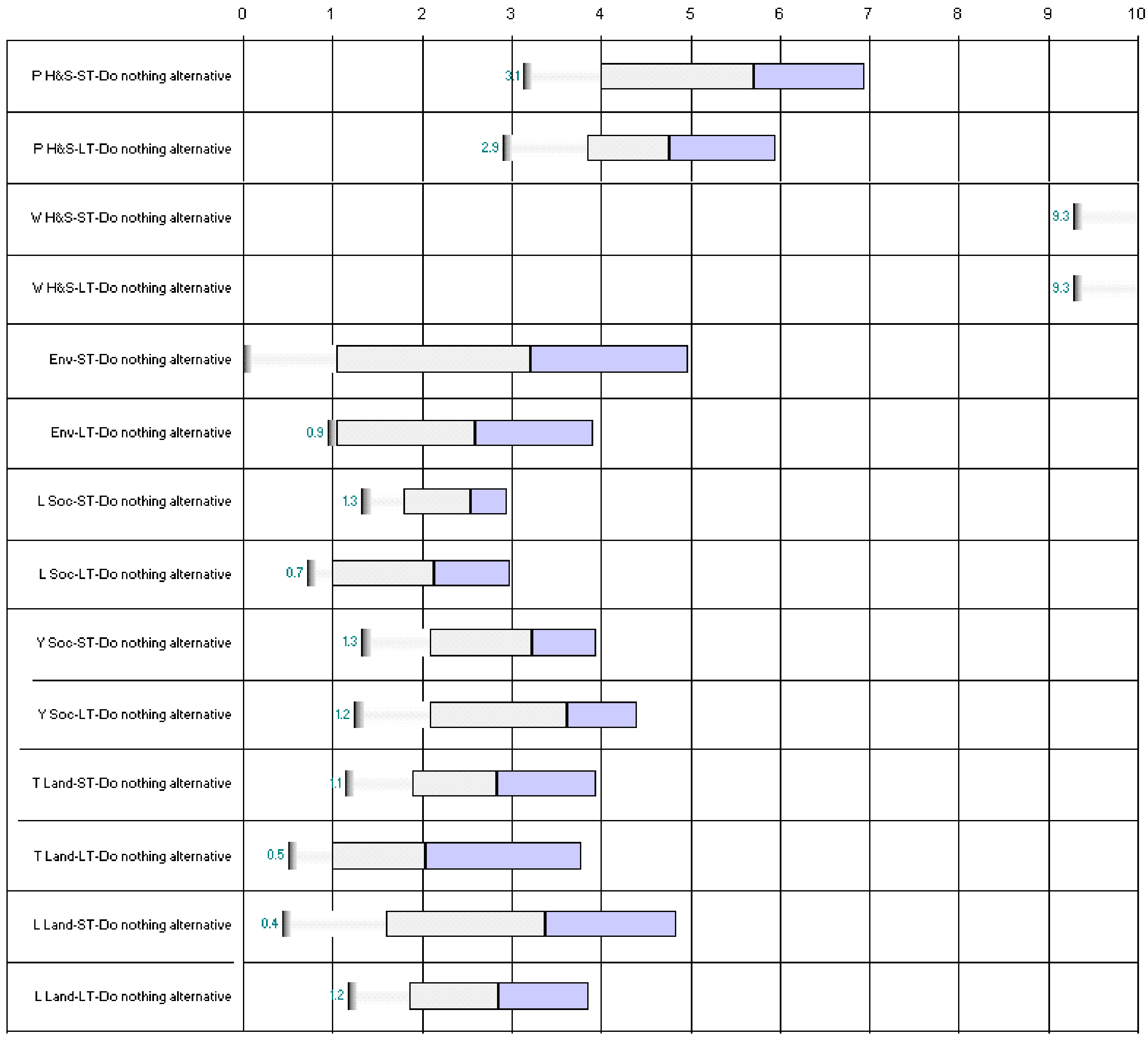


Figure 11.1.   Performance scoring ranges estimated for the “do nothing” alternative [ST = short term, LT = long term]

As indicated by the bars in Figure 11.1, with the exception of public and worker health and safety, the Team estimated that doing nothing would likely lead to consequences characterized by scores of 5 (“poor” performance) or below. In fact, the median and low ends of performance are typically near 3 (“bad” performance) and 2 (“very bad” performance), respectively. With regard to public health and safety, the Team estimated confidence ranges with low ends defined by scores near 4 (“very poor”), indicating (based on the health and safety scoring scale) that the Team would not be surprised if doing nothing resulted in hundreds of serious illnesses or injuries and at least a few fatalities among the public.

With regard to worker health and safety, doing nothing, of course, performs very well, since few if any workers would be present to experience harm. Neither short- nor long-term worker health and safety were assigned perfect scores of 10, though, because some Team members believed that some workers might be harmed during efforts to shut down and abandon the site, and a few believed that some (perhaps "volunteer") workers might be called upon at some future point in time to try to mitigate the consequences of contaminant releases that would surely occur.

11.3 Computation of Expected Benefits

Benefits were estimated on an objective-by-objective basis. To obtain objective-by-objective benefit estimates for the alternatives, the following process was used. First, the performance estimates for the composite alternatives and for the "do nothing" alternative were converted from the log scoring scales into linear measures of performance, as described in Chapter 10. Then, performance values for the three Faro/Rose Creek do-nothing alternative were combined with the performance values for the two Vangorda/Grum alternatives to obtain estimates of performance for the six composite, do-nothing alternatives.[1] Next, for each objective, expected levels of performance were computed by weighting the possible levels of performance by their probabilities, as derived from the risk analysis for the do-nothing alternative (possible levels of performance were weighted by probabilities to account for risk). Finally, the expected benefits for each alternative under each objective were computed by subtracting expected performance under the "do nothing" alternative from the expected performance under the alternative.

11.4 Computation of Expected Costs

Probability weighted costs of the alternatives were not available at the time of the analysis. Therefore, expected costs were derived from previously estimated cost ranges (total costs, discounted at 3% per year) for the component alternatives.[2] Cost estimates for the six composite alternatives were obtained by summing the midpoints of the cost ranges for the Faro/Rose Creek and Vangorda/Grum component alternatives.

11.5 Benefit-Cost Comparison

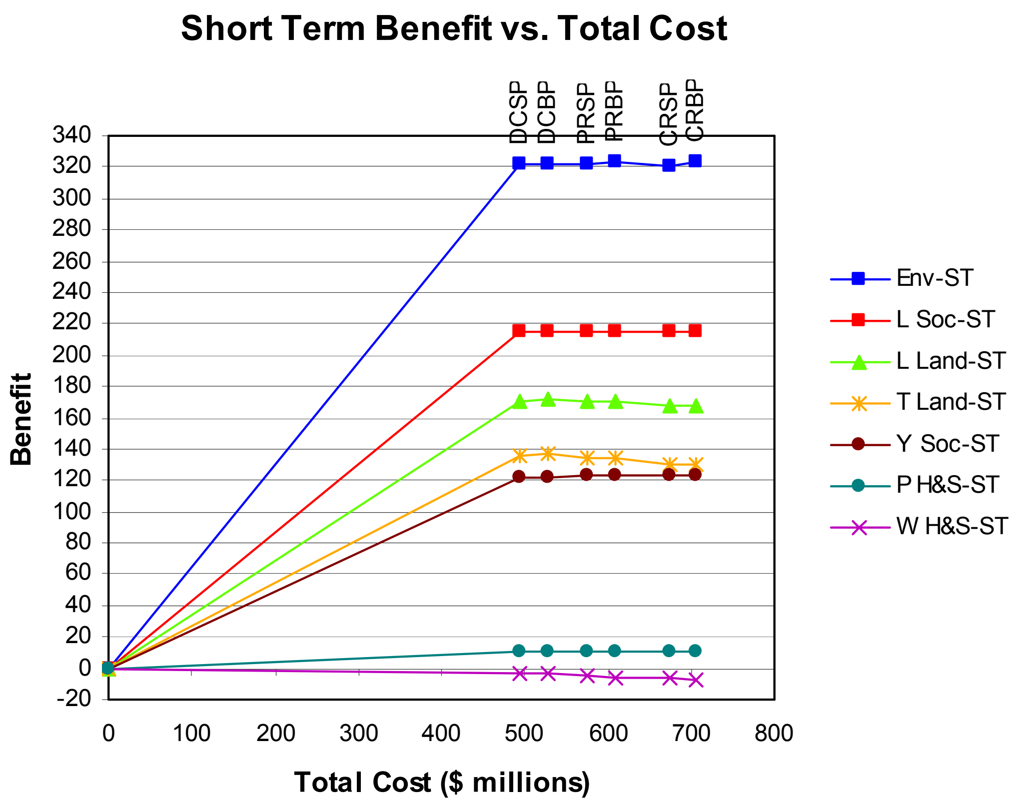
Figure 11.2 shows the relationship between short-term benefits (performance against the objectives during the short-term time period) and costs. Each benefit is expressed on the same linear scale calibrated such that a swing of 300 points approximately corresponds to the difference in value between "very bad"(score of 2) and "ideal" (score of 10) as defined on the corresponding scoring scale. For example, in the case of public health and safety, "very bad" (score of 2) was defined (as indicated by the

1 As in Chapter 9, when scoring "do nothing" under socio-economics, the assumption made was that nothing would be done at either the Faro/Rose Creek areas or at the Vangorda/Grum areas, in other words, "do nothing" was in this case defined as a composite "do nothing."

