Analysis and Recommendations for Whitewater's Avalanche Control and Reporting Procedures

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EXECUTIVE SUMMARY

INTRODUCTION

Sports related avalanche deaths are a risk to outdoor winter sports enthusiasts. In 2014, the Canadian Avalanche Association (CAA) reported 15 avalanche related deaths in Canada and an additional 24 recorded injuries (Avalanche Incident Reports, 2015). Through the educational platform of avalanche bulletins published by the CAA, it is argued that some avalanche injuries and deaths can be prevented and the overall number of deaths per year reduced. The CAA is a not-for-profit, organization that also provides professional training and information exchange platforms to avalanche practitioners. One of the CAA's purposes is to ensure avalanche safety programs and information are provided to the public (CAA Overview, 2015).

To inform people who participate in winter sports, it is the responsibility of association's members, such as commercial ski resorts, to upload information on avalanche and weather observations to ensure accurate reports are being provided. Regulated by WorkSafeBC, British Columbia snow safety departments are also responsible for ensuring their own operations are conducting the safest avalanche control and hazard mitigation practices.

This project is in response to the Canadian Avalanche Association's information exchange program update released in the winter of 2013/14. The updated program provides decision support tools for avalanche hazard and risk mitigation to its users and continues to be the industry's information sharing platform. The client for this project is the snow safety supervisor at Whitewater Ski Resort located south of Nelson, BC. Whitewater Ski Resort is a member of the CAA and routinely performs avalanche control work in the inbounds terrain. The purpose of this project is to review the Whitewater snow safety department's current avalanche reporting procedures, identify what are the CAA's standards and requirements and to present options for change based on the findings.

METHODOLOGY AND METHODS

A needs assessment research approach was undertaken for this project. The current state analysis examined the Whitewater snow safety departmental make-up, its avalanche mitigation procedures, the provincial regulations ski resorts are obligated to follow, and specific policies in place at Whitewater. A data analysis of fifteen seasons of Whitewater's historic avalanche occurrences was also used to provide context for the current state. The desired future state was defined using a two-pronged analysis. First, a review of avalanche control and recording smart practices was conducted then standardized. The smart practices identified are from snow science literature and CAA guidelines. Next, structured interviews were conducted with other managers of snow safety departments. To address the gaps between the current state of Whitewater's snow safety department and the desired future state a strategic planning approach was undertaken. This method was selected to offer a usable implementation strategy to the client that was supported by academic evidence. A literature review identifying effective implementation of a strategic plan was performed.

FINDINGS

Findings from the current state analysis recognized the strengths in the Whitewater snow safety department to effectively mitigate the risk of natural avalanche hazards. The historic data analysis revealed inconsistent data recording procedures and storage practices that should be addressed. The desired future state recognizes the importance of maintaining the smart practices by the department of employing professionally trained avalanche technicians and requiring local terrain knowledge by avalanche control route leaders. The smart practices identified as requiring further development by the department are: the collection of 25 seasons of historic avalanche data for analytical and trends purposes; and the complete documentation of avalanche, snowpack and weather data. Consultation with other snow safety department managers revealed a concern that the Canadian Avalanche Association's Information Exchange program (InfoEx) users may congest the information-sharing platform with unnecessary data by using the program specifically as a decision-support tool.

The five major themes identified from the literature review on the effective implementation of a strategic plan are context, content, process, outcomes and performance measures. The literature also identified resistance to change, leadership, training and rewards as sub-categories within the strategic plan process. Using the literature review findings, strategic action plan options are presented to bridge the gap between the current state and desired future state for the avalanche control and reporting procedures within the Whitewater snow safety department.

OPTIONS TO CONSIDER AND RECOMMENDATIONS

Based on the report's findings, options to consider to bridge the gap between the current state and desired future state for Whitewater's avalanche control and reporting procedures were presented applying different conceptual perspectives of the InfoEx program. The two perspectives are whether the new InfoEx system should be used as a decision support tool or as an information-sharing tool. The recommended action plan weighed the options based on efficiency, effectiveness, client value and frugality to best ensure the change will be successful.

Once the benefits and weaknesses of both options were weighed, it was revealed that it would be more beneficial to the future of the Whitewater snow safety department to adopt the new InfoEx reporting system as an information-sharing tool. This option was recommended since it ensures the snow safety department's relationship with other Canadian Avalanche Association members would be preserved. This option was also selected as it met the resource capacity of the department.

By adopting the recommended option, the client is expected to see the following outcomes: higher quality record keeping, the building of a 25 year avalanche historic record, the development of avalanche forecasting and accuracy testing capabilities, and continued practice of effective avalanche risk and mitigation procedures.

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1.0 Introduction and Problem Definition

Of the estimated 1.5 million avalanches that occur each year in Canada, approximately 100 will damage property and/or involve humans. On record there have been 702 avalanche fatalities in the country since 1782 (Campbell, Bakermans, Jamieson and Stethem, 2007, p. 18) and there has been a significant increase in sporting related avalanche incidents beginning in the 1980s (Brugger, Durrer, Adler-Kastner, Falk and Tschirky, 2001, p. 8). Specific to British Columbia (BC), there were 192 recorded avalanche-related deaths between 1996 and 2014 and 39.1% of these incidents involved skiers and/or snowboarders (BC Coroner Services, 2014, p. 1). The BC Coroner Service investigation also revealed 41.1% of the incidents involved snowmobilers and the remaining incidents included heli-skiing, hiking/climbing and occupational activities (2014, p. 1). In 2014, the Canadian Avalanche Association (CAA) reported 15 avalanche related deaths in Canada and an additional 24 recorded injuries (Avalanche Incident Reports, 2015). Though backcountry skiing, heli-skiing and snowmobiling were the activities responsible for the majority of the incidents, four of the avalanche related injuries occurred at commercial skiing operations (Avalanche Incident Reports, 2015).

In order to reduce the number of avalanche related deaths in Canada, the CAA provides avalanche prevention education for the general public and workers in the industry. The CAA is a not-for-profit, non-government organization based out of Revelstoke, BC, which was established in 1981 (Scott, 2005, p. 207). The CAA establishes the technical standards for this country and is known worldwide for its best practices (Canadian Avalanche Association Overview, 2013).

The CAA relies on an online program for industry members to document and upload information pertaining to avalanche, snowpack and weather observations in order to deliver safety bulletins to the public. The purpose of the safety bulletins is to educate the general public about current avalanche conditions and the program is called the Information Exchange (InfoEx). It was established as a communication tool to ensure people in the industry know what risk factors others are observing.

The CAA introduced an upgraded version of the InfoEx during the 2013/14 season. The upgrade included the introduction of a workflow feature to assist its users in hazard assessment practices. The new version of the InfoEx also features the ability for users to upload historic avalanche records onto the CAA server.

This project addresses the need for the Whitewater Ski Resort, who is the client for this project, to record avalanche control procedures in an effective and efficient manner both for internal purposes and to meet its responsibility to share information with the CAA. This project examines Whitewater's avalanche control and recording procedures to assess if they meet the highest level of safety standards.[1] Meeting these standards is crucial as the lives of guests and employees could be at risk if Whitewater were to fall short of smart practices. A needs assessment analysis was conducted to clarify measures required by the Whitewater snow safety department (WSSD) to transition towards meeting the CAA standards and expectations.

Whitewater's current avalanche reporting method is out of date. There are paper records of avalanche observations dating back to the 1980's. The WSSD has control sheet records since 1997 with the last update to the form being introduced in 2012. Due to the resort's remote location and limited resources, the snow safety department has been relying on a paper reporting system without any method to electronically back-up their information. Consequently, historical data is difficult to analyze and compiling year-by-year comparisons becomes timely and challenging to organize for staff who have other competing roles and responsibilities.

A serious risk to having a paper-based system is the potential loss of historical data from a fire or other natural disasters. This is a realistic risk given the aging infrastructure of the facility and its remote location in a forested area.

1.1 PROJECT OBJECTIVES AND CLIENT

The objective of this project is to review the Whitewater snow safety department's current avalanche reporting procedures, identify the CAA's standards and requirements and present options for change based on the findings. This report will provide the client, the head of the snow safety department, with strategic action plan options to ensure the organization is recording avalanche control routes in an effective and efficient manner while also providing necessary information to the CAA InfoEx. Effective avalanche control and recording procedures refers to the successful completion and meeting of all internal requirements by the Whitewater snow safety department and the CAA's external needs. Efficient avalanche control and reporting procedures refers to the effective practices that are the most time and resource saving. The importance of the strategic action plan options is to ensure WSSD's resource capacity is not spread too thin thus risking the lives of resort guests and employees.

The following deliverables for this report came from performing a needs assessment analysis:

- The client received access to 15 seasons of historic data in an electronic dataset format.

[1] For the purposes of this report, avalanche reporting refers to the documentation of specific avalanche characteristics that when analyzed are meant to assist in hazard recognition and risk reduction measures. Avalanche reporting can be performed internally for in-house analysis and be made to the CAA for industry wide purposes.

- The historic information was used to provide the client with a clear picture of the current state of WSSD, which includes an analysis of the strengths and weaknesses identified during the data analysis stage.
- The needs assessment analysis provides a description of the desired future state for the WSSD by consulting other snow safety department managers and researching known smart practices in the field of avalanche hazard mitigation.
- Criteria for recognizing smart practices was identified and defined in the future state section of the report.
- The client was presented with high-level options to move the WSSD from its current state to the desired future state.

The primary research question that guided this report is: How should the Whitewater snow safety department integrate their avalanche control and reporting methods with the CAA InfoEx methods to ensure smart practices in the industry are being met? To understand the research question effectiveness and efficiency must be defined and conceptualized.

To answer this question, the following secondary research questions were applied:

- How can an organization effectively implement strategic change in the work-place?
- What are the WSSD's existing strengths and weaknesses in avalanche control and reporting procedures?
- What are smart practices for avalanche control and reporting procedures in the industry?
- How have other CAA members adjusted to the use of the new InfoEx database?
- What is the gap between the current state of the WSSD and the preferred CAA future state?

Options to consider and a recommendation were based on themes that arose from the data analysis, interview findings and the literature review. The recommended action plan weighed the options based on efficiency, effectiveness, client value and frugality to best ensure the adopted changes will be successful. These four criteria applied to the options will be defined and conceptualized in the options section of the report.

1.3 ORGANIZATION OF REPORT

There are eight sections of this report. Section 2 is a literature review presenting findings on an effective format to implement strategic change. The sources consulted identify common threats to strategic change as well as successful approaches and tools to support the adoption and implementation. After outlining common themes throughout the literature, a conceptual framework is developed and applied to the remainder of the report. A methodological rundown of the literature review, current state analysis and a desired future state developed through smart practices review and interview findings is provided in Section 3. Section 4 provides the current state of avalanche control and recording procedures at Whitewater. The section begins with providing background knowledge on avalanche classification methods, provincial regulations and policies on avalanche control work, and Whitewater Ski Resort's avalanche terrain and operating procedures.

A future state for the WSSD is presented in Section 5 using the findings of the data analysis, a review of smart practices in the industry and interviews with other snow safety department managers. A discussion of the findings is connected with the literature review in Section 6. Section 7 presents recommended options for the WSSD to integrate the new InfoEx program into existing avalanche control and reporting methods. The report's concluding remarks are found in Section 8.

2.0 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Once the current state and desired future state of the WSSD has been identified for avalanche control reporting procedures, an action strategy must be developed to assist the department in its transition. Change management strategies will be identified to support the transition to the desired future state and address the needs of the department. The literature review identifies an effective format to implement strategic change. The research consulted for this portion of the report included peer-reviewed journal articles and periodicals.

The search strategy began with using Summons through the University of Victoria's Library website. A general 'key words in title or abstract' search was conducted, which included terms such as "strategic planning", "change management" and "strategic management" and their variants. A journal search of *Journal of Public Administration Research and Theory* and *Public Administration Review* was also performed using the key words.

Many of the articles that were accessed consisted of material published between 1990 and 1999. As one article pointed out, there was a great amount of government reorganization that occurred in the 1990's (Chackerian & Mavima, 2001, p. 365). The reform movement led to the publication of many works on change management during that decade. After extracting several popularly cited articles from the 1990's, a filter was applied for the search strategy for articles published later than the year 2000 to gain a more current perspective.

The studies reviewed, identify common threats to strategic change as well as successful approaches and tools to support adoption and implementation. The literature on strategic planning and implementing change recognizes a multiple stage procedure that moves from planning and development to implementation and onto reviewing and analyzing the effectiveness of the overall process.

This chapter begins with an analysis of change management literature on avalanche control procedures before moving into a general strategic planning literature review. The first major theme within strategic planning literature is the establishment of a context for the strategic plan. Next, the importance of recognizing the content of a strategic plan is discussed. The next section examines the process, or *how*, to implement a strategic plan. The process section is broken into four subsections for tools and challenges identified during the implementation process. These subsections include managing resistance to change, the benefits of leadership throughout the strategic planning process, training for management and employees and the use of rewards. The next section is a discussion on the theme of outcomes of strategic planning. The final theme explored in this chapter is the application of performance measures for strategic planning. This chapter concludes with a summary of the literature review findings and development of a conceptual framework for the project.

2.1 CHANGE MANAGEMENT LITERATURE ON AVALANCHE CONTROL

A search for change management peer-reviewed literature on avalanche control practices did not produce any results. The decision was made to expand the search to general change management and strategic planning practices in the public sector. The findings would then be applied to the WSSD's needs assessment to transition the department from its current state to desired future state.

Literature on avalanche control and reporting methods was used to identify smart practices in the field and structure the desired future state for the WSSD. The smart practices analysis can be found in Section 5 of the report.

2.2 ESTABLISHING CONTEXT FOR A STRATEGIC PLAN

The literature suggests exploring the context of the situation or organizational environment to consider whether strategic change is required (Bryson & Bromiley, 1993, pp. 321 & 324; Bryson & Roering, 1987, p. 11; Chackerian & Mavima, 2001, p. 357; de Lancer Julnes & Holzer, 2001, p. 696; Fernandez & Rainey, 2006, p. 171; Kuipers et al., 2014, p. 6; Ponzo & Zarone, 2012; and Wise, 2002, p. 556). In order for strategic change to be successful, Fernandez and Rainey emphasize that a *need* for strategic change must be present (2006, p. 169). By recognizing the background or the context of the situation, a need for change can be communicated to all parties involved (Fernandez & Rainey, 2006, p. 171; and Kuipers et al., 2014, pp. 6-7).

In many of the studies reviewed, the context is broken into two frames of reference: internal and external. The characteristics of the internal environment that are recognized as providing context for change include:

- Availability of resources,
- Internal groups, actors and/or coalitions advocating for/or resisting change,
- The stability of the organizational environment,
- The overhead decision makers' positions on the matter, and
- The vision or goals set out by the organization related to change (Bryson & Bromiley, 1993, p. 321; Bryson & Roering, 1987, p. 11; Chackerian & Mavima, 2001, p. 357; de Lancer Julnes & Holzer, 2001, p. 696; Fernandez & Rainey, 2006, p. 172; Ponzo & Zarone, 2012; and Wise, 2002, pp. 555-556).

Externally Kuipers et al. suggest, strategic change is affected by political systems and socio-economic factors (2014, 6). Bryson & Roering identify these factors as being either opportunistic or threatening (1987, p. 11). The literature frequently mentions the importance of external stakeholders' positions surrounding the change and their engagement in order to establish a strong background (Bryson, 1988, p. 74; Poister & Streib, 1999, p. 309; Bryson & Roering, 1987, 11; Fernandez & Rainey, 2006, p. 170; and Edmonds, 2011, p. 350).

2.3 IDENTIFYING THE CONTENT OF A STRATEGIC PLAN

The answer to *what* will be changed is the content factor of strategic change (Bryson & Roering, 1987, p. 11; Edmonds, 2011, pp. 350-351; and Kuipers et al., 2014, p. 8). For Poister and Streib (1999, p. 309) the content for change could reference an entire system overhaul using strategic management or simply a specific section within the organization that relies on strategic planning. Regardless of the scale of change, content is developed by examining organizational structures, strategies and systems (Edmonds, 2011, p. 350; and Kuipers et al., 2014, pp. 8-9).