[2] Cost data used was provided in a memo from Daryl Hockley, SRK Consulting, December 13, 2007. The expected costs were assumed to be equal to the midpoints on the specified ranges

definitions on the public health and safety scoring scale) as performance resulting in "30 or more fatalities and as many as 1000 serious injuries or illnesses," so a benefit of 300 points correspond to preventing 300 fatalities and roughly 1000 injuries/illnesses (far more health and safety benefit than is actually available from the alternatives, as indicated in the figure). Similarly, for the environment, "very bad" performance (score of 2) corresponds to "permanent, large-scale, ecosystem damage" with "regional loss of some key resources," so an environmental benefit of 300 points corresponds to preventing large-scale, ecosystem damage and regional loss of some key resources (an amount of benefit that, according to the figure, is slightly less than that expected from employing any of the alternatives).

Each benefit is expressed on the same linear scale calibrated such that a swing of 300 points approximately corresponds to the difference in value between "very bad" and "ideal" performance.

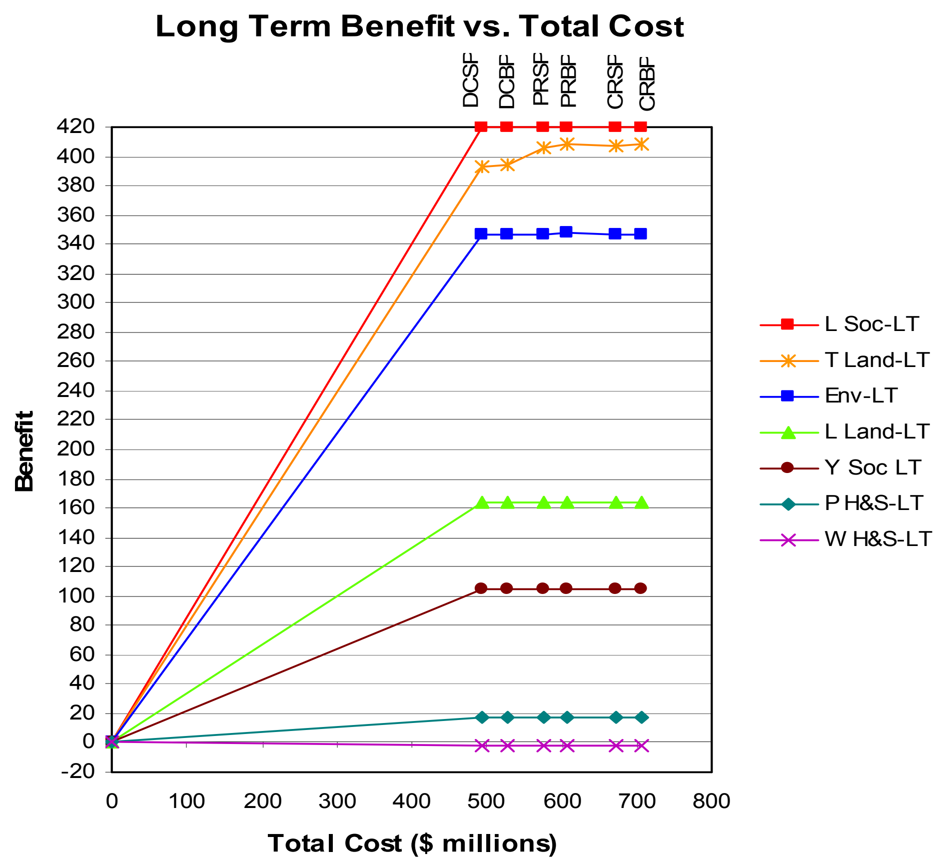


DCSP = Dry Cover (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)
DCBP = Dry Cover (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)
PRSP = Partial Relocation (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)
PRBP = Partial Relocation (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)
CRSP = Complete Relocation (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)
CRBP = Complete Relocation (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)

Figure 11.2. Benefits versus costs, short-term time period.

Figure 11.3 shows the relationship between long-term benefits and total costs, again on the same linear scale of benefit value.

Each benefit is expressed on the same linear scale calibrated such that a swing of 300 points approximately corresponds to the difference in value between "very bad" and "ideal" performance.



DCSP = Dry Cover (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)
DCBP = Dry Cover (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)
PRSP = Partial Relocation (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)
PRBP = Partial Relocation (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)
CRSP = Complete Relocation (Rose Creek Tailings), Stabilize in Place (Vangorda/Grum)
CRBP = Complete Relocation (Rose Creek Tailings), Backfill Pit (Vangorda/Grum)

Figure 11.3. Benefits versus costs, long-term time period.

Note that the plots of benefit versus costs ignore the weights that people might assign to the different types of benefit. In other words a benefit of 300 points (avoiding a "very bad" outcome) in the area of public health of safety is not weighted any differently than avoiding a "very bad" outcome in the environment.

11.6 Observations and Conclusions

According to the results:

- Ignoring weights, the benefits available from the alternatives appear to be mainly in the areas of the environment, local and traditional land use, and local socio-economics. (Indicated by the fact that the plots for these objectives lie highest on Figures 11.2 and 11.3.)
- For nearly all of the objectives, spending more than that required for the least-cost combination does not produce a significant increase in benefit (compared to the amount of benefit available from the least expensive alternative). (Indicated by the fact that the benefit-versus-cost lines are nearly flat in almost all cases.)
- Only in the case of long-term traditional land use is increased spending estimated to produce a significant benefit gain (compared to the benefits of the lower-cost alternatives). (Indicated by the fact that only in the case of long-term traditional land use does the line go up as more expensive alternatives are considered.)
- The fact that, in the short term, the more expensive alternatives were estimated to increase limitations on traditional land use explains why the ranking of alternatives is largely insensitive to weights (as reported in Chapter 10). Placing more weight on traditional land use makes the alternatives that include relocation more attractive in the long term (because the traditional land use benefit-versus-cost line goes up for the long term), but less attractive in the short term. (because the traditional land use benefit-versus-cost line goes down for the short term).
- The conclusion that total benefit does not increase significantly with cost holds regardless of how the various objectives might be weighted, unless long-term traditional land use were to receive the bulk of the weight. (Summing flat lines yields a flat line.)
- Although the analysis can not determine whether the estimated increase in long-term traditional land use benefit justifies spending beyond the least cost alternative, consistent with the principles of cost-effectiveness analysis, consideration should be given to determining whether there are other, less costly mechanisms available for achieving the same or greater long-term traditional land use benefit.

The above conclusions are the logical results of the aggregated judgments of the Assessment Team. Different individuals might well express different judgments, which could lead to different or contrary conclusions.

Chapter 12. Conclusions, Observations and Limitations

This final chapter provides a summary of conclusions and observations and identifies some key limitations of the analysis.

12.1 Conclusions and Observations

The main conclusions and observations derived from the comparative assessment of alternatives are listed below.

1. There are Some Significant Differences among the Alternatives, But No Clear "Winner"

As shown by the objective-by-objective assessment, for 9 out of the 16 objectives (short and long term) performance estimates are very close. These include public health and safety short and long term, worker health and safety long term, environment long term, short and long term local socio-economic, Yukon socio-economic long term, traditional land use long term and local land use long term. More significant differences were estimated for seven objectives including worker health and safety short term, environment short term, Yukon socio-economic short term, cost short and long term, traditional land use short term, and local land use short term.

For the purpose of making a choice, the most significant distinctions among the alternatives are costs and perceived risks (especially low-probability events that could potentially result in significant damage to the environment with consequent limitations to local and traditional land use) and the trade-off between short-term versus long-term performance.

2. The Assessment Indicated High Perceived Risks with Regard to Environmental Performance and Traditional Land Use.

Regardless of which alternatives are chosen, the Assessment Team identified risk scenarios that could, in the opinion of many Team members, lead to very poor performance on some objectives.

Specifically, with regard to the environment, during the short- and long-term periods, the Team's confidence ranges for scores (5½ to 9) indicate the likelihood of some significant violations of environmental standards leading to damage to valued ecosystem components, although such damage was viewed as most likely localized and reversible. However, worst-case (1 chance in 100) scores (typically between 3 and 4) indicate the possibility of serious to very serious problems producing wide-scale reductions in the abundance of some highly valued species lasting over multiple generations.

To an even greater degree, the results indicate pessimism with regard to limitations on traditional land use. In the short-term period, the low end of the Team's confidence range (scores around 4) indicate a belief that there may be serious problems with significant and persistent limitations on traditional land use over a relatively large area. Worst-case, short-term scores (typically 3 or slightly below) indicate the possibility of even more serious impacts (limits on a greater number of more important traditional resources) occurring over a large area. The results are more pessimistic still with regard to worst-case possibilities in the long-term period (where scores as low as 2 or less were obtained). This reflects a view that there is some small chance (1 chance in 100) that there will be permanent and major limitations on traditional land use over a very large area affecting usage of "nearly all" important traditional resources. Indeed, such an outcome, if it were to occur, was viewed, based on scoring definitions, as likely to result in traditions being lost for many people.

3. Despite Concerns Over Environmental and Land Use Risk, the Assessment Indicated Confidence that Any of the Alternatives Will Do a Good Job Protecting Public Health and Safety

Public health and safety confidence ranges fell between 7 to just below 9, depending on the alternatives chosen. According to these scores, the Team would not be surprised to see some minor-to-serious violations of applicable health and safety standards, but no public fatalities or life-threatening illnesses, regardless of which alternatives are selected. The worst-case (1 chance in 100) possibility is perceived to be only a potential for some moderate illnesses and injuries and a small chance of a public fatality. However, no fatalities or serious injuries or illnesses are expected for individuals with average lifestyles who exercise good judgment. Thus, despite the concerns over low-probability, high consequence risks, the Team appears relatively confident that public health and safety will be protected regardless of the alternative chosen.

4. The Assessment Does Not Indicate that Alternatives with Higher Near-Term Costs will Perform Significantly Better or Produce Significantly More Benefits

As shown by the confidence ranges and median performance estimates obtained from the objective-by-objective analysis, the Rose Creek alternative with the highest near-term cost ("Complete relocation") is expected to outperform the other alternatives (by only a small amount) on only 4 out of the 16 objectives: short-term Yukon socio-economics, long-term cost, long-term worker risk, and (barely) long-term local land use. The Vangorda/Grum alternative with the highest near-term costs ("Backfill pit") was estimated for some objectives to perform slightly better and on others to perform slightly worse than the alternative that is less expensive in the short-term ("Stabilize in place"). Thus, the objective-by-objective performance estimates offer little evidence that alternatives that are more expensive in the short-term will result in improved performance.

Similarly, the aggregated performance assessment, which aggregated the objective-by-objective results and used an overall metric based the standard, quantitative definition of risk (probability times consequence) consistently ranked the lowest-cost alternative highest across a range of different weights provided by Team members.

Also, according to the benefit-cost analysis, for nearly all of the objectives, spending more than that required for the least-cost alternatives does not produce a significant increase in benefit (compared to the amount of benefit available from the least expensive alternative). Only in the case of long-term traditional land use was increased spending estimated to produce a significant benefit gain (compared to the benefits of the lower-cost alternatives). The conclusion that total benefit does not increase significantly with cost holds regardless of how the various objectives might be weighted, unless long-term traditional land use were to receive nearly all of the weight.

5. The Assessment Does Indicate that Higher Cost Options will Somewhat Reduce Perceived Risks

As noted above, "Dry cover" was, according to performance scores, estimated to be somewhat more vulnerable to "worst case" risk scenarios. Although "Dry cover" requires significantly lower, near-term costs, it demands higher costs in the long-term for care and maintenance. A risk scenario that concerns many Team members is that the government, for whatever reason, may not continue to provide the funding needed over the long term. A discontinuation of funding might make a failure scenario more likely. Also, if a failure scenario were to occur which resulted in the release of contaminants to the environment, lack of funds to support a rapid clean up might significantly increase the long-term harm to the environment that would result. The advantage of alternatives that are more expensive in the short-term ("Complete relocation" and "Backfill pit") is that they require less spending in the long-term, which reduces the likelihood that funding needs won't be met.

6. Getting Clarity on the Magnitude of Risks and Finding Ways to Mitigate Perceived Risks Would Reduce Barriers to Reaching Consensus over Actions.

The results of the assessment help explain why it has been difficult to generate consensus over what actions to take for dealing with the legacy of the Faro mine. Despite the very careful and comprehensive comparative assessment that was conducted by the Team, the alternatives were not found to differ greatly in their estimated, overall ability to achieve the objectives of Canadians—as noted above, there is no clear "winner." Interestingly, the problem is not that people would logically disagree on which alternative to select because they have different values or assign different weights. Rather, the problem is that, no matter what weights individuals might assign, the choice is still difficult.[1]

Even more importantly, the scores assigned by the members of the Assessment Team indicate the perception that there are significant risks regardless of which alternative is selected, particularly with regard to the environment and land use. Given the lack of a clearly superior alternative and the perceived riskiness of all of the options, not to mention the high costs involved, it is not surprising that the choice has been difficult.

Actions potentially useful for reducing perceived risks and building confidence and consensus include (1) the design of an effective and confidence-inspiring implementation plan; (2) resolution of risks associated with the lack of financial surety and exploration of permanent funding mechanisms; and (3) the design and implementation of the adaptive management regime for the full life-cycle of the closure project.

12.2 Limitations of the Assessment

A key limitation of the assessment relates to the inherent difficulty of the judgments required. In particular, there is tremendous uncertainty regarding technological and other changes that might occur over the next hundreds of years. The Team did not have the benefit of alternative futures analyses and other aids that might have enabled better "out of the box" thinking relevant to the assessment.

Another limitation of the assessment is the dependence of the results on assumptions regarding how the selected alternatives would be implemented. The estimates were based on a specific set of implementation strategy assumptions, documented in Chapter 7. However, the implementation strategy has not yet been fully defined, and the implication is that performance could be better or worse than that estimated by the assessment.

Certain potentially important considerations were identified by the Assessment Team that were deliberately not included within the assessment, due to the lack of sufficient information or understanding. These include the impact of the choice on future mining in the vicinity of the site and the impact of the choice on the potential for reprocessing of the tailings.

Finally, as noted previously, the assessment results are product of the collective, aggregated judgments provided by the specific individuals who participated. Individual Team members may not personally agree with conclusions. A group composed of different individuals could well provide different scores and weights, which could lead to different results.

[1] As demonstrated in Chapter 10, however, there is a clear distinction in estimated aggregate performance in the respective short- and long-term periods. Thus, individuals who would weight performance significantly differently depending on time period might well have clearer preferences over which alternative should be selected.

Appendix 1. Faro Assessment Team Bios

Dan Cornett

Dan is a Registered Professional Biologist and Canadian Certified Environmental Practitioner with 25 years experience working with the environmental assessment and regulatory regimes in northern Canada. He is currently Vice President Access Consulting Group and Vice President Technical Services Alexco Resource Corp. Dan obtained his B.Sc. degree in Zoology from the University of Guelph.

Dan grew up in the Sudbury, Ontario area and worked in the mining industry with Falconbridge Nickel Mines Ltd for many years and continues to work closely with industry in the environmental management area. He was involved with some of the initial reclamation efforts in the Sudbury area and has now seen the benefits of onsite reclamation and revegetation.

In 1985, Dan moved to the Yukon and worked with the Department of Fisheries and Oceans as a Fisheries Biologist documenting the habitats and distribution of Chinook and Chum salmon as part of the Yukon River Basin Study. He subsequently worked with Environment Canada in a regulatory enforcement capacity and with DIAND Water Resources heading up their environmental assessment division until 1993 when he joined Access Consulting Group.

Operating an environmental consulting practice in Yukon has provided Dan with an opportunity to become involved with development projects in a number of industrial sectors. He has completed numerous environmental assessments and project permitting for a variety of resources development projects in Yukon and internationally. He has been instrumental in the coordination and management of the environmental assessment and permitting for large-scale mining operations – Minto Exploration Ltd. – Minto Copper Project, Western Copper Corporation – Carmack's Copper Project; oil and gas projects – Devon Canada – Eagle Plains and Kotaneelee Seismic and Drilling Programs and Yukon Government Carcross and Burwash Sewage Treatment facilities.

In 1998, the City of Whitehorse Robert Service Reconstruction Project received the Transportation Association of Canada Environmental Achievement Award and Dan was the team member responsible for the project assessment, permitting and monitoring.