Bryson and Roering (1987, 11) recognize several steps that are important for developing a strategic plan. First, the plan must clearly lay out key external and internal players involved, what issues will be addressed, as well as the overall purpose for change. Next a mandate must be established in order to identify the “musts” for the strategic change process. This step is different from the “wants”, which Bryson and Roering describe as the organization’s mission and values (pg. 11, 1987). All these steps should be clearly defined with achievable and recognizable qualities (Bryson & Roering, 1987, p. 11; Edmonds, 2011, p. 350; and Kuipers et al., 2014, pp. 8-9).

The strategic plan is action oriented and recognizes obstacles and threats likely to emerge during implementation (Fernandez & Rainey, 2006, p. 173; and Poister & Streib, 1999, p. 309). The literature suggests that in order to reduce ambiguity the action plans must be specific and clear (Fernandez & Rainey, 2006, p. 170). Lastly, Poister and Streib (1999, p. 316) suggests the strategic plan include a management group to supervise and monitor its implementation. The group should pay specific attention to external and internal threats and opportunities. This designated group will handle internal communications, administration concerns and external stakeholders (Poister & Streib, 1999, p. 316).

2.4 THE PROCESS OF APPLYING A STRATEGIC PLAN

The literature tends to relate context and content to answering the “what” question for change management, whereas the process factor is more commonly equated with “how”. Bryson and Bromiley (1993) define process as, “generic activities across entire problem solving sequences” (p. 320). There are different methods to the implementation process; Kuipers et al. (2014, p. 9) recognizes both a binary approach – planned or emergent change, as well as to break down the approach into four categories: top-down, incremental, pluralistic, or individual. Shareef (1994) discusses the importance of subsystem congruency for planned change. In order to implement effective change across an entire organization, subsystems must be strategically targeted. The use of devices to promote change across subsystems prevents the likelihood of organizations reverting back to traditional, ineffective practices (Shareef, 1994, pp. 495, 510-511).

Within the topic of how to implement strategic change, several themes have emerged: resistance to change (Boyne, 2003, pp. 371-372; Bryson & Bromiley, 1988; Bryson & Roering, 1987, p. 20; Chackerian & Mavima, 2001, pp. 359-360; de Lancer Julnes & Holzer, 2001, p. 696; Edmonds, 2011, p. 351; Fernandez & Rainey, 2006, p. 173; Kuipers et al., 2014, p. 9; and Shareef, 1994, p. 510), leadership (Boyne, 2003, pp. 385 & 389; Bryson & Bromiley, 1988; Edmonds, 2011, p. 352; Fernandez & Rainey, 2006, p. 170; Kuipers et al., 2014, p. 11; Poister & Streib, 1999, p. 316; Ponzo & Zarone, 2012; and Shareef, 1994, p. 495), training (de Lancer Julnes & Holzer, 2001, 695; Edmonds, 2011, p. 352; Ponzo & Zarone, 2012; and Shareef, 1994, p. 495-496), and rewards (Boyne, 2003, p. 370; de Lancer Julnes & Holzer, 2001, p. 697; Fernandez & Rainey, 2006, p. 170; and Shareef, 1994, p. 496). These four themes will now be explored.

2.4.1 Managing Resistance to Change

Resistance to change is a major concern for strategic management and is frequently cited as a key cause for implementation failure (Bryson & Bromiley, 1993, p. 330; Bryson & Roering, 1987, p. 11; Chackerian & Mavima, 2001, pp. 359-360; de Lancer Julnes & Holzer, 2001, p. 696; Edmonds, 2011, p. 351; Fernandez & Rainey, 2006, p. 173; Kuipers et al., 2014, p. 10; and Shareef, 1994, p. 510). Factors such as the context of change and workers' personalities have been known to influence resistance (Kuipers et al., 2014, pp. 10-11). Generally, when involvement and participation for strategic change are forced upon the workers, resistance is likely to emerge. This forced participation can be seen in a top-down implementation approach. Nonetheless, the literature also mentions that managers are the most likely to resist change since their position is to maintain status quo (Shareef, 1994, p. 495). However, Poister and Streib (1999, p. 310) point out strategic management does not have to mean forced uniformity through micro managing.

Resistance to change should be identified as a threat to implementation within the strategic action plan and resolutions, specific to the organizational culture should be identified (Bryson & Roering, 1987, p. 11). Other ways mentioned in the literature to avoid resistance to change depend on the availability of resources. Involvement would not have to be forced if more time and better implementation strategies could be established (Bryson & Bromiley, 1993, p. 330). If in the context, the organizational culture is unstable, worker coalitions may be formed around specific solutions to current problems. This situation may require compromise amongst the coalition groups to reach the best solution (Bryson & Bromiley, 1993; p. 321). Chackerian and Mavima (2001) would describe this policy interaction as a trade-off, where there are likely to be winners and losers. Tradeoffs are not ideal for the strategic change process because a competitive environment is likely to emerge (pp. 358-359). Policy interactions based on synergy and a stable environment are less likely to experience resistance to change (Chackerian & Mavima, 2001, p. 360; and Poister & Streib, 1999, p. 317).

2.4.2 The Benefits Of Leadership Throughout the Strategic Planning Process

Since management's resistance to change could result in returning to the original, problem environment, managerial involvement and leadership is necessary to ensure subsystem congruency and multi-layered transformation (Shareef, 1994, p. 495). Kuipers et al. (2014) states, "effective leadership is the key to leading effective change" (p. 11). Leadership groups that include chief executives, top-line managers and key executive staff are crucial to the strategic management process since they can provide structure and guidance to the action plan (Poister & Streib, 1999, p. 316). Shareef (1994, p. 495) emphasizes the importance of an accountability system with clear definitions for successful managerial behaviour and skills within the leadership group. Fernandez and Rainey (2006) also recognize the importance of top management support and leadership as a strategic placement to overcome obstacles. They suggest drawing on personal relationships and coordinated behaviour to address resistance (p. 171). To ensure success, managers must fully commit to their leadership roles (ibid). Furthermore, leaders with a charismatic and transformational attitude are likely to have a more significant impact on implementation success (Boyne, 2003, p. 371).

In order for a manager to be a strong leader, Shareef (1994) outlines the following three overhead requirements:

1. Two-way information sharing to encourage employee participation and enhance the effectiveness of strategic change,
2. The use of rewards to encourage employee performance surrounding change implementation; and
3. The use of new performance criteria specific to change content in order to evaluate and reward employees (p. 509).

Bryson and Bromiley (1993, p. 334) mention the importance of communication and force reduction character traits in a leader to enhance problem solving.

2.4.3 Training for Management and Employees

In order to ensure proper leadership and strategic implementation is practiced, the literature emphasizes the importance of training for management and employees (de Lancer Julnes & Holzer, 2001 p. 695; Edmonds, 2011, p. 352; Ponzo & Zarone, 2012; and Shareef, 1994, pp. 496-497). Similar to managerial behaviour and strong leadership skills being change levers that trigger subsystem congruency, Shareef (1994) identifies training as a crucial tool to link organization subsystems. The report goes on to note that effective training has the ability to offset hierarchical dysfunction (pp. 496-497).

A training plan can be used to identify and target an organization's needs. The research notes that by investigating the organization prior to the change process and by observing the context of the implementation plan proper training can be developed and delivered (Ponzo & Zarone, 2012).

2.4.4 The Use of Rewards

The last common theme throughout the implementation process is a reward or pay based system. A reward system is effective when bringing about change as it builds internal support and aids in mitigating resistance (Fernandez & Rainey, 2006, p. 170). Rewards can be useful in certain work environments where competition is used to promote efficiency through innovation (Boyne, 2003, p. 379). The same study goes on to caution that the use of competition can isolate disadvantaged groups in the work place and have adverse outcomes if applied in the wrong environment (pg. 370). Therefore, proper implantation of a reward system is crucial for strategic change. Like managerial behaviour and training techniques, reward systems are seen by Shareef (1994, pp. 495-497) as a tool to trigger systemic change throughout an organization. Reward systems can take many forms such as skill-based pay, group variable pay, discretionary bonuses, gain sharing or win sharing (Shareef, 1994, p. 497). Based on statistical analysis, reward systems have a significant impact on organizational culture. A performance appraisal method of distribution, where peer groups are responsible for measuring and deciding rewards will ensure a fair and well-received system has been implemented (Shareef, pg. 496, 1994).

2.5 MEASURING THE OUTCOMES OF STRATEGIC PLANNING

A shortfall within strategic change literature is the lack of detailed discussion on outcomes and measuring outcome criteria. In order to measure and assess the outcomes of strategic change, managers will have to revisit their vision and goals discussed in the content section. If executed correctly, the content of change should describe what success would look like for the organization (Bryson & Bromiley, 1993, p. 334; and Bryson & Roering, 1987, p. 11). The likelihood that the outcomes of a strategic plan are successful is increased through the use of strong communication of content and process (Bryson & Bromiley, 1993, p. 334). A well-communicated strategic plan will also recognize the likelihood of conflict and/or resistance and will consider resolution techniques in order to promote successful outcomes (pg. 321). At times, there is a general resistance to attributing outcomes to specific programs (de Lancer Julnes & Holzer, 2001, p. 703). To combat such a resistance, studies suggest returning to the clear strategic plan and directly attributing outcomes to the implementation process (ibid). Though rarely discussed in the literature, advanced description of a successful image of change is also required in order to measure the outputs of a strategy (Kuipers et al. 2014, p. 12).

The outcomes of change include both positive and negative results. These ends can also be intentional or unintentional (Kuipers et al. 2014, p. 12). The adoption of an agreed upon criteria to measure outcomes will lead to an increased chance of change survival (pp. 13-14, 2014). The selected criteria are frequently seen as, “increased efficiency, transparency and equity” (Kuipers et al., pg. 13, 2014). The literature recommends applying the new policy management’s values to outcome criteria, such as efficiency, effectiveness, client value, transparency and frugality (Boyne, 2003, p. 388; and Kuipers et al. 2014, pp. 12-13).

2.6 APPLYING PERFORMANCE MEASURES TO A STRATEGIC PLAN

The final theme within this literature review on strategic change and policy implementation is the use of performance measures throughout the multiple stages of development. The benefits of adopting a performance measurement system include increasing accountability, communication and efficiency (Chackerian & Mavima, 2001, pp. 369-370; de Lancer Julnes & Holzer, 2001, p. 694; and Poister & Streib, 1999, p. 318). Similar to Shareef's (1994) notion of subsystem congruency, Chackerian & Mavima (2001, p. 370) recognize performance measures as having the ability to target multiple systems within the organization.

Performance measures can provide incentives for behavioural change. They can serve as a means to reward specific performances at both an individual and organizational level (Chackerian & Mavima, 2001, p. 369). Specific individuals within the organization can be held accountable for assigned implementation tasks and responsibilities when clear performance measures are applied (Poister & Streib, 1999, p. 318). The results oriented system emphasizes communication focused on outcomes. If negative or unintended outcomes are identified, then discussion can begin early to address the challenges. When recognizing these matters early, positive results can still be achieved (Poister & Streib, 1999, pp. 318-319).

de Lancer Julnes & Holzer (2001) caution against the inaccurate use of performance measures by organizations. Their findings indicate information gathered through performance measures was "not always used to guide decision making" (pg. 694). To avoid this uncertainty, the literature advises that performance measures be used to specifically monitor resource allocation, program monitoring and strategic planning (de Lancer Julnes & Holzer, 2001, p. 694; and Poister & Streib, 1999, p. 318). Resistance to the use of performance measures may indicate a reluctance to criticize a new program. This reluctance can stem from a fear that such criticism could lead to more change (de Lancer Julnes & Holzer, 2001, p. 703).

2.7 LITERATURE REVIEW SUMMARY

The literature identified five contributions for successful implantation for strategic change: context, content, process, outcomes and performance measures. The context provides a background picture of how the organization arrived at its current situation and what internal and external factors will play a role in strategic development. Answering the question what needs to be changed is the content of implementing strategic change. The more clearly and effectively this question can be addressed, the more likely change can be measured. Context and content address the matter of what requires change, and process covers the question of how. A strategic plan that targets several organizational subsystems agreeably will likely result in a more successful implementation process.

The discussion on the implementation process for strategic change identified four themes within the literature. Resistance to change is a popular trend in change management studies, the other three themes are recognized as means to reduce such a resistance. Through the establishment of strong leadership, training and reward systems resistance to change can be effectively reduced.

A recognizable gap in the literature is a thorough discussion on successful outcomes and outputs for strategic planning. Studies emphasize the importance of establishing consistent criteria to measure the outcomes. A clear relationship emerges between the strategic action plan, which outline goals and objectives in the planning stage of change management, and the measurement of outcomes and results once the change has been implemented. Performance measures are to be used throughout the strategic development process to ensure accountability, communication and efficiency are being maintained.

2.8 CONCEPTUAL FRAMEWORK

A conceptual framework for implementing strategic change in the workplace has been designed based on the research question and using the literature reviewed (see Figure 1). The framework is structured as a needs assessment. The first box in the figure below contains the research question – this represents the problem and the overall purpose of the project. To answer the research question a current state analysis must be performed. This research phase is signified by the “current state” box. Section 4 of the report seeks to populate this box. The box titled, “Desired Future State” represents WSSD’s future state once the problem has been solved. To identify what the desired future state is, interviews were conducted with other snow safety department managers and smart practices in avalanche recording procedures were researched. Section 5 of this project identifies WSSD’s future state. The needs identified to move the organization from the current to future state are addressed using Bryson & Bromiley’s (1993) strategic plan model. The arrow titled “Strategic Implementation” represents the bridging of the gaps between the current and future states. The two circles below the strategic implementation arrow represent Shareef’s (1994) three strategic change levers to mitigate resistance to change and to be a reminder throughout the needs assessment process that resistance to change threatens the overall success of the plan.

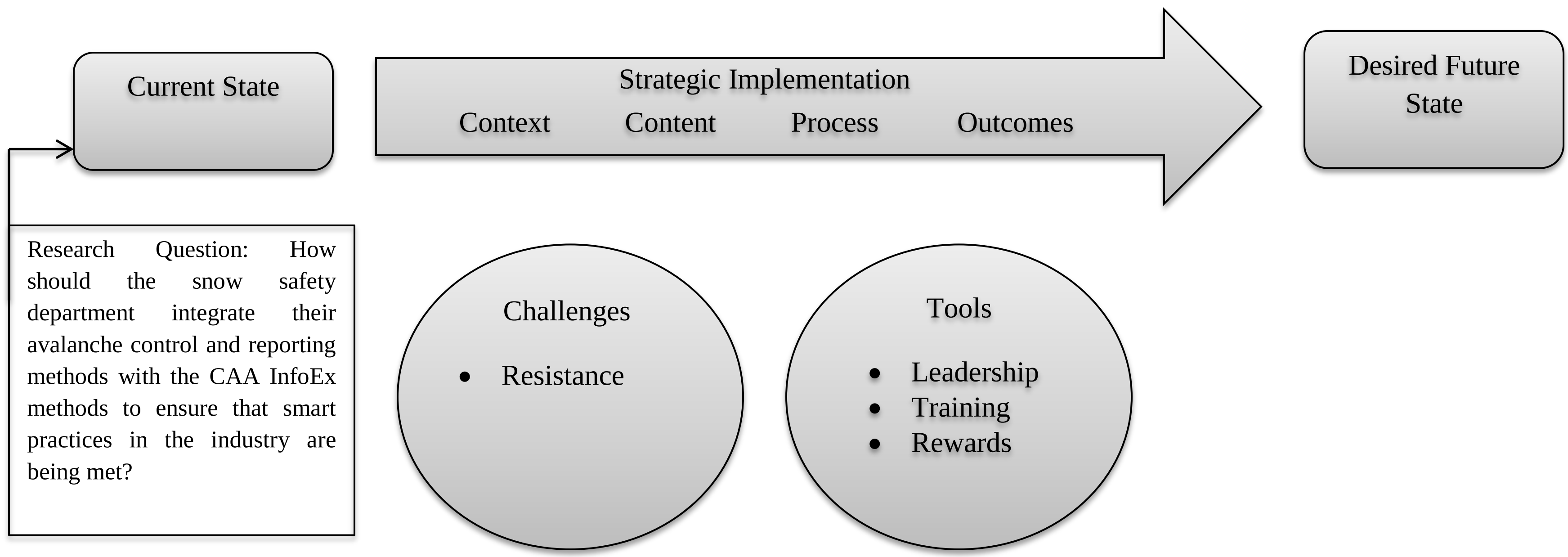


FIGURE 1 CONCEPTUAL FRAMEWORK ILLUSTRATING HOW TO IMPLEMENT STRATEGIC CHANGE TO REACH PROJECT GOALS THROUGH THE PERFORMANCE OF A NEEDS ASSESSMENT

3.0 METHODOLOGY, METHODS AND DATA ANALYSIS

This chapter examines the methodologies and methods used in this research project. The mixed methods approach undertaken in this report is explained based on three phases of research: current state analysis, desired future state identification and the development of a strategic action planning model. The methods used for data collection are described, followed by a brief discussion on data analysis procedures. The section concludes with a discussion of the limitations and delimitations of the research.