Dan has considerable experience with mine decommissioning planning and implementation and was part of the team that reclaimed Viceroy Minerals Corporation – Brewery Creek Mine which received recognition by both the Federal and Yukon Governments. He is presently involved in the decommissioning planning for the Faro mine and the United Keno Mines and assisted with the development of mine closure plans for the Minto and Sa Dena Hes projects.

An active advocate for responsible development in the resource industry, Dan is presently Vice President of the Yukon Chamber of Mines and member of the Yukon Minerals Advisory Board.

Malcolm Foy

Malcolm G. Foy, Hons. B.Sc., R.P. Bio**.**, is a senior environmental biologist with LGL Limited, environmental research associates, with over 30 years of professional work experience. For the past ten years Malcolm has worked almost exclusively with First Nations in northern British Columbia and the southern Yukon, most prominently with the Kaska Nation on its treaty and land claim negotiations and in providing technical advice and input in respect of land and resource use within the Kaska traditional territory. In this capacity, he is currently working with Ross River Dena Council and the Kaska Nation in their participation in the development of a closure and remediation plan for the Faro Mine in the Yukon, and is assisting the Dena Kayeh Institute in its review of the environmental assessment for the proposed Kemess North gold mine project. Malcolm also works with other First Nations and at present is assisting Tahltan Central Council, Treaty 8 First Nations, the Carrier Sekani Tribal Council, and Simpcw First Nation in their participation in environmental processes in respect of several proposed mine, wind power, and gas pipeline projects.

Over his career, Malcolm has participated in a variety of biological or ecological research projects throughout Canada and Alaska. In the mid to late 1970s he worked on baseline marine biological research projects as part of environmental assessments related to proposed oil and gas development in the High Arctic. In the late 1970s and early 1980s he worked from LGL's Newfoundland office on similar environmental assessment projects on the Labrador shelf and the Grand Bank, as well as on fisheries research issues. Based in LGL's Ontario office in the early 1990s, he managed many watershed planning or environmental assessment projects that integrated the skills of a variety of specialists, and worked with Parks Canada on the environmental assessment of several park management plans.

Although Malcolm has been associated with LGL Limited for most of his professional career, he has also spent shorter periods working with the federal Department of Agriculture, the University of Guelph, the National Museum of Natural Sciences, the Arctic Biological Station (federal Department of Environment), the federal Department of Fisheries and Oceans (as a Senior Advisor in respect of fish stock assessments), and the Ontario Ministry of Environment (as a Water Scientist).

Daryl Hockley

Daryl Hockley, P.Eng., P.E., is a Principal in the GeoEnvironmental Engineering Division of SRK Canada. He is a civil engineer with a Master's degree in environmental engineering. He leads SRK's contribution to multi-disciplinary environmental and geotechnical projects, and provides specialist expertise in mine closure and mine waste management.

Daryl's mine closure experience includes leading SRK's multi-project contribution to closure of the WISMUT uranium district in the former East Germany. His recent mine closure projects in Canada include development and implementation of closure measures for the Colomac, Kitsault, Arctic Gold, Discovery, and Venus mines, preparation of closure plans for the Island Copper, Gibraltar, HBMS, and Deloro mines, and review of closure liabilities at over twenty operating and abandoned mines. He is currently involved in two of the largest mine closure projects in the Canadian north, as senior technical advisor for the clean-up of arsenic trioxide dust at the Giant Mine, near Yellowknife, and as technical advisor to the Faro Mine closure project. He is also leading the development of a closure plan for the Red Dog Mine in Alaska.

Daryl has directed applied research projects in his areas of technical interest, including the development of new waste disposal technologies, the behaviour of contaminants at the waste soil interface, mathematical modeling of acidic drainage, measures to delay the onset of acidic drainage, and the use of soil covers in northern climates. He has authored or co-authored over thirty technical papers, and has presented short courses on his areas of expertise to industry and regulators.

In the last five years, much of Daryl's work has been in public consultation related to mine closures. He has led approximately twenty workshops attended by both technical specialists and stakeholders, for mine closure projects in the US and Canada. He developed new methods for consultation with First Nations and applied them successfully in closure projects for the Red Dog mine in Alaska and the Ekati Mine in the Northwest Territory.

Anthony Hodge

Dr. R. Anthony Hodge is a professional engineer in private practice and Kinross Professor of Mining and Sustainability, Queen's University at Kingston.. He received his B. A. Sc. (1972) and M. A. Sc. (1976) degrees from the University of British Columbia (Geological Engineering with a specialization in groundwater hydrogeology). He was awarded his Ph. D. (interdisciplinary) in 1995 from McGill University as a result of work that focussed on reporting on progress toward sustainability. Through March 2007 he was a member of the Independent Peer Review Panel for closure of the Yukon's Faro Mine. He is currently working with the Gitxaala Nation (northwest coastal BC) and the Saugeen Ojibway Nation (Bruce Peninsula, Ontario) and is serving as an Advisor to Canada's Nuclear Waste Management Organization with special responsibilities for ensuring effective aboriginal involvement. In June 2007 he and Ingrid Taggart facilitated a review of northern benefits from Natural Resource revenues which led to the report *Freedom to Choose – Natural Resource Revenues and the Future of Northern Communities* (Walter and Duncan Gordon Foundation, Toronto). In addition to being President of Anthony Hodge Consultants Inc., he is an Associate with the International Institute for Sustainable Development (Winnipeg).

Anthony spent most of the 1980s in the Yukon where he: led a review of energy use in the Yukon and NWT (part of a national assessment); served as Technical Consultant to the Director of the Yukon River Basin Study; participated in a review of environmental and human health concerns related to the abandoned Rayrock and Port Radium mines; for 18 months served as Manager, Yukon Benefits, DIAND with special emphasis on mine and mineral exploration-related transportation and Beaufort Sea development; cocoordinated development of Yukon 2000, a project aimed at creating a long term economic development strategy for the Yukon; and was a public advocate for environmental concerns with the Yukon Conservation Society.

From 1989 – 1992, Anthony was President of Friends of the Earth Canada. In 1992 he was appointed to the Prime Minister's National Round Table on the Environment and the Economy (NRTEE) a position he held until 1996. Through 2001 and 2002 he led the North American component of a global multi-interest review of practices in the mining/mineral industry (MMSD – North America). As part of this work he championed development of *Seven Questions to Sustainability – How to Assess the Contribution of Mining and Mineral Activities*. In 2003 – 2004, he facilitated the Tahltan Mining Initiative (2003 – 2004) which led to publication of the report *Out of Respect – the Tahltan, Mining and the Seven Questions to Sustainability*.

Randy Knapp

Randy Knapp, P.Eng., a founder partner of SENES Consultants Limited, is a chemical engineer with over 30 years experience in environmental projects related to the mining industry. Mr. Knapp is recognized within the industry for his leadership in assessment challenging environmental issues and the development of cost effective and practical technical and solutions. He has an international reputation, which has led to contract work throughout North America, as well as in Europe, the former Soviet Union, Africa, South America, Central America, Mexico, the Caribbean and Australia. Mr. Knapp specializes in projects involving mine liability assessment, decommissioning and closure, site selection, geochemistry, development of monitoring and response plans, acid generation modelling, risk assessment and effluent treatment. Mr. Knapp is author of more than 50 technical papers on mining and the environment.

Ellie Marcotte

Ellie took over the position of Project Coordinator for the Faro Project on behalf of the Selkirk First Nation in 2005. Previously she had worked in social services for Selkirk First Nation following similar work in Alberta. Based in Pelly Crossing, Ellie has a wide range of responsibilities related to managing and coordinating the Faro project activities including communications, field studies, technical and information workshops.

Stephen Mead

Born and raised in London, England, Stephen graduated from Aston University with a degree in Chemical Process Engineering. He started his career with London Underground Limited, measuring and modeling airborne particulates generated as a result of operations of the London subway. Following a two year research project in conjunction with Texaco Oil Co., developing a fire retardant grease, Stephen moved to North America. After receiving a Masters Degree in Education from the University of Fairbanks, Stephen spent six years developing curriculum and teaching applied Industrial Science in alternative high schools in Alaska.

Following a move to the Yukon, he spent time as Executive Director of the Yukon Literacy Coalition, as well as the Boys and Girls Club of Whitehorse. He also worked for a private environmental consulting firm, focusing on remediation of contaminated hydrologic sites before joining the Yukon government as technical advisor to the Faro Mine closure planning process in 2005. He has recently been appointed Senior Project Manager for the overall closure planning process.

Miley W. (Lee) Merkhofer

Dr. Merkhofer, a partner of Folio Technologies, LLC, has more than 25 years of experience in the research, teaching, and application of decision and risk analysis to environmental problems. He previously served as Manager of Research Programs for the Decision Analysis Group, SRI International (1975-1983), Vice President of Applied Decision Analysis, Inc. (1984-1998), and Partner of PricewaterhouseCoopers, LLC (1998-2001).