3.1 METHODOLOGY

The methodology used in this project was a mixed methods approach to answer the primary research question: *How should the Whitewater snow safety department integrate their avalanche control and reporting methods with the CAA InfoEx methods to ensure smart practices in the industry are being met?* A needs assessment was undertaken to answer this research question and provide the client with: a clear description of the current state of the WSSD; a defined ideal future state based on smart practice research and expert consultation; and to provide strategic action plan options to move the department from the current state to the ideal future state. This meant an integrative approach of combining historic quantitative data analysis, qualitative interviews, smart practices and a literature review were applied throughout several phases of research in order to conduct the needs assessment.

In the initial phase of research, a current state analysis was conducted by applying an exploratory methodology to historic data. The needs assessment began as Donijo Robbins recommends in *Understanding Research Methods*, by outlining the current actions, strengths and weaknesses within WSSD's avalanche control and reporting practices (2009, 9). The current actions identified include the departmental make-up, avalanche mitigation procedures, and the provincial regulations ski resorts are obligated to follow. Specific plans in place at Whitewater were also identified. The current state analysis can be found in Section 4 of this report.

The second phase of research relied on smart practices and consultation with other snow safety departments to identify the ideal future state for the WSSD. The consultation with other members of the CAA helped define what ideal avalanche reporting practices should entail. The findings from the interviews were also used to recognize practices that should be avoided in the WSSD's future state.

Lastly, a literature review on strategic planning was conducted to address the gap between WSSD's current state and the desired future state. The approaches applied throughout the three phases of research will now be expanded.

3.1.1 NEEDS ASSESSMENT ANALYSIS

The initial phase of the needs assessment analysis was to conduct a current state analysis. This was performed to provide the client with a clear description of the current state of the WSSD.

Beginning with a clear description of the department's current state ensures the client and researcher are approaching the project from the same angle and using shared language. The current state provides the structure for the needs and transitions required.

To identify the current state of the WSSD's avalanche mitigation practices the following areas were explored:

- The departmental make-up,
- Avalanche mitigation procedures,
- The provincial regulations ski resorts are obligated to follow, and
- Specific policies in place at Whitewater

The WSSD's fifteen seasons of historic avalanche data collection were also used to describe the current state. Once the data was inputted into an electronic database, reports could be generated to recognize strengths and weaknesses within the recording procedures. The client provided certain variables to identify significant avalanche control and recording practices within the data analysis. As Robbins explains, data collection for exploratory research is a good starting point to recognize strengths and weaknesses within an organization (2007, p. 9). This phase of the research sought to answer one of the secondary research questions: *What are the WSSD's existing strengths and weaknesses in avalanche control and reporting procedures?*

To perform a needs assessment, a clear description of the desired future state had to be established. Before addressing the needs of the WSSD, an agreed upon end goal should be compared to the current state. To determine an effective future state, a two-pronged analysis was conducted. First, a review of avalanche control and recording smart practices was conducted then standardized. Next, structured interviews were conducted with other managers of snow safety departments. A thematic content analysis was constructed based on the interview transcripts. Each of these methodologies will now be explored.

3.1.2 SMART PRACTICES

Smart practices within the snow safety industry were researched and examined for effective application of avalanche control and reporting procedures at Whitewater. Jennings recognizes that research methods literature blends the terms *best*- and *smart* practices without a consensus on a proper definition (2007, p. 73). This project applies the term *smart* rather than *best* since a comparison is not provided with other practices to determine which are best for avalanche hazard mitigation. For the purposes of this research, *smart practices* have been defined using two of Jennings characteristics for best practices:

1) identifying successful initiatives addressing important issues, and
2) seeking inspirational guidelines for decision making (2007, pg. 74).

To ensure the practices being reviewed are in fact smart practices, Jennings' five best practice criteria were applied to the avalanche control and reporting procedures. The five criteria were:

1. Fit with local need and context,
2. Empirical evidence about effects,
3. Theoretical underpinnings,
4. Cost, and
5. Level of risk (2007, 78).

The criteria are defined and conceptualized in Section 5. The smart practices are weighed based on the criteria to confirm their validity. The findings of the smart practice section were used to construct a desired future state for the WSSD.

In terms of the scope for smart practices, the research cites North American literature as European practices predominantly emphasize passive and permanent measures for avalanche mitigation. The passive model used in Europe is due to the settlement patterns of towns and villages within avalanche terrain. As Jamieson and Stethem mention, land planning and zoning in North America prevent the risk of settlement exposure to avalanches; therefore a more active approach to avalanche control procedures is taken here (2002, p. 37). The North American literature was gathered from snow science journals, documents released by the CAA to its members, and proceedings from snow science workshops.

Although an older document, Peter A. Schaerer's classic 1970 article provides most of the smart practices identified in this report. Peter Schaerer received the Order of Canada for his work with avalanche safety and has been described as the "father of avalanche safety in Canada" (Spaar, 2010, 29). In 1981, Peter Schaerer founded the CAA and was the association's first president (Scott, 2005, 207). In terms of generalizability, the CAA cites Schaerer's research in their current avalanche recording standards for association members; thus implying there is usability across many areas of avalanche work for Schaerer's methods (Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches, 2007). This portion of the research sought to answer one of the secondary questions: *What are smart practices for avalanche control and reporting procedures in the industry?*

3.1.3 Qualitative Data Analysis

A desired future state was constructed using an interview consultation process with four managers of other snow safety departments. The purpose of the interview process was to determine how other snow safety operations have adjusted to the new InfoEx system. To conduct the interviews, an ethics proposal was submitted to and approved by the University of Victoria's Human Research Ethics Board (HREB). Based on the interview findings, useful procedures were identified that can be applied to the future state of the WSSD's avalanche control and reporting procedures. The findings were also used to outline practices that have not been successful for other operations that should be avoided by the WSSD. The structured interviews sought to identify the current state of other operations and how participants adjusted to the integration challenges they discovered as being problematic.

Thematic content analysis of consultation research was applied to aid in the definition of a desired future state for avalanche reporting procedures within the WSSD. This method was applied to address one of the secondary research questions: *How have other CAA members adjusted to the use of the new InfoEx database?*

3.1.4 Strategic Action Planning

It was found through the first two stages of research for the WSSD's adjustment from their current to the desired future state that a strategic action planning approach would be effective. This method of research was selected to offer a usable implementation strategy to the client that was supported by academic evidence. A literature review identifying effective implementation of a strategic plan was performed. Based on the themes identified in the literature, the project's conceptual framework was developed and applied throughout the needs assessment process. The findings from the literature review were applied to the unique Whitewater situation and used to present two options to meet the needs of the department. The third phase of research sought to answer one of the secondary research questions: *How can an organization effectively implement strategic change in the work-place?*

3.2 METHODS

This section describes how the data was collected for the three phases of the research.

3.2.1 Document Review

To provide a general background on Whitewater, internal company documents were used and external documents and information available on their website was also used. The current state analysis was conducted using primary data from the WSSD's historic avalanche control sheets. The department had archived 15 seasons of avalanche control sheets dating back to 1997. As per agreement with the client, the researcher inputted the 15 season of internal avalanche information into the InfoEx database. Once inputted, a historic dataset was downloaded into a Microsoft Excel file from the CAA InfoEx server for data analysis purposes. This data provided information on the frequency of avalanche occurrences at the resort to help better understand the current state by identifying the WSSD's current actions, strengths and weaknesses on avalanche control and recording procedures.

Historic data was also compiled from the internal avalanche terrain closure forms. There were only seven seasons of terrain closure forms archived by the WSSD, which served as primary data for this project. The information was uploaded manually into the Microsoft Excel file to cross reference with the avalanche control information. This information was collected to analyze the WSSD's historic efforts to mitigate avalanche risk. With this available information, the department's strengths and weaknesses could be identified based on the frequency of natural avalanche occurrences during periods of open terrain.

Secondary data was reviewed to establish the desired future state for the WSSD based on smart practices for avalanche control and reporting measures. Documents referenced included publications from the Canadian Avalanche Association and peer-reviewed articles from snow science journals. The client provided the researcher access to CAA documents on guidelines and standards for avalanche reporting procedures for its members.

3.2.2 Literature Review

The literature review was undertaken to address the needs identified in the current state and desired future state analysis portion of the research. Peer-reviewed literature was collected on strategic change management practices from various public administration journals. A thematic analysis was applied to the research to identify agreed upon methods to effectively implement strategic change in the workplace.

3.2.3 Interviews

Structured interviews were conducted in the Fall of 2014 with managers of other snow safety operations in the Rocky and Selkirk Mountain regions to better understand how operations were adjusting to the new InfoEx database. The InfoEx divides the country into regions by mountain range. Based on geographical proximity to the Whitewater Ski Resort other CAA member ski resorts that conduct regular avalanche control work were selected from the Rocky, Monashee and Selkirk Mountain regions. Initially, four snow safety managers from ski resorts in the Monashee and Rocky Mountain regions of the country were contacted. The following three participants agreed to participate in the interview process:

1. The avalanche safety director from Fernie Alpine Resort in Fernie BC,
2. The director of public safety at Marmot Basin near Jasper Alberta,
3. The director of operations at Kicking Horse Mountain Resort in Golden, BC.

A fourth participant was contacted in late Fall 2014 to round out the consultation process. The final participant was the head avalanche technician from the BC provincial Ministry of Transportation and Infrastructure Highways Department at the Kootenay Pass in the Selkirk Mountains.

In total four participants were interviewed for the process. The University of Victoria's HREB approved the researcher's request to conduct the interviews prior to the interviews being conducted assigning protocol number 14-233.

The participants were invited to participate in the interviews through e-mail, asked to sign a letter of consent and once the letter was signed, the individuals were then interviewed over the phone. The interview questions focused on the department's previous avalanche reporting procedures and attempted to understand if the new InfoEx program benefited the operation's current system of reporting (see appendix 1 for interview questions).

The decision to not conduct interviews within the Whitewater Ski Resort organization was arrived at through consultation with the client. The client was of the opinion that currently there exists too great a level of variance among the different shift supervisors. The client predicted that interviews with various supervisors would produce a considerable range of responses, highlighting the current subjective approach to snow safety management. It is the client's goal to greatly reduce this subjectivity by implementing changes based on analysis of the historic avalanche records and the implementation of accepted industry smart practices.

3.3 DATA ANALYSIS

Once the historic avalanche data was downloaded into a Microsoft Excel spreadsheet, usable variables could be identified for quantitative analytic purposes. The variables used in the report were selected based on recommendations made by the client and a professionally trained avalanche technician. Wren McElroy, the client and professional avalanche instructor, contributed variables using her senior avalanche knowledge and training. The previous president of the CAA, Ian Tomm also contributed usable variables to analyze the data. These individuals, based on their knowledge, expertise and experience were deemed to be capable of determining which reports would offer critical insight into avalanche control procedures (see appendix 2 for a list of the variables used).

Qualitative data analysis was completed on the interview transcripts, which were created using audio recordings of the interviews. A thematic content analysis was performed using Anderson's (2007, pp. 2-3) 15-step process. Anderson's process included isolating common themes within all interview transcripts and grouping material into distinct categories (see appendix 3 for Anderson's 15 steps). The relevant criteria used to categorize the respondents' answers included: current avalanche procedures, the InfoEx and outstanding needs. Central themes emerged based on reoccurring responses by the participants within the aforementioned three categories. Based on these themes, a narrative was constructed for each participant's responses.

3.4 LIMITATIONS AND DELIMITATIONS

This section describes the limitations and delimitations within the research.

3.4.1 RESEARCH LIMITATIONS

There are three limitations identified in this research project:

1. The disparity between the size of the WSSD and the snow safety departments consulted.
2. The limited amount of historic avalanche control and terrain closure documentation.
3. The clarity and legibility of some historic avalanche control sheets.

The representatives of the three ski resorts interviewed for this report are employed by much larger organizations than Whitewater. They have larger snow safety departments. Whitewater is a uniquely small resort, which does not have any real estate profits or the visitor capacity the other resorts have. Due to the privately owned nature of ski resorts, annual revenue and visitor information is hard to come by. The three ski resorts contacted all reported having over 100,000 annual skier visits during the 2011 season. These figures were the most recent available statistics. Applying the listed price of a day ticket from each resort's website from 2011 can provide an estimate of each resort's annual revenue from lift ticket sales. Table 1 illustrates the estimated revenue from lift ticket sales based on annual skier visits using Business in Vancouver newspaper's figures and the rates of day tickets in 2011 from the Kootenay Business website. The fourth interview participant from Kootenay Pass has a different source of funding. The Ministry of Transportation and Infrastructure Highway Department has a publically funded program with state of the art resources available to the Kootenay Pass operation.

TABLE 1 ESTIMATED ANNUAL REVENUE SKI RESORTS BASED ON ANNUAL SKIER VISITS

Resort	Annual Skier Visits	Rate of Day Ticket	Estimated Revenue (millions)
Fernie Alpine Resort	385,000	$68.00	$26.2
Kicking Horse Mountain Resort	150,000	$75.00	$11.2
Marmot Basin	200,000	$76.00	$15.2
Whitewater Ski Resort	66,000	$63.00	$4.0

(Business in Vancouver, 2011; Jasper National Park of Canada, pc.gc.ca, 2009; Annual revenue of the Kootenays' largest ski resorts, kootenaybiz.com, 2011; Marmot Basin Lift Tickets, skisnowboard.com, 2011).

The historic data available for analysis in this report does not encompass a complete avalanche cycle. The literature recognizes the need for 25 years of avalanche observations to capture a whole avalanche cycle, which includes high and low years of activity (Schaerer, 1970, pg. 399,). Though the operation has been open for 40 seasons, data storage procedures prevented the availability of older avalanche control sheets. The avalanche terrain closure documents were not a priority archival document like the control sheets and thus the researcher only had access to the last seven years of such information.

The lack of clarity and limited legibility of some historic avalanche control sheets made inputting the information difficult. Arbitrary reporting processes prevented certain avalanche observations from being analyzed.

3.4.2 Delimitations

Based on the scope and boundaries of this report three delimitations were identified:

1. The input and data analysis of only two of the eight avalanche zones at Whitewater.

2. The selection of variables of interest for the quantitative data analysis.
3. The regional scope and consultation performed for the interviews.

Due to time and resource limitations, only two of the eight avalanche zones at Whitewater were examined. The entirety of the data available was inputted for the two zones; however, 15 seasons of avalanche information still requires electronic archiving for the other six avalanche zones.

Time and resource restrictions prevented a more detailed analysis of the historic dataset. Schaerer (1970, p. 400) recognizes the importance of a well-rounded avalanche defense plan. This means data analysis is only one portion of an affective avalanche defense approach. In addition to data analysis there is a need to use weather observation data and for avalanche technicians to have a strong knowledge of local terrain. The analysis conducted in Section Four is meant to offer a basic overview of the historical reporting features of the dataset and a current state analysis. Ideally, snow science professionals examine multiple variables in their avalanche control efforts, including factors such as wind loading, snow formation build up, and critical thought required in assessing the data.

The decision to consult managers of snow safety departments regionally limited the participant group. Implementation strategies could have been gathered through the consultation of many CAA regions; however, due to time and resources, the Selkirk and Rocky Mountain regions were only consulted. The consulted regions were likely to experience similar avalanche mitigation requirements as Whitewater due to weather and snowpack considerations.

4.0 CURRENT STATE ANALYSIS

4.1 INTRODUCTION

This chapter provides an overview of the current state of Whitewater's avalanche control and reporting procedures. Robbins encourages a needs assessment to be performed by identifying the current actions, strengths and weaknesses of the organization (2009, 9). A description of the current state of the WSSD was established by analyzing the organizational structure and the historic avalanche data that was inputted into the InfoEx database. After providing a brief background section on avalanche categorization and regulations, this chapter explores the current actions of the WSSD to mitigate avalanche risk. The analysis of historic data identifies the strengths and weaknesses of the department.

4.2 BACKGROUND ON AVALANCHE CHARACTERIZATION AND CONTROL

There are numerous characteristics used to analyze and study avalanches. For the purposes of this project, avalanche size and trigger type will be the two most commonly used characteristics. Trigger type refers to the natural or artificial activating cause of the slide. The artificial release of an avalanche through the use of explosives or ski cutting is the result of avalanche control work. Ski resorts must perform control work in avalanche terrain to ensure employee and public safety are maintained. WorkSafeBC oversees and regulates avalanche control work in the ski industry. WorkSafeBC consults the CAA for information on the enforcement and regulation of smart practices in the avalanche control and recording industry. Avalanche types, control work and regulations will now be explored in greater detail.

4.2.1 TYPES OF AVALANCHES

The WSSD categorizes avalanches in numerous ways. The following are some examples of how avalanches can be categorized for analytical purposes:

- Trigger type
- Location
- Aspect
- Avalanche snow type: Slab or Loose
- Slab dimension by width, or thickness
- Avalanche slide length
- Size

Avalanche size and trigger type are common categorization techniques used by the WSSD. The sizes of avalanches are classified on a one to five Canadian standardized scale: half sizes are also recorded. The most common avalanche size occurrences at Whitewater are size 1 and 1.5. Size 2 and 2.5 have also been recorded at Whitewater. It is extremely rare for size 3 avalanches to occur within Whitewater's tenure. There have never been size 4 or 5 avalanches at Whitewater. Appendix 4 provides a breakdown of the number of avalanche occurrences by size for B and C zones. Table 1 illustrates the Canadian avalanche size scale first developed in 1981 by David McClung and Peter A. Schaerer (1981) with updated descriptions from the CAA.

TABLE 2 CANADIAN AVALANCHE SIZE CLASSIFICATION SYSTEM WITH DESCRIPTIONS (CAA, 2007).

Size	Description
1	Relatively harmless to people
2	Could bury, injure or kill a person
3	Could bury a car, destroy a small building or break a few trees
4	Could destroy a railway car, large truck, several buildings or a forest area up to 4 ha
5	Largest snow avalanche known; could destroy a village or a forest of 40ha

4.2.2 Avalanche Control and Regulations

The purpose of avalanche control work is to protect lives and property from snow avalanches (Schaerer, 1970, p. 400). For commercial ski resorts, active avalanche control includes ski cutting and the use of explosives to affect unstable snow in start zones and to trigger controlled releases of avalanches (Jamieson & Stethem, 2002, pp. 43-44; and Ueland, 1996, p. 218). Charges can be delivered to an avalanche start zone by hand or by the use of a projectile – such as a gun or Avalauncher (Gubler, 1977, pg. 419). The Canadian ski industry is estimated at using half the annual total amount of explosives utilized for avalanche control work within the country (Jamieson & Stethem, 2002, p. 43).

WorkSafeBC (WSBC) is the regulatory agency setting work place safety standards for British Columbia ski areas. The agency's Occupational Health and Safety (OHS) regulations are legally binding. Specifically, OHS section 4.1.1 "Snow avalanche assessment" reviews the basic requirements for avalanche control and reporting procedures (Workers Compensation Act, 2013). WSBC consults with the CAA as a stakeholder to ensure regulations are consistent with industry smart practices (Obad, 2014). The OHS section 4.1.1(6) (2014) orders workplaces exposed to avalanche hazard must have, "an avalanche safety program that provides for:

> (a) the regular monitoring of weather, snow and avalanche conditions in the area of the workplace, at intervals the qualified person considers will be effective,
>
> (b) the implementation of closures or other measures, as specified in the avalanche safety program, and
>
> (c) safe work procedures to be followed by persons working at the workplace (Workers Compensation Act, 2014).

The WSSD follows all the above regulations. Weather observations are monitored and recorded two times a day. Avalanche conditions are monitored and updated daily and occurrences are recorded at the time of observation.

Whitewater's avalanche safety plan (ASP) is updated based on annual avalanche occurrences and results. The document outlines snow safety procedures and unique characteristics that effect weather, snow and avalanches at Whitewater. According to the ASP, the purpose of avalanche control work is "to minimize[e] risk to skiers (employees and guests) from avalanches within Whitewater resort tenure ... [and] to recognize and mitigate avalanche danger within or affecting the ski area boundaries" (2012, p 3). The ASP also specifies avalanche control route leaders must have three years of avalanche experience, and two of those years should be specific to Whitewater (2012, p.6).

The CAA has established an online resource to assist its members in documenting and saving avalanche and weather observations. The CAA's InfoEx is the online database and resource for subscribers from avalanche safety programs to upload, share and access weather, avalanche and snow observations (InfoEx, avalancheassociation.com). There are different formats professionals are able to use to record information regarding avalanches. The CAA recognizes avalanche information being recorded in *observation* and/or *summary* format.

Avalanche observations are specific recordings of an avalanche (or avalanches) that occurred at a specific location and time. Accurate descriptions of all available characteristics should be included in these observations. Avalanche summaries are less accurate and are meant to provide a general characterization of a broad geographical area. Summaries are often completed at the end of the workday. Their purpose is to reduce data by being concise and organized (Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches, 2007, pp. 43 & 54). Both styles of reporting can be uploaded into the CAA's InfoEx.

4.3 WHITEWATER AVALACHE MITIGATION

The avalanche terrain surrounding Whitewater is divided into eight zones. The snow safety department is responsible for recording avalanche activity and control efforts for each zone on in-house control sheets. The purpose of a control sheet is to provide a visual representation of the results of avalanche occurrences. The form is divided into two sections: an image of a zone for drawing results and a table for recording and quantifying results (ASP, 2012, 121).

For the purpose of this research and due to time and resource limitations, only two of the eight zones were examined. The zones analyzed are referred to as Upper Powder Keg, B zone and Catch Basin, C zone. These zones are the most frequently controlled and are therefore indicative of daily operations at Whitewater. There are 11 avalanche paths in the Upper Powder Keg, B zone and 19 in the Catch Basin, C zone. Avalanche paths are identified using the letter of the zone followed by the ordinal placement along the ridgeline (e.g. C5).

4.3.1 Whitewater's Snow Safety Department

Whitewater's snow safety department is made up of 70 personnel, which include trail crew staff, rail park attendants and volunteer patrollers as well as the 16 full-time and eight part-time professional ski patrol positions (pro patrol) (McElroy, 2014, p. 4). The pro patrollers are responsible for performing avalanche control work and delivering first aid treatment to guests and staff on the mountain. The other daily duties patrollers are responsible to complete include attending morning and afternoon meetings to discuss objectives, opening the mountain to the public, performing patrol run sweeps at the end of the day and addressing general run maintenance throughout the day.

If avalanche control work is required, the supervisor will also appoint a control route leader. This person is responsible for ensuring all control work has been recorded on in-house forms as well as uploading results to the InfoEx. Before commencing an avalanche control route, the snow safety staff discusses the number of explosives needed to complete the route, which paths will be targeted, their anticipated results and if certain areas are expected to be problematic or require special attention. The results of control work should remain effective until snow and or weather conditions change at which point danger must be reassessed.

The WSSD is in charge of closing avalanche terrain when the avalanche risk is high. The avalanche terrain will also be closed to the public during control work. Procedurally, the snow safety department documents the date and time the avalanche terrain is opened and closed. When Whitewater is experiencing several consecutive days of heavy snowfall and strong winds, the snow safety department may close access to the avalanche hazard terrain until the storm cycle passes.

4.4 DATA REVIEW: AVALANCHE CONTROL AND REPORTING PROCEDURES

The current state of the WSSD's avalanche control and reporting procedures was identified through historic data analysis. The following section outlines the strengths and weaknesses of the current state based on the data findings.

Fifteen seasons of historic avalanche records from control sheets were entered into the CAA InfoEx database to be compiled and examined. This information serves as the quantitative data for this report. The historic data analysis can be used to identify the strengths and weaknesses of the current state of the WSSD.

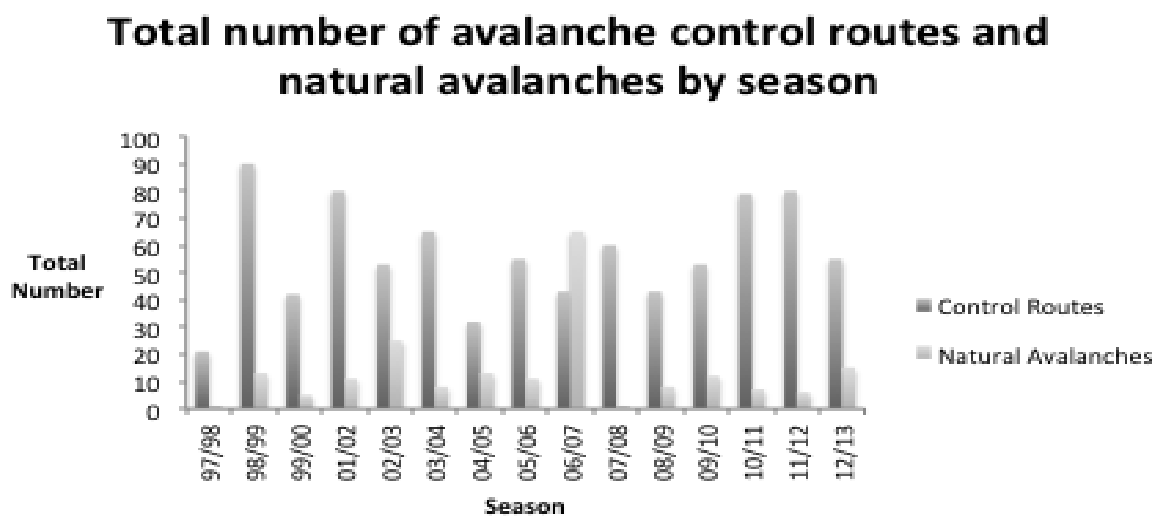
It should be noted that an accurate representation of the current state of the WSSD lacks access to electronic database information. It was only once this needs assessment was conducted that the historic data was converted into an electronic format. The information being analyzed can highlight the current state of avalanche mitigation and recording procedures, however, the new tools available for filtering the data should be examined as a tool to bridge the needs for the

WSSD as it is a new system. The benefits to having a new electronic database are explored in Section 6 of this report.

4.4.1 Preliminary Analyses of Historic Data

The statistical information highlighted the number of control routes completed each season, allowing for the total number of controlled avalanches to be extracted. Figure 2 represents the total number of avalanche control routes and natural avalanche occurrences by year. This data was further categorized to identify the trigger used to create the avalanche. Other characteristics that were applied to the filtered data were the specific avalanche paths found in each zone and the resulting size of the avalanche generated. All the above information was used to generate highly specific statistics on Whitewater's avalanche history. As a project deliverable the filtered data, figures and tables were provided to the WSSD as an electronic file.

FIGURE 2. TOTAL NUMBER OF CONTROL ROUTES AND NATURAL AVALANCHES BY SEASON.



4.4.2 Annual Reporting Using Avalanche Observations

An examination of the statistics drawn from the 2012/13 season indicated 55 control routes were completed during the 120 days of operation. The ASP (2012, p.124) estimates that it takes the snow safety department four hours to complete a control route. These figures equal a total of 220 hours of avalanche control work for the 2012/13 season, or an average of 1.83 hours per day. The accident summary for the same season indicates 283 accidents (McElroy, 2013, p.8). There were 61 staff injury accidents. These incidents require greater amounts of documentation and are more time consuming for the snow safety staff. The average of one hour per accident was applied for visitor incidents and two hours for staff injuries to result in 344 hours of first aid work, or an average of 2.86 hours per day. The snow safety daily duties amount to 3.75 hours each day. Based on the calculated averages from the 2012/13 season, 8.45 hours of the 9 hour day were occupied by snow safety related activities. Table 3 illustrates the same formula applied over the last four seasons to indicate the average amount of time for snow safety related activities.

TABLE 3. BREAKDOWN OF THE AVERAGE AMOUNT OF TIME FOR SNOW SAFETY ACTIVITIES

	12/13	11/12	10/11	09/10
Operational Days	120	129	124	122
Control Routes	55	80	79	53
Total hrs/season For Control Work	220	320	316	212
Average hrs/day For Control Work	1.83	2.48	2.55	1.74
Total Visitor Accidents	222	241	224	234
Total Staff Injuries	61	60	61	40
Total hrs/season For First Aid	344	361	346	314
Average hrs/day For First Aid	2.86	2.8	2.79	2.57
Average Occupied hrs For Snow Safety Activities	8.45	9.03	9.09	7.56

Note: 2010/11 saw the opening of the Glory Ridge Chair – doubling the inbound terrain. The 3.75 hours applied to the snow safety other duties (non-first aid or avalanche related activities) was lower in 2009/10 season at a level of 3.25 due to the smaller inbound terrain.

4.5 CURRENT STATE RISK ANALYSIS

Once processed and uploaded the historic avalanche information can be used to analyze avalanche hazard at Whitewater Ski Resort. The two components of avalanche hazard that were explored are the number of naturally triggered avalanches and the number of large-scale avalanches measuring above 2.5 on the Canadian scale. (*A reminder that these two areas are not necessarily mutually exclusive*). These are two important characteristics to examine as both types of avalanches could result in injury or death to employees and guests of the resort.

4.5.1 NATURAL AVALANCHES

According to the data, Whitewater has had 264 natural avalanches in the past 15 seasons. The annual average of natural avalanches is 17.60. There were 109 natural avalanche occurrences during Whitewater's hours of operation. Of the 264 natural avalanches, 98 were recorded as occurring overnight using "O/N" as a classification system during non-operational hours. There were 15 cases where specific times of occurrences were recorded outside of the resort's operating hours. Due to the exact times provided, it can be assumed a member of the snow safety department was present to witness the slide take place. There were 42 cases that did not include a specific time or the "O/N" time classification. Table 4 provides a break down of the time of occurrence for all natural avalanches at Whitewater.

TABLE 4. NATURAL AVALANCHES SINCE 1997 CATEGORIZED BY TIME OF OCCURRENCE.

Time of Occurrence	Number of Cases
Over Night	98
Outside Operation Hours	15
Inside Operation Hours	109
No time recorded	42
Grand Total	264

The occurrence of natural avalanches during operational hours was cross-referenced with the historic zone closure documents to determine whether any slides took place when the terrain was open to the public. There were seven seasons of documented zone closures available. There were 73 cases of natural avalanches that occurred during operational hours that could not be cross-referenced with zone closure information. There were 8 cases where zone closures could not be confirmed due to the missing closure and opening times. Of the 109 natural avalanches that occurred within operational hours, 16 occurrences were during zone closures. This means in the 15 seasons of Whitewater's historic recordkeeping there were at least 12 known natural avalanches to occur during operational hours in terrain open to the public. Appendix 5 provides a table of these 12 incidents.

4.5.2 Large Scale Avalanches

Following a large snowstorm it may be unavoidable for the snow safety department to produce large-scale avalanches that do not enter the bottom of a slide path. The snow safety department is likely to anticipate large avalanches when 24-hour snowfalls are greater than 10 cm. For risk analysis purposes, acknowledging that heavy snowfall will generate large-scale avalanches, a filter is applied to the data to capture occurrences when *less* than 10 cm of snow accumulated in the previous 24 hours. There were two recorded large-scale avalanches with less than 10 cm of new snow. There were five days on which large-scale avalanches occurred and the 24-hour snow accumulation portion of the control form was not filled in. Divided across those five days were 19 large-scale avalanches. Refer to Table 5 for these large-scale events.

TABLE 5. SIZE 2.5+ AVALANCHES OCCURRENCES WITH LESS THAN 10 CM OF SNOW IN THE PAST 24 HOURS, OR BLANK SPACES.

Date	Size	Trigger	Location	24hr snow (cm)
99-02-07	2.5	Xe	C6a	-
99-02-07	2.5	Xe	C7a	-
99-02-07	2.5	Xe	C7b	-
02-02-23	2.5	Na	C1f	-
02-02-23	2.5	Na	C3a	-
02-02-23	2.5	Na	C4b	-
02-02-23	2.5	Na	C5	-
02-02-23	2.5	Na	C7a	-
05-01-20	2.5	Na	C1g	-
05-01-20	2.5	Na	C3b	-
05-01-20	2.5	Na	C4b	-
05-01-20	2.5	Na	C5	-
05-01-20	2.5	Na	C6a	-
05-01-20	2.5	Na	C6b	-
05-01-20	2.5	Na	C7a	-
05-01-20	2.5	Na	C7b	-
06-01-07	2.5	Xe	C2	-
06-02-28	2.5	Na	C6a	9
06-02-28	2.5	Na	C6b	9

4.6 HISTORIC DATA ANALYSIS LIMITATIONS

Certain aspects of data entry could not be completed using the parameters provided by the InfoEx database. The inability to record non-events (size 0 results or faulty explosives) into the InfoEx prevented the documentation of 26 avalanche mitigation efforts. Refer to Appendix 6 for a breakdown of these incidents.