Lee is experienced at addressing decisions related to a wide range of important problems, including helping NASA quantify the risks of space missions, evaluating clean-up strategies for hazardous waste sites, and helping local governments improve water and wastewater services. He has served on advisory panels for the U.S. National Academy of Sciences, Environmental Protection Agency, Department of Energy, Office of Technology Assessment, and the National Academy of Sciences. He has received grants and awards from the U.S. National Science Foundation, Office of Naval Research, and the Defense Advanced Research Projects Agency.

Lee was Winner, Best Decision Analysis Application of 1988, Decision Analysis Competition, Operations Research Society of America and Runner up, Best Decision Analysis Application of 2000, Decision Analysis Competition, Institute for Operations Research and Management Sciences (INFORMS). He is Member of Phi Beta Kappa and Sigma Xi. He is an editor of the journal *Decision Analysis*, and has served as an elected officer of the Decision Analysis Special Interest Group, INFORMS, and as an elected officer of the U.S. Society for Risk Analysis.

Lee received his Ph.D., Engineering-Economic Systems, Stanford University (1975), his M.S., Electrical Engineering, Stanford University (1971); and B.S., Physics (summa cum laude), Stanford University (1970). He has published over two-dozen professional papers and is the author of the book *Decision Science and Social Risk Management* and co-author of the book *Risk Assessment Methods*. One of Lee's current special interests is teaching young people ways to improve their decision-making skills.

Michael Nahir

Michael Nahir is a professional engineer and currently the Manager of Engineering with the Contaminated Sites Program in the department of Indian and Northern Affairs Canada in Ottawa. He has 17 years of experience in the assessment and remediation of contaminated sites obtained mostly within the federal government.

Michael specializes in the remediation of abandoned mine sites and contaminated sites in Arctic and cold climates and has been the project engineer or project manager of numerous remediation projects. He is the author of several peer reviewed papers and is the co-founder and co-chair of the *Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates* Conference which began in the early 1990s.

Michael received a Masters Degree in Civil and Environmental from University of Alberta and Bachelor of Science in Engineering from University of Manitoba. When not working or hanging out with the family, Michael can be seen riding the wind on his sailboat.

Bill Slater

Bill Slater is the sole proprietor of an independent environmental consulting business operating since 2003 and a bicycle guiding business operating since 2004.

Bill Slater Environmental Consulting provides technical, regulatory and policy consulting services in environmental management, environmental impact assessment, water management, mining and infrastructure development. Clients include government agencies (federal, First Nation, territorial and municipal), independent resource management agencies, non-government organizations and private companies. Bill Slater Environmental Consulting has worked collaboratively with other consultants on a variety of projects.

Prior to starting his consulting business, Bill had over ten years of experience working in Yukon for the federal and territorial governments in the fields of environmental assessment, water management and First Nation land claim implementation. On behalf of governments, he led technical reviews of large mine development proposals as well as mine closure plans. Bill is very familiar with Yukon's project permitting and environmental assessment regimes and has advised both governments and First Nations extensively on the development and implementation of Yukon's environmental and socio-economic assessment legislation: the *Yukon Environmental and Socio-economic Assessment Act*.

Bill graduated with distinction from the University of Guelph in 1988, receiving an honours degree in Agricultural Engineering and the Association of Professional Engineers Gold Medal for highest academic standing. Bill currently resides in Whitehorse where he enjoys the outdoors with his wife and two children.

Kathlene Suza

Kathlene Suza is the Project Coordinator for the community office of the Faro Mine Closure Planning Office in Ross River. Kathlene was born and raised in the Ross River area and worked for many years in the health and social service sector, in Ross River, in Prince Rupert, Prince George and Edmonton.

Since the mid 1990s, Kathlene has worked in a variety of positions related to land and resource management, within First Nations' governments and the mining industry. This included work with: Anvil Range Mining Corporation as Human Resources Supervisor and Aboriginal Employment Manager; Westmin Resources and Redfern Resources as First Nation liaison officer, for Ross River Dena Council and Taku River Tlingit, respectively; Kaska Nation and Ross River Dena Council in relation to treaty and land claim negotiations in British Columbia and Yukon; Deloitte and Touche, in their capacity of the Interim Receiver for the Faro Mine, as a liaison officer with Ross River Dena Council. Kathlene is the mother of two children and has five grandchildren.

Assessment Foundation - Ross River Dena/Kaska (December 15, 2004)		
Original Item	*Where addressed in the Current Objectives Hierarchy*	*Comment*
1. Protect human health and safety		
Kaska **Objective 4: Ensure that the health and safety of people using the land and people downstream of the mine are protected.** **Sub-Objectives** 1. Re-locate the tailings to the Faro Pit and remove the dams in the Rose Creek Valley. (K4.1) In addition, some of the other issues and concerns related to the tailings and described in Objectives 1 (Point 4) and Objective 3 (Point 2) can be considered to be health and safety issues as well. 2. Ensure that all water management structures are sized to handle maximum probable floods, taking into account events of high rainfall combined with snowmelt. (K4.2) – The implications of the failure of water management structures, including the Rose Creek Diversion Channel, are discussed in Objective 3, Point 3. This is, of course, a health and safety issue, as well as an environmental issue. 3. Meet or exceed environment and health associated regulations and standards, including those related to water quality and soil contamination. (K4.3) -- 4. By re-locating the tailings to the Faro Pit, reduce the problem of dusting of vegetation and possible metal uptake by game animals that may be hunted and consumed by humans. (K4.4) -- 5. Continue to monitor metal levels in country foods, including fish, wildlife, and edible plants. (K4.5)	**Objective 1. Maximize public health and safety, and** **Objective 2. Maximize worker health and safety, and** **Objective 3 Maximize restoration, protection and enhancement of the environment.**	• Tailings relocation is one of the alternatives being assessed • Design to maximum probable flood requirement that is standard practice and is required of all alternatives being assessed • Adherence to regulations and standards (environment, health, safety etc.) is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. This issue could be expressed as an assumption. • Dust as a contaminant pathway is addressed in Objective 3, Environment, and its influence diagram. • The following is included in the overarching implementation strategy. It is noted as an "assumption" in the assessment. It does not vary between options. Thus it is not a factor in judging the relative merits between options. - A commitment to monitoring of contaminant levels in country food (including fish, wildlife, and edible plants)
2. Protect the environment including land, air, water, fish and wildlife.		
Kaska	**Objective 3. Maximize restoration and protection of the**	• Adherence to regulations and standards (including those

Objective 3: Ensure that the environment (water, land, and air) and its fish and wildlife are protected. **Sub-Objectives** 1. Meet or exceed environment and health associated regulations and standards, including those related to water quality and soil contamination. (K3.1) 2. Re-locate tailings to Faro Pit, and restore Rose Creek Valley and Rose Creek to original condition. (K3.2) 3. Ensure that all water management structures are sized to handle maximum probable floods, taking into account events of high rainfall combined with snowmelt. (K3.3) 4. Waste rock dumps should be re-sloped, covered, and re-vegetated with native plants to restore some semblance of a natural environment with the purposes of restoring wildlife habitat and improving the aesthetics of the site. (K3.4) -- The re-sloping, covering, and re-vegetation of waste rock dumps is described as Point 5, of Objective 1, above. It is an issue that is related to both the re-establishment of traditional uses on the land and an environmental protection and rehabilitation issue.	**environment.**	governing water quality and soil contamination) is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. This issue could be expressed as an assumption. • Partial and complete tailings relocation are alternatives being assessed. • Design to maximum probable flood requirement that is standard practice and is required of all alternatives being assessed • Environmental restoration is covered in Objective 3, Environment; Grooming (re-sloping, covering, re-vegetation) the land to capture the nature and spirit of local land forms is covered in Objective 7 and 8, Land Use as well as Objective 3, Environment.
3. Return Mine Site to an acceptable state of use, that reflects original use where possible		
Kaska **Objective 1 -- Restore the mine site to maximize the re-establishment of traditional land uses. (K1)** **Sub-Objectives** 1. Use traditional knowledge in the planning process, and give traditional knowledge the same weight as scientific knowledge. (K1.1) 2. Restore the site to allow the use of hunting and trapping trails and trap lines that existed prior to mining. (K1.2) 3. Provide more access across the haul road (e.g. ramps) at traditional trails. (K1.3) This would assist in meeting the secondary objective described in #2, above. 4. Re-locate tailings to Faro Pit, and restore Rose Creek Valley and Rose Creek to original condition. (K1.4) 5. Waste rock dumps should be re-sloped, covered, and re-vegetated with native plants to restore some semblance of a natural environment with the purposes of restoring wildlife	**Objective 7. Minimize limitations to traditional land use, and** **Objective 3. Maximize restoration and protection of the environment.**	• Both "traditional" and "local" land uses are addressed in the influence diagram • Re-establishment of traditional land uses (including hunting, trapping, and fishing) is addressed within the influence diagram • The following factors are included in the overarching implementation strategy. They are explicitly noted as "assumptions" in the assessment. They do not vary between closure options. Thus they do not help in judging the relative merits between options. - A commitment to protecting the culture and traditional pursuits of affected First Nations; - A commitment of the use of traditional knowledge and to giving traditional knowledge equal weight to "scientific" knowledge factors in the planning and implementation process; - A commitment to enhancing access across the haul