An example of the arbitrary nature of avalanche recording methods at Whitewater can be observed through the documentation of subdivided avalanche paths by various recorders. While there are 18 recognized avalanche paths in C Zone, reports generated by various recorders have further subdivided these into a total of 31 avalanche paths. Similarly, the B Zone has 11 recognized avalanche paths, however various recorders have subdivided this region into a total of 38 distinct paths. The arbitrary nature of this recording practice makes accurate data analysis impossible. Table 6 represents an example of the arbitrary avalanche path sub-division.

TABLE 6. THE NUMBER OF TIMES THE AVALANCHE PATH C7B WAS ARBITRARILY SUB-DIVIDED TO INCLUDE C7C AND/OR C7D.

Location	C7b	C7c	C7d	Grand Total
Total times recorded	273	13	3	289

4.7 WSSD'S CURRENT STATE SUMMARY

The strengths of the WSSD can be summarized as demonstrating effective hazard and risk mitigation practices. The historic data has identified that the WSSD has been effective at ensuring potentially harmful avalanches do not occur in open avalanche terrain where resort guests and employees could be placed at risk. The current actions being taken by the WSSD ensure the regulations established by WorkSafeBC are being correctly followed. The WSSD's active ASP is an example of an additional effective action undertaken by the department.

The weaknesses identified in the current state analysis predominately revolve around inconsistent data recording practices. The lack of saving certain critical documents, such as the zone closure forms, prevented the analysis of risk management measures. This loss of information weakened the ability to analyze the current state. Another concern identified from the historic avalanche records was the resource capacity of the department. Though the department is able to work within operational hours there is limited time available in the day to introduce additional roles and responsibilities.

In terms of the conceptual framework established in Section 2, the findings of this chapter can be used to more accurately describe the "current state" box. Figure 3 has been included to illustrate the summarized remarks of this chapter into the conceptual framework.

FIGURE 3 REVISED CONCEPTUAL FRAMEWORK CURRENT STATE

5.0 FUTURE STATE ANALYSIS: SMART PRACTICES AND INTERVIEWS

The purpose of this section is to determine the desired future state of WSSD's avalanche control and reporting practices. If a strategic action plan is to be adopted to address the department's needs, a clear image of the desired future state will assist in measuring the action plan's outcomes. This chapter of the report contains two sections: a review of smart practices for avalanche control and reporting procedures; and the findings from four interviews conducted with managers of other snow safety operations.

The smart practices review validates the effectiveness of many of the WSSD's current practices for recording and conducting avalanche control work. The practices are measured against smart-practice criteria and ranked in order of importance for the WSSD's desired future state.

The interview findings are meant to identify new practices that the WSSD may benefit from adopting if the department's resource capacity allows. The interview findings must also be examined through a critical lens to identify practices that would not be effective if adopted by the WSSD.

5.1 SMART PRACTICES FOR AVALANCHE CONTROL

Hall and Jennings emphasize the importance of having clear goals when researching smart practices (2008, 695). Their method applies criteria to the identified practices to measure and weigh the overall validity and reliability of each practice. For this project, the goal of the smart practices research is to develop the WSSD's future state for effective and efficient avalanche control and reporting procedures, which meet internal and external requirements. The five criteria used to weigh the smart practices for avalanche control and reporting procedures have been taken from Jennings' *Best Practices in Public Administration: How do we know them? How can we use them?* (2007). Jennings' follow-up article co-authored with Hall *Taking Chances: Evaluating Risk as a Guide to Better Use of Best Practices* (2008) also provides usable definitions for the five criteria. The criteria used are: fit with local need and context, empirical evidence about effects, theoretical underpinnings, cost, and level of risk (2007, 78). These criteria will be applied in the following manner:

Fit with local need and context – refers to how the practice would function within the WSSD's environment using the department's available resources.

Empirical evidence about effects – refers to whether the practice is supported by experimental evidence to achieve the intended outcomes.

Theoretical underpinnings – meant to be informal in nature, refers to if the practice will likely bring about the desired outcomes through theoretical knowledge (Hall and Jennings, 2008, 698).

Cost – refers to the amount of time, resources and money required from the WSSD to implement or perform the identified practices.

Level of risk – refers to the likelihood the practice would result in unintended and negative outcomes on personal, organizational and societal levels and if there is any uncertainty as to whether the practice will be effective.

The following four procedures will be explored and weighed based on the above criteria to determine their importance in the WSSD's future state:

1. Complete avalanche observations should include weather, snowpack and avalanche data observed and recorded on the spot, immediately following the occurrence.
2. Twenty-five years of historic avalanche data is required to be able to accurately analyze a full avalanche cycle of a specific area.
3. The individuals performing avalanche control work should be professionally trained.
4. Avalanche technicians should possess a strong geographical knowledge of the terrain they are working in.

5.1.1 Recording Accurate Avalanche, Weather and Snowpack Data

Since Peter A. Schaerer's classic 1970's report, the Canadian avalanche community has emphasized that avalanche observations are most reliable when made on the spot, immediately after the occurrence (Schaerer, 1970, p. 398, Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches, 2007). Consideration should be taken to record all characteristics within the description. Ideally, avalanche and weather observations should be taken at the same time to draw relationships between the two (Schaerer, 1970, p. 400). Due to Schaerer's extensive research and experience in the avalanche community, his work in snow science journals is frequently cited and serves as empirical evidence on effective methods for avalanche control and reporting practices (Fitzharris, 1987, p. 115; and Haegeli & McClung, 2003, p. 255)

The theoretical underpinnings of this practice are emphasized by the most current CAA report, released to its members, outlining Schaerer's classic, smart practices for recording weather, snowpack and avalanches. These practices make up the CAA's observation guidelines. The CAA report provides detailed and technical procedures for making accurate weather and snowpack observations. Blank forms and examples have been provided with descriptions for why each section of required data is crucial for the collection process (Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches, 2007). The WSSD strives to follow the guidelines and procedures established by the CAA; therefore, the conceptual model for avalanche control and reporting procedures developed using Schaerer's contributions to the CAA as its founder (Scott, 2005, p. 207), also make up the WSSD's theoretical framework.

The recording of data is an existing practice at Whitewater. The need for a more thorough implementation of this practice is evidenced by the inconsistencies in the data recording procedures identified in the historical data analysis. The costs associated with upgrading the practice involve the training and supervision by senior staff for the department. The level of risk associated with upgrading data recording practice will be tied to the commitment made to this by the leadership of the snow safety department. A lack of supervision and accountability by senior snow safety staff members is likely to leave the WSSD in its current state of inconsistent data recording practices.

5.1.2 25 Years of Historic Avalanche Data

Schaerer recognizes there is an increased likelihood of a winter every 10-22 years that creates larger and more frequent avalanches than most seasons (1970, p. 399). It is ideal to have 25 years of observations to establish a reliable history of avalanche occurrences and weather observations. A quarter century worth of data ensures a complete system has been documented in the event records began in a low avalanche activity cycle (Schaerer, 1970, p. 399).

The practice of capturing 25 years of historic data meets the smart practices evaluation criteria. Schaerer's claim that capturing 25 years of data is crucial for data analysis purposes is rooted with deep empirical evidence as he has 30+ years of experience observing and recording avalanche occurrences at Roger's Pass. For the WSSD context, the historic data available for analysis for this report does not encompass a complete avalanche cycle. For now, the 15 seasons of data is simply a starting point. As Schaerer mentions, the reason for requiring 25 years of information is to ensure all possible avalanche activity is captured. Therefore in theory, a thorough data record will be met by adopting this practice. The costs associated with this practice to the department are predominantly the time and commitment required from the staff to ensure the data is collected and stored effectively over such a long period of time. Based on Schaerer's empirical evidence, the risk of this practice not producing the desired outcome of a complete data record is low.

5.1.3 Professionally Trained Avalanche Technicians

The technical experience level of the observer, forecaster and avalanche control personnel is crucial to ensure accuracy across the whole avalanche control process (Gubler, 1977, p. 3; Schaerer, 1970, p. 399; and Ueland, 1996, p. 217). As Ueland notes, the validity of the information gathered relies on the training and knowledge of the individuals involved. To gain an accurate full description of weather, snowpack and avalanche observations, the observer must know all the crucial characteristics – a skill and insight that can be gained with experience and training (Ueland, 1996, p. 217).

When examining the smart practice of employing professionally trained personnel against Jennings' criteria, the benefits of the practice emerge. The theory behind this practices is that professionally trained avalanche technicians are more likely to perform and conduct avalanche control work to a higher level of quality than untrained individuals. Evidence in support of the practice can be seen in the requirements from WorkSafeBC that qualified persons conduct avalanche control work (Workers Compensation Act, 2014). Moreover, Whitewater's local need supports this practice within its ASP by requiring all professional snow safety staff to be CAA trained (ASP, 2012, 6). As CAA training is a job requirement for the WSSD staff, the cost of this practice falls on the individual and not the department. The risks associated with this practice are low as the CAA is a world leader in avalanche practices and the level of training it provides (Lea, 2014).

5.1.4 Avalanche Technicians with Geographical Knowledge

Ueland notes work experience within the snow safety industry as being critical (1996, 217); however, a further requirement is familiarity with a specific geographical location. Further, an advantage that avalanche safety programs at ski resorts have is the ability to observe slide paths on a daily basis (Ueland, 1996, p. 217). Similar to accessing historic weather and avalanche observations, various authors have argued that an experienced professional who has long-term geographical knowledge of the region is more likely to understand and predict when and where certain start zones will release (Schaerer, 1970 p. 400; and Ueland, 1996, p. 217).

The benefits of Ueland's requirement that avalanche technicians possess strong knowledge of local terrain emerge by applying Jennings' criteria. The theoretical nature of the practice is that local terrain knowledge will strengthen the technicians ability to assess and predict avalanche behaviour in the area. When Adams surveyed experts within the avalanche industry, 95% of respondents recognized local terrain knowledge as being a "moderate to very great" variable for accident prevention (Adams, 2004, 4). As per Whitewater's ASP, snow safety staff are required to have two years experience in local terrain before leading avalanche control routes (ASP, 2012, 6). The main cost associated with this practice is the time required by senior staff members to train and educate new staff on Whitewater's terrain. The risks of negative or unintended outcomes for this practice are moderate. Based on the inconsistent data collection from Whitewater's historic records, a noteworthy risk associated with avalanche technicians requiring two years of experience at the resort is one of experienced staff developing a relaxed or apathetic attitude toward avalanche recording practices.

5.1.5 Smart Practices Summary

It has been determined that the identified practices constitute smart practices based on the discussion of avalanche control and reporting procedures using Jennings' criteria. The desired future state of the WSSD should ensure all four practices are implemented. Table 7 has been provided to sum up the smart practices based on Jennings' criteria and rank them by order of their need to be addressed within the WSSD.

TABLE 7 AVALANCHE CONTROL AND REPORTING PROCEDURES WEIGHED USING SMART PRACTICE CRITERA

Jennings' Criteria and Practices	Local need and context	Empirical Evidence	Theoretical Underpinnings	Cost	Level of Risk	Rank
Complete avalanche observations	Existing policies in place, further training required	Yes	Yes	Training and supervision	Medium	2
Twenty-five years of historic avalanche data	Physical storage limitations, data processing required	Yes	Yes	Time, space, resources	Low	1
Professional training for avalanche technicians	Existing policies in place	Yes	Yes	Existing practices in place	Low	4
Avalanche technicians require local terrain knowledge	Existing policies in place	Yes	Yes	Existing practices in place	Medium	3

As the department currently recognizes and follows these practices for their avalanche control and reporting procedures, the future state should not abandon any of these measures. The future state of the WSSD should ensure the practices that are not currently being fully met are addressed. Using the findings in Table 7 it would appear that acquiring 25 years of data is the smart practice furthest from completion at this time. The second area requiring the most attention is the need for a complete data recording system, as evidenced by the inconsistent recording practices highlighted in the data analysis section. The practice of requiring local terrain knowledge by avalanche technicians is listed as third since the perceived risk of apathetic recordkeeping is a moderate risk. Lastly, the final practice of ensuring all avalanche technicians are professionally trained was observed as low cost, low risk and strongly in place currently within the department and is therefore ranked as the least important for areas requiring attention.

The WSSD's current state does not include access to the electronic database of historic avalanche information. The smart practice of acquiring 25 years of historic avalanche data for analytical purposes is part of the desired future states for the WSSD. The benefits of having a new electronic database to build, process and analyze a 25-year record will be considered as a need to bridge the gap between the current and future state of the department. The benefits of an electronic database are discussed in Section 6.

5.2 FINDINGS: INTERVIEWS

Interviews were conducted with snow safety supervisors from other Western ski resorts to better understand how their operations were adjusting to the new InfoEx database. Participants were selected as a result of their avalanche control work and their contributions to the CAA's InfoEx database. The interview questions focused on the department's avalanche reporting procedures as well as attempted to understand the impact of the new InfoEx reporting system.

The interviews were conducted with supervisors from Kicking Horse Mountain Resort, Fernie Alpine Resort, and Marmot Basin. These three resorts frequently conduct avalanche control work within their ski area tenures and upload results into the InfoEx database. Revelstoke Mountain Resort was contacted but unable to participate.

Information was also collected from the head snow avalanche technician at Kootenay Pass with the BC Ministry of Transportation and Infrastructure Highways Department. The proximity of Kootenay Pass to Whitewater Ski Resort makes them, the resort's nearest neighbour[2] that inputs avalanche occurrences into the InfoEx. The geographical relationship means the avalanche technicians at Kootenay Pass will access the WSSD's observations on the InfoEx for their own avalanche forecasting practices. As an InfoEx user who refers to the WSSD's observations, the Kootenay Pass supervisor is in the position to offer a unique perspective on the strengths and weaknesses of Whitewater's current recording methods.

The consultation process sought to gather information on three topics: current avalanche procedures, the new InfoEx program and outstanding needs. The key findings for current avalanche procedures can be divided into two subcategories: current avalanche recording techniques and reporting capabilities. The discussion on the new InfoEx program exposed positive and negative opinions from all participants. When asked about the positive and negative aspects of the InfoEx, respondents commented on experiences with the computer program as well as more broad feelings on information sharing. Key themes that emerged from the outstanding needs topic were a combination of issues within the InfoEx program and general avalanche recording methods. Table 8 presents a point form break down of the key themes identified within each category. This sub-section examines the findings of each interview by participant.

[2] The term nearest neighbour in avalanche control terminology can have two separate meanings. Geographically nearest neighbour references the nearest CAA member to upload avalanche observations to the InfoEx. A specific style of statistical analysis is known as the Nearest Neighbour Model. This model compiles and analyzes historic avalanche observations for the purpose of recognizing previous situations similar to "a day like today" (Buser, 1983, pg. 156).