habitat and improving the aesthetics of the site. (K1.5)		road (e.g. ramps) at traditional trail crossing is • Environmental restoration is covered in Objective 3, Environment; Grooming (re-sloping, covering, re-vegetation) the land to capture the nature and spirit of local land forms is covered in Objective 5, Land Use as well as Objective 2, Environment.
4. Maximize local and Yukon benefits		
Kaska **Objective 2: Maximize economic and social benefits to the Kaska in the implementation of the closure plan. (K2)** **<u>Sub-Objectives</u>** 1. Ensure that the closure plan has provision for training and capacity building. (K2.1) 2. Establish scholarships for Kaska students who wish to pursue higher education. (K2.2) 3. Provide job-mentoring opportunities for Kaska members. (K2.3) 4. Provide other socio-economic benefits to the Kaska. (K2.4)	**Objective 4. Maximize local socio-economic benefits**	• The following factors are included in the overarching implementation strategy. They are explicitly noted as “assumptions” in the assessment. They do not vary between closure options. Thus they do not help in judging the relative merits between options. - Provision of training and capacity building for the Kaska people - Establishment of scholarships for Kaska students who wish to pursue higher education - Provision of job-mentoring opportunities for Kaska members. • The overall provision of socio-economic benefits for the Kaska is covered in Objective 3, Socio-economic benefits

<table>
<tr><th colspan="3">Assessment Foundation,
Selkirk First Nation, December 15, 2004</th></tr>
<tr><th>Original Item</th><th>Where addressed in the Current Objectives Hierarchy</th><th>Comment</th></tr>
<tr><td colspan="3">2. Protect human health and safety</td></tr>
<tr><td>Selkirk
Objective: Protect the quality and quantity of water in the Pelly River to ensure the health of Selkirk people” (S.I)
<u>Sub-Objectives</u>
1. The Closure plan must ensure that the quality of water in the Pelly River is protected.
2. To meet CCME water quality standards in Rose and Vangorda Creeks.
3. To protect terrestrial resources in the Pelly River drainage from contamination from the mine site (metals, hydrocarbons, other chemicals).
Objective: Prevent spread of contamination through the air (S.II)
<u>Sub-Objectives</u>
1. To ensure the contaminated waste is not being spread to surrounding plants, animals and water drainage through the air by wind or evaporation.
2. To meet Yukon Contaminated Sites soil standards at the mine site
Objective: Prevent seepage of contaminated water into the groundwater (S.III)
<u>Sub-Objectives</u>
1. To ensure that the tailings are properly stored and safely contained (see objectives # 2 and #5).
2. To ensure that pit drainages and waste rock seepages are contained, collected and/or treated.</td><td>Objective 1. Maximize public health and safety, and
Objective 3. Maximize restoration, protection and enhancement of the environment.</td><td>• Water quality in the Pelly River is covered in both Objective 1, Health and Safety and Objective 3, Environment
• CCME levels are guidelines. Adherence to regulations and standards (environment, health, safety etc.) is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. This issue could be expressed as an assumption.
• Protection of the terrestrial ecosystem is covered by Objective 3, Environment.
• Contaminant pathways via air (dust, wind, evaporation etc.) is covered by Objective 2, Environment.
• Adherence to regulations and standards (including Yukon Contaminated Sites soil standards) is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. This issue could be expressed as an assumption.
• The success of ensuring “proper” and “safe” storage of tailings is a key aspect of the assessment. All of the objectives come to play in making this judgment.
• Similarly, achieving success at containing, collecting, and/or treating pit drainage and waste rock seepage is a key aspect of the assessment. It is explicitly considered in objectives 1 (health and safety), 2 (environment), 4 (costs), and 5 (land use)
• Tailings relocation to the pit is an alternative being assessed. Removing all threat of pollution to the Pelly</td></tr>
</table>

Objective: Remove the tailings and all the contaminated soils to a safe place away from the river drainage" (S.IV) **<u>Sub-Objectives</u>** 1. To remove the threat of pollution to the Pelly River Basin by removing the wastewater and tailings in the tailings ponds to another site. 2. To remove the waste to a safe place far away from any river drainage system. 3. Ensure that the new site for holding the waste is not a threat to the surrounding area. 4. To investigate the extent of historic tailings release and potential clean up measures.		River Basin from the mine site is not possible. • Moving all of the waste to a safe place far away from any river drainage system is not possible. Relocating all or part of the Tailings to the Faro pit is an alternative being assessed as is relocating portions of the waste rock into the Vangorda Pit. • Ensuring any "new site" is not a threat to the surrounding area is covered by the Objective 2. Environment. • An Investigation of historic tailings releases has been completed including a summary of their extent and recommendations regarding potential clean up measures. (CHECK THIS)
2. Protect the environment including land, air, water, fish and wildlife.		
Selkirk **Objective: Protect the quality and quantity of water in the Pelly River to ensure the health of Selkirk people" (S.I)** **<u>Sub-Objectives</u>** 1. The Closure plan must ensure that the quality of water in the Pelly River is protected. 2. To meet CCME water quality standards in Rose and Vangorda Creeks. 3. To protect terrestrial resources in the Pelly River drainage from contamination from the mine site (metals, hydrocarbons, other chemicals). **Objective: Prevent spread of contamination through the air" (S.II)** **<u>Sub-Objectives</u>** 1. To ensure the contaminated waste is not being spread to surrounding plants, animals and water drainage through the air by wind or evaporation. 2. To meet Yukon Contaminated Sites soil standards at the mine site **Objective: Prevent seepage of contaminated water into the groundwater" (S.III)**	**Objective 3. Maximize restoration, protection and enhancement of the environment.**	• Water quality restoration and protection is covered in Objectives 1, Health and Safety, 3, Environment and 7. Land Use (stream water for tea) • CCME levels are guidelines. Adherence to regulations and standards (environment, health, safety etc.) is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. This issue could be expressed as an assumption. • Restoration and protection from contamination of terrestrial resources in the Pelly River drainage basin is covered in Objective 2, Environment. • Contaminant migration is covered in Objective 2, Environment and Objective 1, Health and Safety. • Adherence to regulations and standards (including those governing water quality and soil contamination) is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. This issue could be expressed as an assumption. • The success of ensuring "proper" and "safe" storage of tailings is a key aspect of the assessment. All of the

Sub-Objectives 1. To ensure that the tailings are properly stored and safely contained (see objectives # 2 and #5). 2. To ensure that pit drainages and waste rock seepages are contained, collected and/or treated. **Objective: Remove the tailings and all the contaminated soils to a safe place away from the river drainage" (S.IV)** **Sub-Objectives** 1. To remove the threat of pollution to the Pelly River Basin by removing the wastewater and tailings in the tailings ponds to another site. 2. To remove the waste to a safe place far away from any river drainage system. 3. Ensure that the new site for holding the waste is not a threat to the surrounding area. 4. To investigate the extent of historic tailings release and potential clean up measures. **Objective: Monitor the water, the land, the animals and the plants as long as required" (S.VII)** **Sub-Objectives** 1. To provide an ongoing environmental monitoring program that measures short and long-term effects from the site, in particular monitoring of the site, the water, animals, plants and fish in the effected Pelly River drainages that effect human health. **Objective: Involve Selkirk First Nation in ongoing monitoring and inspection" (S.VIII)** **Sub-Objectives** 1. To employ and train Selkirk people to do the site monitoring and inspection. **Objective: Work together to ensure the Pelly River is protected" (S.X)** **Sub-Objectives** 1. To ensure that Selkirk are involved in the development and implementation of the closure plan. 2. That the plan is consistent with the objectives of the Yukon		objectives come to play in making this judgment. • Similarly, achieving success at containing, collecting, and/or treating pit drainage and waste rock seepage is a key aspect of the assessment. It is explicitly considered in objectives 1 (health and safety), 2 (environment), 4 (costs), and 5 (land use) • Tailings relocation to the pit is an alternative being assessed. Removing all threat of pollution to the Pelly River Basin from the mine site is not possible. • Moving all of the waste to a safe place far away from any river drainage system is not possible. Relocating all or part of the Tailings to the Faro pit is an alternative being assessed as is relocating portions of the waste rock into the Vangorda Pit. • Ensuring any "new site" is not a threat to the surrounding area is covered by the Objective 2. Environment. • An Investigation of historic tailings releases has been completed including a summary of their extent and recommendations regarding potential clean up measures. (CHECK THIS) • The following factors are included in the overarching implementation strategy. They are explicitly noted as "assumptions" in the assessment. They do not vary between closure options. Thus they do not help in judging the relative merits between options. - a commitment to monitoring and enforcement - the monitoring time frame that is committed to (during and after remediation) and the involvement of Selkirk People monitoring and enforcement. - The involvement of Selkirk people in the development and implementation of the closure strategy - A commitment to ensure consistency with the Yukon Waters Act and the Selkirk First Nation Final Agreement - A commitment to incorporating Selkirk traditional knowledge into the closure plan as well as a ground truthing of knowledge gathered. • Design to maximum credible earthquake (MCE) and

<table>
<tr><td>Waters Act and the Selkirk First Nation Final Agreement.
3. To incorporate Selkirk traditional knowledge into the plan. That the knowledge gathered is ground truthed on the land.