TABLE 8. THE KEY THEMES IDENTIFIED FROM CONSULTATION RESEARCH

Categories	Current Operating Procedures		Opinions on the new InfoEx		Outstanding Needs
Subcategories	Recording	Reporting	Positive	Negative	
Fernie Alpine Resort	- Paper occurrence sheets - Record explosives use regardless of whether an avalanche occurred - Use Excel spreadsheets for any agreeable data.	- Limited with reporting capabilities - Use Excel based only on agreeable data entered - Does not feel further level of detail is something the program needs	- Useful as an information sharing system - Brought the CAA's industry conceptual model into forefront - Ensures all operations using same language - Ensures all operations coming to same conclusions - Useful data storage system	- Computer assisted platform required for information presentation - Should not be used as a decision support tool - Does not have intimate knowledge of terrain - Less effective for information sharing due to too much data - key points are being lost - Staff may be locked to a computer all day	- Medium electronically that captures avalanche occurrences to the level department is looking for
Marmot Basin	- Paper control sheets - Draw picture of avalanche results - Record avalanche statistics on form - Information transferred into InfoEx as a back-up	- Not done daily - Flip through all control sheets for season, stored newest to oldest - Previous seasons control sheets stored in binders by piece of terrain as far back as 1990's - Case studies of major historic events compiled from control sheets	- Program training provided by CAA - New workflow - Data storage capabilities	- Inability to review new staff submissions to server - Double data entry with in-house forms - Private in-house information sharing unavailable - Uploaded information that does not need to be shared with industry becomes "noise" - Teasing out information can be difficult	- Nearest Neighbour data analysis capability for historic reports - Different user log-in levels for data submission on InfoEx
Kicking Horse Mountain Resort	- Google Earth based program - Able to draw in results over top of satellite image - Developing an Excel based program for more powerful querying capabilities	- Ability to query by date or area using Google Earth - Able to use historical reporting as far back as work done in current season	- Customizable workflows - Timesaving data entry methods within program	- Double data entry with in-house forms	- Would not like to lose ability to draw results over top of pictures - Nearest Neighbour reporting capabilities - Single point of data entry - Automatic polling of telemetry data into InfoEx
Kootenay Pass	- Paper control sheets - Draw picture of avalanche results - Record information in columns on same sheet - Use Ministry's central database SAAWS	- Using SAAWS to filter by avalanche size, weather, snowfall, avalanche path, or area - Running reports not done frequently but used annually - Useful for resource tracking purposes	- Daily workflow customizable for internal publication only - Access for nearest neighbour snowpack information - Access to special messages released by CAA - CAA training for program - Remote access capabilities	- Several computer bugs initially - Initial learning curve to tease out information	- In the field, drawing avalanche results electronically that auto populates all required forms

5.2.1 Fernie Alpine Resort

The avalanche safety director at Fernie Alpine Resort is in charge of the implantation and maintenance of the avalanche safety program for the resort. Fernie's snow safety department has the challenge of having large-scale avalanche paths with remote start zones that lack easy access. Their explosive delivery program relies on throwing bombs, using four gun installations, one helicopter, and some tramlines in certain locations. Ski cutting is also used for avalanche control. Fernie's snow safety department records avalanche control work using a series of occurrence sheets. Any time an avalanche over size 1.5 is initiated, they will note it in occurrence record to keep track of what was released, when and where. Based on operational feasibility size one avalanches are not recorded. Nonetheless, any avalanche initiated with explosives, will be recorded. Furthermore, if Fernie's snow safety department fires an explosive, they will still record when and where that happened, regardless of whether an avalanche occurred.

The recording system is a paper one and is relatively simple. The department has been trying to think creatively on how to step into the digital world. Only certain parts of the program can be logged electronically.

The system uses Excel spreadsheets to organize the data and to put it into table formats in order to draw conclusions. The Excel program has inherent limitations in terms of what can and cannot be entered into such a recording system. Nonetheless, the department has been unable to find an electronic medium that captures avalanche occurrences to the level that they are looking for. The director commented that even with the advancements being seen on Google Earth, the paper control sheets still serve as a strong historic reference tool. The director recognized that there are challenges when trying to look at larger groups of information. If this is to be done, the snow safety department must process the data first, before they can look for event relationships within it. Capturing each individual avalanche occurrence in relation to historic weather patterns and other defining characteristics is a challenge that the director was not certain is needed at Fernie in order to ensure best snow safety practices are maintained. Looking at historical information and summarizing avalanche activity to a certain day has proven to be reliable enough.

The introduction of the new InfoEx program was not entirely usable to Fernie's snow safety department for two major reasons. Firstly, the usability of the program relies heavily on computer assisted morning meetings. Fernie does not have computers with projectors to facilitate that style of meeting. Secondly, and as a continuation of the first point, Fernie did not find the InfoEx to be a useful decision support tool. Instead, the director chose to focus on the InfoEx's original intended purpose: to be an information sharing system. After making this distinction, working with the program became easier. The director came to this decision through a belief that the InfoEx system could not advance avalanche technicians' terrain knowledge. It was the director's belief that this knowledge would be acquired experientially and not through a database system. The director identifies value in using the InfoEx system as an information-sharing tool for hazard assessment, data collection and key events. The director has found that access to this information validates the Fernie snow safety department's own decision-making process.

The director had several concerns for the introduction of the InfoEx program at Fernie. The director has a strong belief that snow safety personnel should not become deskbound, data entry clerks. This could be a real danger because in avalanche control, the department needs to keep staff outside with, "their heads in the snow -- that is where things are happening" (Interviewee #1).

In the director's opinion, the strength of the InfoEx program rests its ability to support information sharing. As long as that point is maintained, it is successful. As the program has gained increased complexity many practitioners, he reported speaking with, expressed concern that the program was becoming less effective due to there being too much data.

5.2.2 Marmot Basin

The director of public safety for Marmot Basin in Jasper, Alberta was interviewed to discuss the resort's experience with applying the new InfoEx program to its avalanche control and reporting procedures. Marmot Basin is a well-established resort and has captured and recorded weather data since the 1960's and avalanche control information since the 1980's. Data collection and preservation is a priority to their snow safety department. The new InfoEx program has been a benefit to the department as it has a data storage component.

Marmot Basin's current avalanche recording system relies on paper copies of avalanche control sheets. The form provides a picture of the avalanche terrain and allows snow safety staff to draw the size, trigger point, length and width characteristics of the slide on the image. Below the image is a table to capture date, time, location, trigger type and other pertinent information not captured in the drawing. The snow safety department also records detailed information about their control routes into a logbook. The information is then transferred to the InfoEx as a data backup. An in-house daily hazard form is filled out at the end of each day and is used to offer the next day's staff an understanding of the previous day's events. Though the new InfoEx program offers a daily hazard form, it does not allow staff to make free hand comments as they can on their in-house form. The director of public safety did not believe that the InfoEx program was designed to incorporate this type of freehand comment, as it would not be useful for other external stakeholders to have access to such information. The information that is pertinent to the next day staff is perceived as 'noise' on the InfoEx.

Throughout the season, avalanche control sheets are divided by zone and organized from newest to oldest, allowing the snow safety department to look through the forms easily. Glancing back throughout the season allows staff to identify any anomalies in the results that may have occurred. The same examination can be done for previous years of control sheets as they are kept in binders organized by zone.

More recently, Marmot Basin has begun to work on building case studies from their control sheets. The department is identifying any incidents of avalanches triggered by skiers accidentally or remotely and any larger than average avalanche events to use in these case studies. With this information, the snow safety department is looking for anything of interest or of excessive consequence. The snow safety department uses the case studies to build their historic records and to aid in the training of new staff learning about Marmot Basin's terrain.

When the new InfoEx program was introduced to Marmot Basin the adjustment was reported as having been fluid due the training offered by the CAA. The director of public safety did comment that the snow safety staff had to adjust to the move away from the shorthand method they were familiar with in the in-house forms. Another adjustment that the department had to get used to was the teasing out of information from the database. The raw data presented was overpowering and challenging to manage due to the manner in which it was presented. This problem was resolved by a system upgrade to the program by dividing the information into tabs on the screen.

Marmot Basin's snow safety department has a variety of experience levels amongst avalanche technicians. As the department trains entry-level technicians, the InfoEx would be more usable if there were different user settings to prevent uploading information before a senior staff member had the opportunity to review it.

5.2.3 Kicking Horse Mountain Resort

From Kicking Horse Mountain Resort (KHMR) the director of operations was contacted and interviewed about avalanche control work at the resort. The director is responsible for the safety and avalanche program at the mountain. Due to the expansive terrain, all members of the snow safety department participate in avalanche control work.

The introduction to the new InfoEx program has not replaced KHMR's previous recording systems. The director of operations did not think a full substitution would occur until the InfoEx could capture all the information required for data documentation and distribution purposes that the current in-house program provides.

KHMR relies on a Google Earth program to record their avalanche control work. The program was created in-house. A benefit of using Google Earth includes visual aids within the program. Avalanche results are traced over the satellite image. This process allows the snow safety department to capture various characteristics of the slide, such as its length and width.

The director also remarked on the benefits of Google Earth to educate staff on terrain features since the satellite images are obtained in the summer months when rock formations and other geomorphic traits are visible. Nonetheless, Google Earth is only able to generate reports for a current season. The snow safety department would like to have the ability to filter weather and date parameters to produce historical records from multiple years. This style of desired reports would be considered Nearest Neighbour analysis.

KHMR created an Excel based program due to the limited interactive component of Google Earth. The program has been updated from an original project that was outsourced a few years ago. A benefit of using Excel for avalanche risk planning is the program's ability to recreate and transfer data to numerous forms. The snow safety department relies on the avalanche hazard information to be passed on to their grooming and maintenance staff for over-night work and to the daily avalanche information forms provided to the general public. The Excel program has also been encoded to obtain data from the resort's remote telemetry and weather stations for accurate and up-to-date data recording.

The director reported that the introduction of the new InfoEx program into the reporting procedures at KHMR brought about mixed emotions from the snow safety department staff. Some benefits of the program identified were the customizable workflows for hazard and risk analysis. Populating the forms can be done in a timely manner as the program allows for data to be stored until the user wishes to remove it. Nonetheless, double data entry is required at KHMR as the department is still relying on its own risk analysis forms rather than the ones provided through the InfoEx. From the director's perspective, having the ability to automatically sync the InfoEx with their telemetry and weather data would address some of the inefficiencies of the current double entry issues.

5.2.4 Kootenay Pass

The manager of the Kootenay Pass avalanche control program with the Ministry of Transportation and Infrastructure was contacted for an interview due to the pass' close proximity to the Whitewater Ski Resort in the Selkirk mountain range. The head snow avalanche technician is responsible for daily forecasting and hazard mitigation efforts. The remote avalanche control system uses 23 cannons installed amongst 47 avalanche paths to protect Highway 3 from avalanches. The system is called Gazex. Helicopter bombing is also used to affect avalanche terrain that is not accessible to the Gazex system. The current manager of the program has a background of 10 seasons with the Whitewater's snow safety department.

Avalanche observations at Kootenay Pass are recorded in a similar manner to Whitewater's process. Avalanches are recorded on paper control forms that include a picture of terrain on which to draw the avalanche slide paths and a data column to record basic information such as size, depth, how far the slide ran, the snow layer it failed on, etc. The Ministry has a central database that all avalanche information is recorded in. Their program is called SAAWS: snow avalanche and weather systems. The program contains all historic information on avalanche control operations since the highway was opened in 1962. Examples of stored information include road closures, the length of time the road was closed, the hazard levels that the pass was at during the closure, all the avalanche observations, and automated weather reports. SAAWS was described as being similar to the InfoEx as it is a platform to store and retrieve data, run reports, run graphs, and look at long-term trends. The reports generated from SAAWS are used by the avalanche control team at Kootenay Pass for year-end reporting, resource tracking and information sharing procedures.

When asked where the Kootenay Pass avalanche team would like to see the avalanche recording practices go in the future, the head avalanche technician described an ideal situation as having an iPad or tablet available in the field for the technicians to use their fingers to draw in the deposit on the screen and have that visual image saved in a database. This system would allow for the correct dimensions to be recorded on an image, in order for the length and width measurements to be obtained by the dragging of a finger from the start of a slide to the bottom of the slide path on the screen. This system would be most affective if the program was capable of auto populating all this information from the tablet-based image into a database. Right now, the Kootenay Pass avalanche team has to write all observation in the field in note form and return to the office to input observations into a computer. The ideal program would save work.

The Kootenay Pass avalanche control team uses the InfoEx program as part of their daily procedures. The team has customized the workflow tool to provide an outline for their AM and PM meetings. The workflow was described as a series of prompts for the team such as:

- What is the weather forecast?
- What is your hazard level?
- What avalanche activity are you expecting to see?
- What are the staffing requirements?

Kootenay Pass is unique for avalanche control work purposes in that it is open 24 hours a day. The chronic nature of the avalanche risk to the public and staff require the operation to monitor staffing needs closely. The workflow form has a section for nearest neighbours. The prompts within this section ask, what are the nearest neighbours seeing? The control team looks at snow layer sensitivity, avalanche size and snow failure plane observations made by neighbouring users. The head of the program described access to this type of information as being of value for avalanche forecasting purposes. A limitation that the program head commented on was that weather observations provided by nearest neighbours on the InfoEx are not always useful. These observations are variable from one place to another and Kootenay Pass' control team relies on their own remote weather stations.

The introduction of the new InfoEx program was widely accepted at Kootenay Pass. All avalanche control team members received the CAA's program training. Due to the daily use of the program, avalanche technicians learnt the program quickly. Any technical problems that appeared during the introduction of the new program were fixed quickly when Kootenay Pass team members relayed their problems to the CAA.

5.3 SUMMARY OF FUTURE STATE ANALYSIS

The review of smart practices in the avalanche control and recording industry revealed four major themes throughout the literature. The first theme encourages accurate and precise recording of snow, weather and avalanche data. The second theme identified was to have access to historic data for referencing and analytical purposes. Thirdly, avalanche personnel must have technical training. The final theme for smart practices of avalanche control and recording procedures emphasized professional's understanding of local terrain. The WSSD's current state has prioritized these four themes, but recognized gaps in three practices; therefore, an ideal future state for the department would ensure these practices were maintained and outstanding issues addressed.

From the interviews conducted, similarities have emerged in regards to how snow safety departments record their avalanche data. The avalanche control sheet or occurrence form in paper format with an image for drawing results, and a table for recording information is widely practiced. The ability to free hand the information is a beneficial tool that electronically has yet to be replicated. The Google Earth program is beginning to offer certain electronic options usable to some snow safety departments but it would appear until such time that electronic technology and resources improve, the paper control forms will remain in use.

Two of the managers commented on their concerns about uploading data into the InfoEx program that would be unusable to other users. Though the InfoEx has been established as an information exchange program, users are still aware of applying a critical lens on what information is worth sharing.

The decision-making tools in use for snow safety departments are predominantly in-house tools that have been customized to the individual departments. Local terrain knowledge and history are key factors that are important to each of the snow safety departments. Though there is variance across the snow safety departments, each department is essentially recording avalanche control work in a generally similar manner.

Returning to the conceptual framework established in Chapter 2, the findings on the future state analysis are used to populate the "future state" box in Figure 1. The conclusions drawn from the smart practices review encourage the WSSD to continue to: build their historic data archive, monitor and record snow, weather and avalanche observations; and staff the department with trained technicians with a strong knowledge of local terrain. These points are represented by the bullet encouraging the department to maintain smart practices.

Based on the interview findings, Whitewater's strong relationships with other CAA members using the InfoEx should be maintained. This relationship can be upheld by the WSSD not congesting the database with unnecessary information. Figure 4 represents the revised conceptual framework on the future state.

FIGURE 4 REVISED CONCEPTUAL FRAMEWORK ON DESIRED FUTURE STATE

Desired Future State

- Have 25-years of historic avalanche record for analytical purposes
- Renewed emphasis on the smart practices of:
  - Ensuring personnel have local terrain knowledge while preventing apathetic documentation practices
  - Documenting thorough weather, snow and avalanche data
- Maintain the smart practices of hiring professionally trained personnel,
- Maintain strong relationships with CAA members

6.0 DISCUSSION AND ANALYSIS OF NEEDS

In the 2012/13 season the CAA updated its information exchange (InfoEx) platform. The new version of the program has more avalanche forecasting and operational hazard assessment capabilities. The program saw the addition of a historic database. CAA members can upload historic avalanche records into the InfoEx for information storage and reporting practices. As professional members of the CAA, ski resorts are encouraged to upload information on avalanche occurrences and weather observations into the InfoEx database.

The introduction of the new InfoEx database provoked the question: is Whitewater's snow safety department recording avalanche control work in an effective manner? A further question raised by the introduction of the revised program is: how should the snow safety department integrate their avalanche control and reporting methods with the CAA InfoEx methods to ensure that smart practices in the industry are being met? To answer these questions a needs assessment was conducted to clearly define the current state of Whitewater's avalanche control and reporting procedures and the desired future state of the department.

A literature review was conducted to establish an effective format to implement strategic change in the WSSD workplace. The literature identified five components recommended for the successful implementation of strategic change: context, content, process, outcomes and performance measures. This format can be applied to address the needs of the WSSD to transition from its current state to a desired future state. An effective strategic action plan can also be used to integrate the InfoEx system with the WSSD's current avalanche control and reporting methods.

This chapter discusses the needs of the WSSD to transition the department from its current state to a desired future state. Historic data analysis has also been used to identify the benefits of an electronic database for avalanche recording purposes. The findings from the current state analysis section of this report will be used to identify strengths and weaknesses in the department; thus, providing a context for recommended strategic change. The findings from the smart practice review and interviews were used to determine the future state of the WSSD. The identified smart practices for avalanche control work ensure any change to the current system continues to reflect smart practices in the industry.