Objective: Use the best methods and technology to protect the Pelly River drainage basin" (S.XI)
<u>Sub-Objectives</u>
1. To design structures that provide for maximum credible earthquake (MCE) and probable maximum flood (PMF) at the tailing site until the threat of contamination is removed.
2. To design stable structures that minimizes potential failures until such time as the threat of contamination is removed.</td><td></td><td>maximum probable flood (MPF) thus designing stable structures that minimize potential failures, are standard practice and are required of all alternatives being assessed. Thus, these are not factors that differentiate between alternative options.</td></tr>
<tr><td colspan="3">3. Return Mine Site to an acceptable state of use, that reflects original use where possible</td></tr>
<tr><td>Selkirk
Objective: "Protect the culture and traditional pursuits of Selkirk people" (S.VI)
<u>Sub-Objectives</u>
1. To protect Selkirk peoples' traditional use and occupancy of the Pelly River Basin and their continued use of the natural and traditional resources of the Selkirk homeland.
2. To ensure the continued traditional use of aquatic and terrestrial resources.
3. If Selkirk's cultural and traditional pursuits are affected, then they are compensated.</td><td>Objective 3. Maximize restoration, protection and enhancement of the environment, and

Objective 7. Minimize restrictions on traditional land use.</td><td>• Potential contaminant migration in the Pelly River system is covered by Objective 1, Health and Safety and Objective 3, Environment.

• The potential physical reach of the implications from the closed site will have to be addressed as an assumption.

• Traditional use of aquatic and terrestrial resources are addressed in Objective 5, Land Use.

• The following is included in the overarching implementation strategy. It is noted as an "assumption" in the assessment. It does not vary between options. Thus it is not a factor in judging the relative merits between options.
- A commitment to compensation iff Selkirk's cultural and traditional pursuits are affected</td></tr>
<tr><td colspan="3">4. Maximize local and Yukon benefits</td></tr>
<tr><td>Selkirk
Objective: Jobs and other economic benefits from the closure plan should go to Selkirk people" (S.V)
<u>Sub-Objectives</u>
1. To implement a plan that provides socio-economic benefits,</td><td>Objective 4. Maximize local socio-economic benefits, and

Objective 2. Maximize worker health and safety</td><td>• The overall provision of socio-economic benefits for the Kaska is covered in Objective 4, Socio-economic benefits

• Worker health and safety are covered in Objective 1, Health and Safety</td></tr>
</table>

including jobs and training, for Selkirk people. 2. Worker health and safety requirements are met.		
Other Objectives		
Selkirk **Objective: Look after immediate concerns during care and maintenance such as heavy rainfall or spring run-off" (S.IX)** 1. To develop an interim plan that addresses immediate threats such as flooding or spring run-off or earthquakes. **Objective: Involve Selkirk FN as a full partner in all but financing the plan" (S.XII)** 1. Selkirk is a full partner in reviewing, selecting, and implementing the Closure Plan. **Objective "Long term commitment" (S.XIII)** 1. To propose a closure plan with resources for short and long-term care and maintenance to achieve closure objectives.	**Objective 3. Maximize restoration, protection and enhancement of the environment, and** **Objective 4. Maximize local socio-economic Benefits and Objective**	• Interim planning • The following factors are included in the overarching implementation strategy. They are explicitly noted as "assumptions" in the assessment. They do not vary between closure options. Thus they do not help in judging the relative merits between options. - Development of an interim plan that addresses immediate threats such as flooding or spring run-off or earthquakes - Financial surety covering resource requirements for short and long-term care and maintenance to achieve closure objectives

Assessment Foundation - Government of Yukon December 15, 2004		
Original Item	*Where addressed in the Current Objectives Hierarchy*	*Comment*
3. Protect human health and safety		
Yukon Government 1. Protect public health and safety	**Objective 1. Maximize public health and safety.**	• Covered by Objective 1
2. Protect the environment including land, air, water, fish and wildlife.		
Yukon Government 1. Prevent, reduce or mitigate environmental degradation	**Objective 3. Maximize restoration, protection and enhancement of the environment.**	
3. Return Mine Site to an acceptable state of use, that reflects original use where possible		
Yukon Government 1. Return land to an acceptable state of use, that reflects original use or an acceptable alternative, where practicable	**Objective 3. Maximize restoration, protection and enhancement of the environment,** **Objective 7. Minimize restrictions on traditional land use, and** **Objective 8, Minimize restrictions of local land use.**	
4. Maximize local and Yukon benefits		
Yukon Government 1. Provide economic opportunities for FN residents, local residents and Yukoners in general	**Objective 4. Maximize local socio-economic Benefits, and** **Objective 5. Maximize Yukon socio-economic benefits**	• The provision of economic opportunities for FN residents, local residents and Yukoners in general is covered in Objective 2, Socio-economic Benefits
Other Objectives		
Yukon Government 1. No transfer of deferred costs to YG	**Objective 6. Minimize Costs**	• Covered in Objective 4, Minimize Cost

Assessment Foundation, Environment Canada, December 15, 2004		
Original Item	*Where addressed in the Current Objectives Hierarchy*	*Comment*
4. Protect human health and safety		
Environment Canada **Objective:** Meet Section 36(3) of the Fisheries Act, post closure.	**Objective 3, Maximize the restoration, protection and enhancement of the Environment**.	
2. Protect the environment including land, air, water, fish and wildlife.		
Environment Canada 1. Meet Section 36(3) of the Fisheries Act , post closure.	**Objective 3, Maximize the restoration, protection and enhancement of the Environment**	• Adherence to regulations and standards (including Section 36 (3) of the Fisheries Act throughout the project life, is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. This issue could be expressed as an assumption.
3. Return Mine Site to an acceptable state of use, that reflects original use where possible		
Environment Canada	**Objective 5. Minimize limitations to land use.**	--
4. Maximize local and Yukon benefits		
Other Objectives		
Environment Canada 1. Demonstrate Federal Government leadership in setting of objectives. 2. Identify early actions to reduce longer risk terms.		• Demonstration of federal government leadership in setting objectives is outside of the scope of the assessment • Item 2 is covered by the implementation strategy. It is explicitly noted as an "assumptions" in the assessment. It does not vary between closure options. Thus it does not help in judging the relative merits between options. - the phasing of activities in such a way that early actions are taken to reduce longer-term risk.