6.1 IDENTIFYING THE BENEFITS OF AN ELECTRONIC DATABASE

The WSSD's current state does not include access to the electronic database of historic avalanche information. The needs assessment conducted for this project converted the WSSD's historic avalanche information into an electronic format. Once formatted, the historic data was analyzed to construct a clear image of the WSSD's current state. The tools available to filter and analyze the data can be used for forecasting purposes and testing the accuracy of forecasters' work. Professional avalanche technicians provided variables to analyze avalanche data as listed in appendix 2.

6.2.1 AVALANCHE FORECASTING THROUGH DATA ANALYSIS

Before commencing work on an avalanche control route, a control team can generate reports from the database for routes that were managed under similar weather and snowfall conditions in the past. By referencing the historic reports, the control team is able to maintain a high level of preparedness.

Size 1 to 1.5 avalanches are the two most frequently recorded avalanches for control work. The snow safety department is interested in identifying where larger (size 2+) avalanche results are most likely to occur. Only avalanches greater than or equal to size 2 on the Canadian scale have been included in this portion of the analysis. The frequency of large-scale avalanches in specific slide paths indicates the areas where special attention is required by snow safety staff.

This style of forecasting analysis can be conducted by applying a filter to the dataset column indicating the amount of new snow that accumulated in the past 24 hours. The information is grouped into five categories: 0 cm, 1-9 cm, 10-19cm, 20+cm, or blank. Pie charts are used to represent the frequency of size 2+ in each slide path on the snowfall parameters listed above. Based on the results the Catch Basin, C zone C2, C3b, C4b and C5 were the slide paths that produced the most avalanches (see Figure 5). Similarly, for the Upper Powder Keg B zone, slide paths B5a, B6b, and B9a were the highest avalanche producers (see Figure 6). It should be noted that there were 166 avalanche results, which could not be used in the forecasting information as the snow accumulation category on the reporting form, was left blank.

FIGURE 5.FREQUENCY OF LARGE-SCALE, CONTROLLED AVALANCHES IN CATCH BASIN WITH LESS THAN 10CM OF SNOW IN THE PAST 24 HOURS

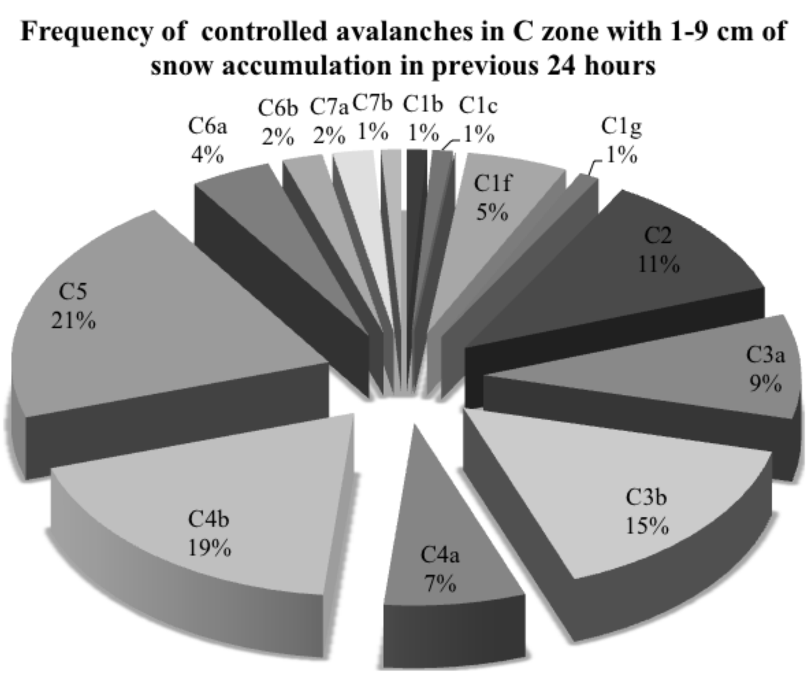
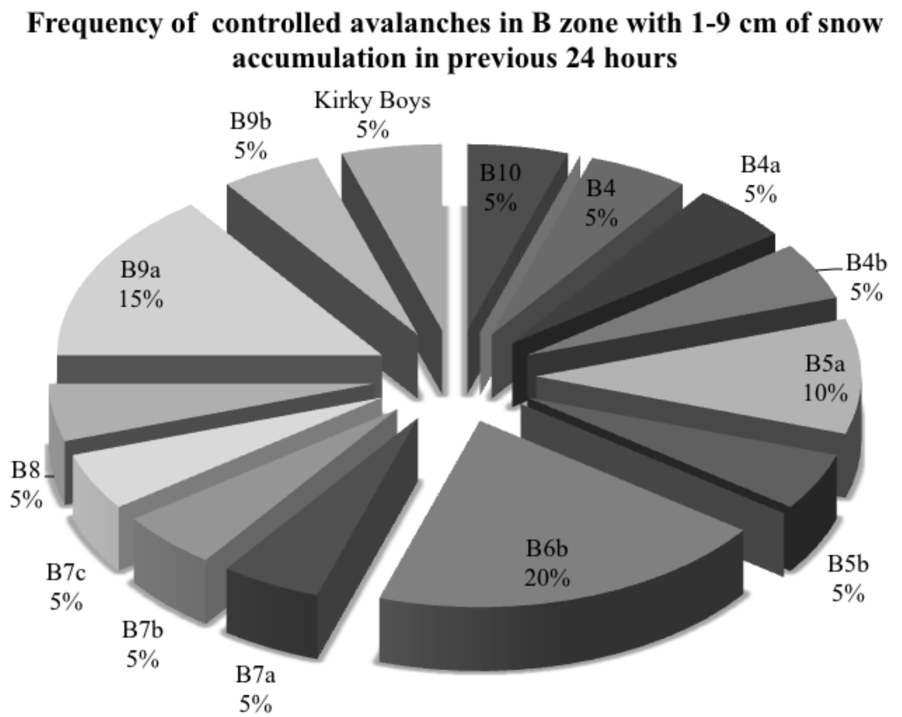


FIGURE 6. FREQUENCY OF LARGE-SCALE, CONTROLLED AVALANCHES IN UPPER POWDER KEG WITH LESS THAN 10CM OF SNOW IN THE PAST 24 HOURS



6.1.2 Testing Forecaster Accuracy Using Data Analysis

The snow safety department's objectives for avalanche control work are to mitigate avalanche hazard and prevent the occurrence of natural avalanches. The results of control work should remain effective until snow and or weather conditions change at which point danger must be reassessed. Occurrences of uncontrolled avalanches following control route work can be used to measure the WSSD's accuracy and effectiveness in forecasting and managing avalanche hazards. Avalanches occurring shortly after control route work should raise questions as to whether circumstances were overlooked or ignored.

An electronic database can be used to analyze scenarios when natural avalanches occur following recent control route work. For the purposes of this report, a two-day period was selected as the definition of recent. A filter is applied to the data to limit analysis to the periods in which there is less than 10cm of new snow in the previous 24 hours. For the WSSD, there were avalanche incidents on three separate days that matched these parameters during the 15 year period in which data was collected. Table 9 presents a breakdown of the occurrences of natural avalanches following control route work.

TABLE 9. OCCURRENCE OF NATURAL AVALANCHES WITHIN TWO DAYS OF CONTROL ROUTE WITH LESS THAN 10CM OF SNOW IN THE PREVIOUS 24 HOURS.

Date of Natural Slide	06-03-08			13-01-25		13-03-02
Location	C3b	C5	C7a	C5	C6a	C5
Size	1	1	1	1	1	1
Date of Last Control Route	06-03-06	06-03-06	06-03-06	13-01-24	13-01-24	13-03-02
Trigger Type	Xe	Xe	N/A	N/A	Sc	N/A
Size	2	1	N/A	N/A	1	N/A
# of days between Na and Control Route	2	2	2	1	1	
Snow accumulation	8	8	8			

6.2 A REVIEW OF THE CURRENT STATE

The input of 15 seasons of historical data into the InfoEx database has provided an opportunity to review the avalanche control and recording techniques of the WSSD. By identifying strengths and weaknesses to Whitewater's existing avalanche control policies and practices a clear image of the current state and department's needs has emerged.

6.2.1 The Strengths of Avalanche Control Work

The three avalanche incidents in Table 9 are important occurrences to analyze as guests and employees were both potentially exposed to risk. It is difficult to apply critical analysis of the identified incidents as several years have passed since the latest occurrence. The effectiveness of such analysis relies on the WSSD discussing and reviewing the decisions they arrived at during the control route work. In order to ensure proper risk analysis and hazard mitigation practices, the snow safety department should consider adopting a process of routinely generating this type of report following the occurrence of an uncontrolled avalanche to monitor whether the most recent control route work was conducted productively.

Effective avalanche risk mitigation should also prevent the occurrence of large-scale (+2.5) slides if there has not been new heavy snowfall. There has only been one large-scale avalanche occurrence with less than 10 cm of new snow in the past 15 seasons at Whitewater. The naturally triggered slide propagated across two slide paths, C6a and C6b, with 9cm of new snow in the previous 24 hours. This information can be used to recognize dangerous slide path locations.

The rarity of the occurrences of natural avalanches following control work and large-scale avalanches with less than 10cm of new snow is an indication that Whitewater's snow safety department is conducting avalanche hazard mitigation effectively. Ideally, there will not be an increase in these incidents moving forward. If the WSSD generates similar reports with an increase in outcomes following the adoption of a strategic action plan, that could be an example of a negative and unintentional outcomes (Kuipers et al. 2014, p. 12). Nonetheless, a continual monitoring of these two variables is important for avalanche risk mitigation measures.

6.2.2 The Weaknesses of Avalanche Recording Procedures

The avalanche observation data analysis is limited by the way in which it was recorded. Entering the 15 seasons of avalanche observations electronically, highlighted the importance of regulating the observation process. As discussed in the risk analysis portion of Section 4, the snow safety department occasionally did not record the times of natural avalanche occurrences or indicate if the slides took place overnight. This inconsistency prevented a thorough analysis of 42 natural avalanche occurrences as seen in Table 4. Similarly, in the forecasting portion of this section, there were 166 noted avalanche occurrences in which the weather variables were left blank on the reporting form and were therefore unable to be used to compile the figures 5 and 6 pie charts.

The analysis of natural avalanches during operational hours is difficult due to the lack of terrain closure documentation and properly completed forms. There were a total of 81 avalanche occurrences that could not be cross-referenced with zone closure information. The purpose of cross-referencing terrain closure documents with natural avalanche occurrences is to determine whether the snow safety department actively prevented the public from entering potential avalanche terrain. Due to poor record storage, the WSSD has lost nine seasons of terrain closure documents. It is known that 73 natural avalanches occurred during operational-hours within those nine seasons that cannot be cross-referenced. Of the remaining seven seasons of historical data, there were eight natural avalanches that could not be cross-referenced due to careless and/or illegible recording. Due to these inconsistencies, an analysis of whether or not the public was placed at heightened risk was impossible.

The WSSD's arbitrary reporting process added further limitations to the data analysis. The recorder's subjective interpretation of events lacked parameters to promote consistency across multiple recorders. There were 31 distinct avalanche paths from which observations were recorded in C Zone; however, according to Whitewater's ASP there are only 19 recognized avalanche paths in Zone C. Similarly, according to the historic data, 38 paths were allocated in the B zone, yet the ASP only recognizes 11 distinct avalanche paths in Zone B. The limitations within the paper reporting method are predominantly human factors.

6.2.3 Resource Availability

The information presented in terms of resource availability within the department compares the number of hours dedicated to avalanche control work, first aid, mountain rescues, and other snow safety daily duties. The figures provided of the average occupied hours for snow safety activities in Table 3 of Section 4 would indicate a lack of time left in the nine-hour day for training and engagement related activities.

The resource availability data for the past four seasons indicates the majority of the nine-hour day was already occupied by daily duty tasks. In two of the years, these duties actually slightly exceeded the nine-hour workday and in another year, fell just short of nine hours. Ramifications of this dynamic may be that patrollers do not take lunch breaks or may bill for overtime. This is an area of concern in terms of implementing strategic change as working at this high level on a chronic basis may contribute to lower morale, as staff may feel pressured to complete work within their required workday.

As Bryson and Bromiley discussed in the literature, the lack of availability of resources can be a contributing agent to resistance of change within an organization (1993, pp. 321, 331-332). The analysis of the average daily duties breakdown can be used to determine whether resistance to change could be expected within the WSSD. The limited amount of left over daily time could be an area of concern moving forward. Efforts to improve avalanche-recording methods could face resistance among snow safety department staff should there be an increased time demand not factored into the daily duty breakdown. Such a dynamic will require a restructuring of current procedures rather than simply adding additional recording expectations lest this could sabotage the organization's potential to achieve their ideal future state.

6.3 DEVELOPING A CLEAR IMAGE OF THE FUTURE STATE

There is an expectation from the CAA that the WSSD will upload relevant avalanche information onto their server; however, the decision of how much the program will be combined with existing avalanche recording procedures should be explored. Analyzing the strengths and weaknesses of electronic data storage can shape the desired future state of the WSSD's avalanche control and reporting procedures. The key benefits of electronic data storage supports the adoption of an electronic storage system; however, the obstacles identified regarding the InfoEx program specifically, raise the question as to whether this is the correct platform for addressing all of Whitewater's needs.

6.3.1 The Strengths of Using an Electronic Database

The Whitewater Ski Resort is a long running operation. Historic information storage is an important aspect of avalanche hazard and mitigation procedures; however, due to limited space and resources the physical storage of 40 years of information has proven difficult. As seen with the avalanche terrain closure forms, certain documents have not been saved. Uploading this data onto an electronic server provides an information backup and archival tool.

Access to statistics inputted in the new InfoEx system is a timesaving resource. The snow safety department is able to generate valuable statistics for the year-end report presented to management and the resort owners by using the new InfoEx database. The avalanche figures relevant to the report include the number of control routes performed throughout the season, the number of explosives used and any incident that may be classified as a major historical avalanche event.

An electronic database can be used to identify useful information for avalanche hazard mitigation. The WSSD can analyze risk and strengthen their avalanche defense planning using information accessed by improved electronic record keeping. Identifying major historical events and points of interest based on avalanche occurrences increases the local terrain knowledge of the snow safety department staff. An agreed upon smart practice in the industry is for avalanche technicians to possess sound knowledge of local terrain (Schaerer, 1970, p.400; and Ueland, 1996, p. 218).

6.3.2 The Weaknesses of Using the InfoEx as an Electronic Database

Though there are benefits to storing and accessing historical avalanche observations electronically, the InfoEx database may not be the ideal platform for data storage. The dropdown option style of data input in the InfoEx database prevents the documentation of incidents that are classified as anomalies. When the avalanche control procedures do not trigger avalanches, the attempt is still documented on control sheets for hazard mitigation and resource tracking purposes. The incidents in appendix 6 were unable to be uploaded into the InfoEx database, as "*no result"* is not an available option to record. For resource reporting purposes, there were 29 explosive charges not accounted for within the InfoEx data recording even though those resources were used. Though this information may not be crucial for the external avalanche community, Whitewater's internal snow safety records would benefit from recognizing these events. The results also illustrate due diligence is being practiced at the resort. Non-avalanche results can indicate when slide paths have snow that settles differently and which paths may be more challenging to produce results from. A more responsive electronic database for Whitewater's snow safety department would consider such internal requirements and be able to track non-results.

The consultation with two supervisors of snow safety departments revealed an argument against uploading individual avalanche observations into the InfoEx database. Their reasoning was that uploading single avalanche occurrences would create congestion within the system. The initial purpose of the InfoEx program was to offer an information exchange platform for users in the avalanche control industry. Users rely on the information uploaded to the InfoEx for their own avalanche forecasting and control purposes. Two of the managers interviewed remarked that there is a risk the effectiveness of the program is being lost due to the uploading of excessive data. All contacted departments relied on in-house recording systems for avalanche reporting and did not see the new InfoEx system as a replacement to their current programs. Rather than uploading individual avalanche observations, summary reports were perceived as being sufficient.