Assessment Foundation, Fisheries and Oceans Canada, December 15, 2004		
Original Item	*Where addressed in the Current Objectives Hierarchy*	*Comment*
5. Protect human health and safety		
Fisheries and Oceans Canada Objective: Restoration of the physical and chemical stability of the site to a condition equal to or greater than that which existed prior to the development of the mine.	**Objective 2. Maximize restoration and protection of the environment.**	• Physical stability is a design feature of all alternatives. The relative success at ensuring physical stability over the short and long terms will be assessed in Objective 2, Environment. • The issue of continuing geochemical activity lies at the heart of this project. Unless a currently unknown technological solution emerges in the future, there will be a need to actively manage this site for 500 -1000 years. The relative ability of alternatives to address the geochemical issues over the short and long term will be assessed in Objective 2, Environment.
2. Protect the environment including land, air, water, fish and wildlife.		
Fisheries and Oceans Canada 1. Restoration of the physical and chemical stability of the site to a condition equal to or greater than that which existed prior to the development of the mine.	**Objective 2. Maximize restoration and protection of the environment.**	• Physical stability is a design feature of all alternatives. The relative success at ensuring physical stability over the short and long terms will be assessed in Objective 2, Environment. • The issue of continuing geochemical activity lies at the heart of this project. Unless a currently unknown technological solution emerges in the future, there will be a need to actively manage this site for 500 -1000 years. The relative ability of alternatives to address the geochemical issues over the short and long term will be assessed in Objective 2,

		Environment.
3. Return Mine Site to an acceptable state of use, that reflects original use where possible		
Fisheries and Oceans 1. Restoration of the productivity of the aquatic habitats etc	**Objective 5. Minimize limitations to land use.**	• Restoration of the productivity of aquatic habitats etc. is covered in Objective 2, Environment.
4. Maximize local and Yukon benefits		
Other Objectives		
Fisheries and Oceans Canada Restoration/reclamation plans, activities and undertakings should be phased and integrated.		• The following factor is included in an overarching implementation strategy. It is explicitly noted as an "assumptions" in the assessment. It does not vary between closure options. Thus it does not help in judging the relative merits between options. - the phasing and integration of restoration/reclamation plans, activities and undertakings

Appendix 3. Objectives Crosswalk.
Links between Issues Raised Previously (Objectives, Sub-Objectives, Influence Factors, Assumptions) and their Treatment in the Assessment

Notes:

1. Objectives used in the assessment have been articulated to avoid “double-counting” and to signal a direction of preference. Thus, they are designed to facilitate identification of any differences that may exist between options as follows:
   - more **health and safety** for the public and workers is better than less;
   - more **environmental restoration and protection** is better than less;
   - more local and Yukon socio-economic benefits is better than less;
   - less **cost** is better than more;
   - less **limitation on traditional land use** is better than more; and
   - (more **acceptability** judged by implicated parties is better than less)
2. Cost-effectiveness is address in drawing a comparison between cost (addressed in Objective 4) and the other objectives. This comparison will be done in the final steps of the assessment along with a sensitivity analysis that will examine the results of such a comparison in light of various weights applied to each objective.
3. Tailings relocation is identified by the Kaska as a sub-objective. For the purposes of the assessment, it cannot be listed as both an alternative to be considered (a means of achieving what is desired) and an objective (what is desired). It is maintained as an alternative to be considered.
4. Adherence to regulations and standards (environment, health, safety etc.) is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. CCME levels are guidelines.
5. Projected success at ensuring “proper” and “safe” storage of tailings is a key aspect of the assessment. All of the objectives come to play in making this judgment.
6. Investigation of historic tailings releases has been completed including a summary of their extent and recommendations regarding potential clean up measures.
7. Sources for input on objectives, sup-objectives, and influencing factors include:
   - Objectives Approved by the Oversight Committee, July 6, 2006
   - Faro Decision Objectives with input from the Selkirk First Nation, Ross River Dena/Kaska, Government of Yukon, Environment Canada, and the Department of Fisheries and Oceans, December 15, 2004
   - Faro Decision Objectives with input from the Town of Faro, January 23, 2005
   - Faro Decision Objectives with input from INAC, January 27, 2007

Original Objective	***Example Influencing Factors Captured in the Influence Diagrams***	***Assumptions*** *The following factors will be incorporated in the overarching implementation strategy. They will be noted as **assumptions** in the assessment. They do not vary between closure options and thus they do not help in judging the relative merits between options.*
Objective 1. Maximize Public Health and Safety	***Objective 2. Maximize Worker Health and Safety***	
1. Protect human health and safety.	**All factors contributing to public and worker health and safety:** • Potential contaminant migration in surface water and groundwater • contaminant pathways via air (dust, wind, evaporation etc.) • Surface water quality (Vangorda [water supply for the town of Faro] Creek, Rose Creek, Pelly River) • Groundwater: containing, collecting, and/or treating pit drainage and waste rock seepage	• Adherence to regulations and standards is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. • A commitment to monitoring of contaminant levels in country food (including fish, wildlife, and edible plants) • Design to maximum credible earthquake (MCE) and maximum probable flood (MPF) is standard practice and is required of all alternatives being assessed • the phasing of activities in such a way that early actions are taken to reduce longer-term risk; the strategic phasing of implementation • cleanup of the Metaphina Site in Faro
Objective 3. Maximize the Restoration, Protection, and Enhancement of the Environment		
2. Protect, and to the extent practicable, restore the environment, including land, air, water, fish and wildlife.	• land, air, surface water, groundwater, fish, and wildlife • restoration and protection of the terrestrial and aquatic ecosystems (including all implicated parts fo the Pelly River drainage basin.) • dust generation • restoring an ecosystem than can support continued traditional use of aquatic and terrestrial resources • restoring the productivity of aquatic habitat • containing, collecting, and/or treating pit drainage and waste rock seepage	• The reach of the project (both around the mine site and downstream including the Pelly River) • a commitment to monitoring air, water, land and terrestrial and aquatic biota in the affected area • the monitoring time frame that is committed to (during and after remediation) and the involvement of First Nations people in the monitoring • Adherence to regulations and standards is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. • Design to maximum credible earthquake (MCE) and maximum probable flood (MPF) is standard practice and is required of all alternatives being assessed • Development of an interim plan that addresses immediate threats such as flooding or spring run-off or earthquakes • the phasing and integration of restoration/reclamation plans, activities and

	• ensuring physical stability over the short and long terms • capacity to address geochemical issues	undertakings in such a way that early actions are taken to reduce longer-term risk; the strategic phasing of implementation • A commitment to ensure consistency with the Yukon Waters Act • Adherence to regulations and standards (including Section 36 (3) of the Fisheries Act throughout the project life, is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply
Objective 4. Maximize Local Socio-economic Benefits ***Objective 5. Maximize Yukon Socio-economic Benefits***		
3. Maximize local and Yukon socio-economic benefits.	• Local and Yukon benefits • employment over the short and long term both quantity and quality • $ and # of Yukon/local and FN suppliers • Benefits for the Kaska and Selkirk First Nations • Provision of economic opportunities for First Nation residents, local residents, and Yukoners in general • Socio-economics benefits for Faro	• the phasing and integration of restoration/reclamation plans, activities and undertakings in such a way that early actions are taken to reduce longer-term risk; the strategic phasing of implementation • Adherence to regulations and standards is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. • involvement of Selkirk People the development and implementation of the closure strategy including monitoring and enforcement. • Yukon and FN training programs • A commitment to FN participation in monitoring • A commitment to ensure consistency with the Selkirk First Nation Final Agreement • Provision of training and capacity building for the Kaska people • Establishment of scholarships for Kaska students who wish to pursue higher education • Provision of job-mentoring opportunities for Kaska members • advance job training in Faro • use of local businesses and contractors where possible • apprenticeship program for Faro • access to the site for education, research, and tourism • access to the back country for recreation (including hunting and ski-doo trips etc.) • location of the principle closure office once implementation begins • the time frame and schedule of implementation activities • a Yukon-preference policy for those implementing the closure plan

		• long-term use of the Grum Administration Building
Objective 6. Minimize Costs		
4. Manage long-term site risk in a cost-effective manner.	Initial capital costs and long term maintenance costs (expressed in both present value and flows of current dollars over time) related to: • phasing and integration of closure implementation in a way that minimizes long-term risk. • containing, collecting, and/or treating pit drainage and waste rock seepage	• A commitment to short-term care and maintenance, addressing immediate issues and identifying early actions to minimize risks while the Final Closure Plan is developed • The phasing and integration of closure implementation in a way that minimizes long-term risk. • Adherence to regulations and standards is required by law of all alternatives being assessed. It is not possible to put forward an alternative that will not meet the regulations and standards that apply. • Financial surety covering resource requirements for short and long-term care and maintenance to achieve closure objectives
Objective 7. Minimize Restriction on Traditional Land Use ***Objective 8. Minimize Restrictions on Local Land Use***		
5. Return the mine site to an acceptable state of use that reflects pre-mining land use where practicable.	• Both "traditional" and "local" land uses • Re-establishment of traditional land uses (including hunting, trapping, and fishing) is addressed within the influence diagram • Ensuring the continued traditional use of aquatic and terrestrial resources • Grooming (re-sloping, covering, re-vegetation) the land to capture the nature and spirit of local land forms • Water quality restoration and protection (stream water for tea) • A commitment to compensation if First Nation cultural and traditional pursuits are affected	• A commitment to protecting the culture and traditional pursuits of affected First Nations; • A commitment of the use of traditional knowledge including the traditional use of the aquatic environment • A commitment to giving traditional knowledge equal weight to "scientific" knowledge factors in the planning and implementation process; • A commitment of the use of traditional knowledge • A commitment to enhancing access across the haul road (e.g. ramps) at traditional trail crossing • A commitment to ensure consistency with the Selkirk First Nation Final Agreement • A commitment to incorporating Selkirk traditional knowledge into the closure plan as well as a ground truthing of knowledge gathered