6.4 SUMMARY AND IDENTIFYING THE NEEDS

An analysis of the strengths and weaknesses of the WSSD's existing avalanche control practices along with the benefits and obstacles of electronic data storage practices can direct the department's needs moving forward. The analysis of the current state of the WSSD indicates natural and large-scale avalanches are being mitigated effectively. The current policies in place at Whitewater for the observing and recording of snowpack, weather and avalanche information, the hiring of trained personnel and the requirement of strong local terrain knowledge have all been recognized as smart practices within the snow safety industry. The strengths identified within the current avalanche control practices by the WSSD should not be hindered by the introduction of a strategic action plan.

An effective strategic action plan will address the weaknesses identified in the existing avalanche recording procedures. These weaknesses can be summarized as reflecting inconsistent data recording practices in terms of form completion and arbitrary avalanche path assignments. The ability to cross reference the occurrence of natural avalanches with terrain closure information should be readily available.

The use of an electronic database to forecast and measure the accuracy of the WSSD promotes accountability and reduces liability. An electronic database is capable of providing more than a clear image of the current state of affairs – it can also be used as a decision-making support tool for forecasting purposes.

The introduction of electronic data storage should also be considered to preserve the historic record and support fast reporting and analysis opportunities. The ability to reference 25 years of historic avalanche data has been recognized as a smart practice in the avalanche industry. The use of an electronic database to store this information has been identified as the best method to conserve space and resources. The client's options to consider, should weigh whether the InfoEx database is the best-suited instrument for the task. An effective strategic action plan option will support a strong relationship with other CAA members. A strategic action plan should ensure the CAA receives the required observations from Whitewater for the InfoEx database.

6.5 CONCEPTUAL FRAMEWORK REVISITED

The revisions to the conceptual framework's current situation and desired future state can now be combined with the existing framework introduced in Section 2. A central concept within the framework is the emphasis on developing and adopting a strategic action plan to achieve the desired goal of having a consistent avalanche recording procedure. The revised framework has integrated the strengths and weaknesses identified in the discussion section. The options laid out in Section 7 will address the strategic implementation topics of context, content, process, outcomes, and the challenges and tools required.

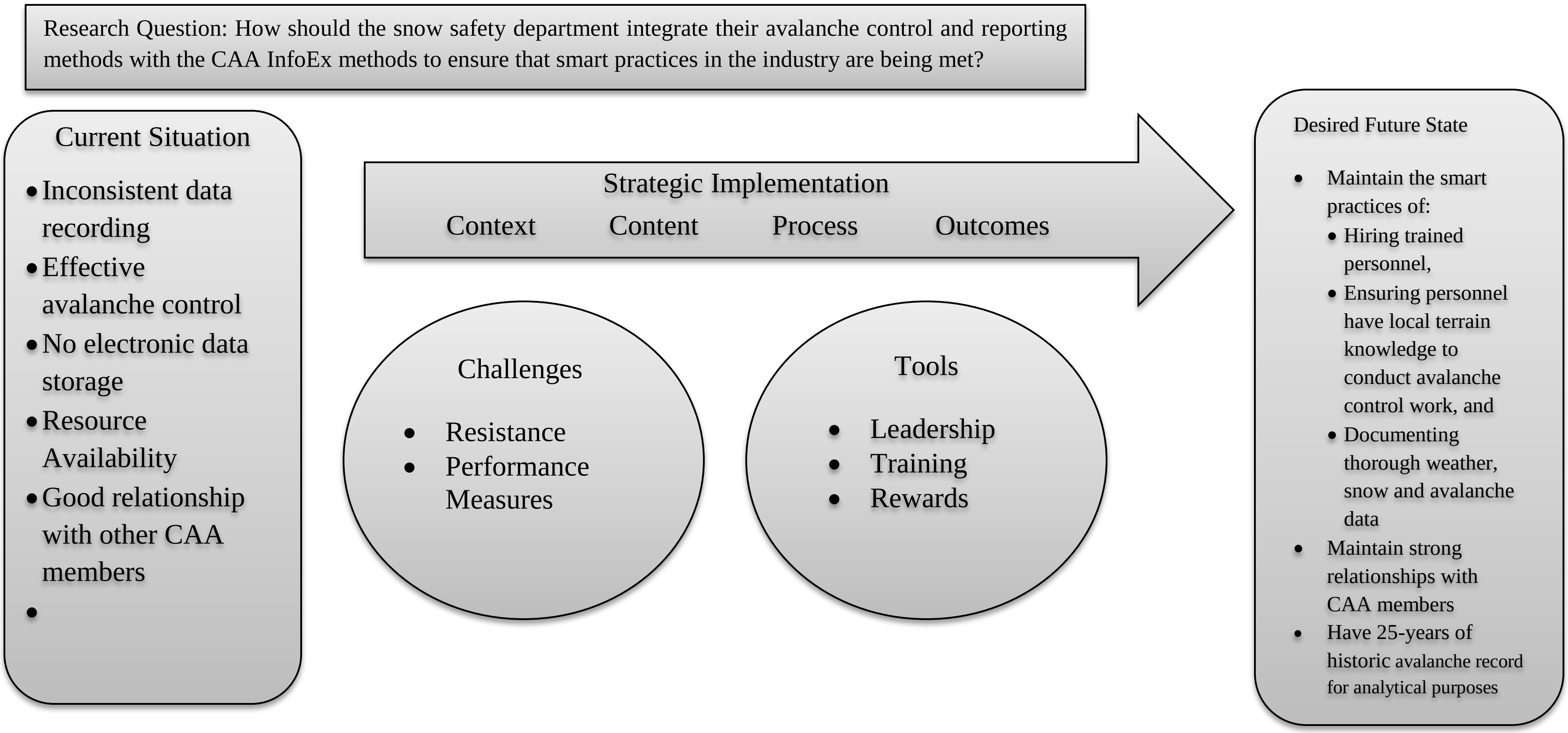


FIGURE 7. REVISED CONCEPTUAL FRAMEWORK ILLUSTRATING HOW TO IMPLEMENT STRATEGIC CHANGE TO REACH PROJECT GOALS

7.0 OPTIONS TO CONSIDER & RECOMMENDATIONS

This section examines strategic options for the WSSD to consider to transition to the desired future state. The options are presented and conceptualized within the WSSD context. Next the options are measured and weighed against defined criteria. Based on the scoring of each option a recommendation is presented.

7.1 OPTIONS

This section outlines three options available for the WSSD to integrate their avalanche control and reporting methods with the CAA InfoEx methods to ensure that smart practices in the industry are being met. The options are based on the strengths and weaknesses identified in the WSSD's current avalanche procedures. The benefits and obstacles of using an electronic database and the opinions of the research participants are considered within the presented options. The first option presented examines the client's option to maintain status quo. The next two options involve the development and adoption of strategic action plans based on differing conceptual perspectives of the InfoEx program.

The following three assumptions underlie the presented options:

1. The current method of uploading avalanche summaries into the InfoEx database has contributed to a good relationship with other CAA members;
2. If the WSSD were to upload all avalanche observations into the InfoEx database the good relationship may be jeopardized due to the expressed opinion during consultation that too much noise in the program could lead to efficiency loss; and
3. The use of paper control forms to initially document avalanche observations should not be stopped since three-quarters of consultation participants acknowledged the beneficial nature of the forms.

The options will be weighed using the new policy management values outlined by Kuipers et al. (2014, p. 13) efficiency, effectiveness, client value and frugality. The criteria will be defined and conceptualized in Section 8.2 of this chapter.

7.1.1 OPTION 1: STATUS QUO

The historic data analysis findings determined effective avalanche control procedures are in place at Whitewater. The selection of the status quo option would ensure these practices are maintained. The consultation process indicated that the use of paper control sheets to document avalanche observations is a widely adopted practice. WSSD's current documentation practices are generally effective for day-to-day practices.

The status quo option would align with the notion presented by the avalanche safety director at Fernie Alpine Resort that further recording methods may not be required for the operation. A benefit to the status quo option would be the maintenance of good relationships with other CAA members. Risks related to maintaining status quo involve losing the potential benefits of electronic data storage. The current weaknesses identified with the inconsistencies of control forms would not be addressed and could continue to be practiced. The resource allocation would likely continue to reflect the Table 2 Section 4 figures of being under 9 hour days as no new requirements would be introduced.

The short-term implications of this option would be limited and likely not felt. If no further data storage methods are adopted, the WSSD is exposed to a high risk of valuable information being lost in the long-term. In ten years time, once 25 years of historic avalanche data has been recorded, it will be difficult to analyze the avalanche cycle with data recorded in the current format. The data would have to be processed before analysis could occur. This would likely be a time and resource consuming processes.

There would be no implementation strategy required for this option.

7.1.2 Option 2: the InfoEx as a Decision Support Tool

Option two involves the adoption and development of a strategic action plan to introduce the InfoEx program as a decision making tool to the WSSD. The key features of option two are to upload avalanche observations onto the InfoEx server as a data storage method; and introduce training, leadership and performance measures to address the inconsistent recording practices.

In terms of the development of a strategic action plan, the context of the action plan would focus on the use of the InfoEx program as a decision support tool. The content of the action plan would be to address the weaknesses in the WSSD's data recording practices and the electronic storage of data.

After key decision makers choose to adopt a strategic action plan, the process required to address the content specific factors rely heavily on leadership and training procedures by senior snow safety staff members. The process of adopting recording methods to address current inconsistencies will require strong leadership skills. Shareef (1994, p.495) emphasizes leadership skills through the use of two way information sharing. The senior snow safety staff members can provide evidence of the poor documentation practices using the historical reports and statistical figures. The expansion of training procedures for recording avalanche observations should promote accountability and ensure consistent data reporting.

The electronic data storage through the InfoEx database will require an adjustment in the existing routine. Instead of submitting avalanche summaries to the InfoEx following a control route work, the department will be required to submit avalanche observations. This will be a more time consuming practice.

Performance measures can be applied to the training and leadership practices required to implement this option. According to the literature, when used effectively, the use of performance measures will increase accountability, communication and efficiency (Chackerian & Mavima, 2001, pp. 369-370; de Lancer Julnes & Holzer, 2001, p. 694; and Poister & Streib, 1999, p. 318). The ability to quantify the completion of accurate recorded documents can serve as a performance measure for the training and leadership skills applied to this content matter. An increase in inadequate documentation of avalanche occurrences would indicate implementation failure and negative results to the strategic action plan.

As mentioned in Bryson & Bromiley (1993, p. 334), and Bryson & Roering (1987, p. 11), if executed correctly, the content of change should describe what success would look like for the organization. The outcome of addressing inconsistent recording procedures will be measured using a quantitative analysis at the end of each season to determine how many avalanche occurrence documents are missing variables. The electronic storage of avalanche occurrences can be measured based on reports produced from the InfoEx database.

The costs and risks associated with option two include resource availability and external stakeholder relationships. A concern about the InfoEx program mentioned by the avalanche safety director at Fernie Alpine Resort was that it bound avalanche technicians to the computer. The availability of snow safety resources for the 2012/13 season at Whitewater only indicated 33 minutes of the nine-hour day not accounted for with daily responsibilities (Table 2, Section 4). The process of uploading avalanche observations into the InfoEx will likely require this remaining time. Avalanche occurrences must be uploaded by the end of the day to be submitted with the other field observations for the InfoEx.

Since option two relies on the existing computer program, there should be no monetary costs associated with this option. Uploading avalanche observations into the InfoEx may jeopardize the WSSD's relationship with other CAA members. The consultation research indicated half the snow safety managers contacted were concerned that increased information on the platform may affect the usability of the program.

7.1.3 Option 3: the InfoEx as an Information Sharing Tool

Option three involves using the InfoEx as an information-sharing tool. This option involves the adoption and development of a strategic action plan to increase the level of consistency in avalanche observation documentation and requires the creation of an in-house electronic method of storing information. The key features of option three are to continue to upload avalanche summaries onto the InfoEx server; introduce training, leadership and performance measures to address the inconsistent recording practices; and create an in-house electronic backup/storage system for avalanche observations.

The context of the strategic action plan proposed for option three is set by the consultation research that revealed an external pressure from other InfoEx users for the WSSD to only upload usable data into the system and not provide too much material risking the loss of key information. The WSSD's relationship with other CAA members is important in order to ensure that industry related information continues to be shared. These relationships could be viewed as external stakeholder's positions as well as external threats or obstacles as mentioned by Fernandez and Rainey (2006, p. 171).

With support from management, the content of the strategic action plan should include the development of an alternative electronic database to address external concerns raised in the interview portion of this report. Similar to option two, the content of option three's strategic action plan will also address the recording inconsistencies of avalanche observations.

The process for implementing the strategy will include the development of a training plan with senior staff for accurate documentation of avalanche observations on the paper control forms as well as in the new database. Once trained, senior staff will be expected to mentor and train junior snow safety department staff on the correct procedures. The strategic action plan will be most successful if the senior staff and decision makers take on a leadership role during this process.

The outcome of option three's strategic action plan will be an increase in consistent documentation of avalanche observations, the ability to store and analyze avalanche observations electronically and the maintenance of positive relationships with other CAA members on the InfoEx. The use of performance measures similar to the ones discussed in option two will indicate whether the strategic action plan has been a success. These checks can be scheduled throughout the season to ensure practices are being maintained.

One of the costs and risks associated with option three is resource availability. The creation and adoption of a new electronic database will require the WSSD to perform data entry in addition to its existing practices. The concern expressed by the avalanche safety director at Fernie Alpine Resort about avalanche technicians being bound to the computer would still apply to option three's strategic action plan. The available 33 minutes of the WSSD staff's nine-hour day identified as remaining based on the 2012/13 season indicates there is time available for this double data entry that will be required, however this window of opportunity is rather tight (Table 3, Section 4).

The benefits of option three include preserving a strong relationship with the other CAA InfoEx users; ensuring Whitewater's avalanche records are electronically backed-up; the ability to electronically analyze the records; and increasing the consistency of the recording process. Since avalanche occurrences would not be uploaded into the InfoEx database, the strict time requirement of uploading data by day's end is removed. Option three offers the WSSD a more flexible option for electronic uploading on busier days.

7.2 CRITERIA

The criteria used to weigh the three options are efficiency, effectiveness, client value and frugality. The criteria will be defined then compared against the current state of the WSSD's avalanche control and recording practices. A comparison of options based on the criteria is presented in table form (Table 10) and weighed to establish which option would be most ideal.

Efficiency – Refers to the ratio of strategic action plan outcomes to inputs (Boyne, 2000, p. 368). For these criteria, inputs will be classified as WSSD's time.

The WSSD's current reporting system on avalanche observations is inefficient due to the level of outputs being produced. Prior to accessing any usable historic reports, the data would have to be processed and inputted into a database. The inconsistent data recording practices mean the WSSD would also be required to go back and attempt to cross-reference the control sheets with other historic data in attempt to find missing variables if that is even possible.

Effectiveness – Refers to the quality of the strategic action plan outcomes: consistencies in avalanche recording methods, electronic storage of avalanche observations, and the ability to generate historic avalanche reports.

The number of avalanche occurrences that could not be analyzed due to missing information implies that the data recording practices currently in place at Whitewater are not effective. The incomplete nature of avalanche control forms and inability to generate historic avalanche reports using Whitewater's current avalanche recording and reporting practices implies the system is ineffective.

Client Value – It is the client's goal to reduce the level of subjectivity between different snow safety department shifts by implementing changes based on analysis of the historic avalanche records and the implementation of accepted industry smart practices.

The current state of WSSD's avalanche recording and reporting practices are inconsistent with the client's goals. The historic data analysis revealed inconsistencies based on incomplete forms and subjective analysis of avalanche observations across multiple recorders.

Frugality – Refers to the monetary cost of adopting the option.

The WSSD is on a restricted budget and are unlikely to out-source work for the creation or development of any new program. All projects must be completed in-house with existing resources.

The three options will be measured against the above criteria on zero to three scales. Table 10 illustrates the rating scale is applied as follows:

TABLE 10. THE RATING SCALE APPLIED TO THE OPTIONS AGAINST THE CRITERIA

Score	Description
0	Did not meet criteria
1	Partially met criteria
2	Somewhat met criteria
3	Met criteria

The criteria have also been ranked by level of importance based on likelihood of adoption. Table 11 illustrates the ranking of criteria:

TABLE 11. THE RANKING OF CRITERIA IMPORTANCE

Rank	Criteria
1	Efficiency (Score multiplied by 4)
2	Frugality (Score multiplied by 3)
3	Effectiveness (Score multiplied by 2)
4	Client Value (Score multiplied by 1)

Based on the options and criteria presented, Table 12 presents the options using the above scoring system. The criteria are presented in the columns by order of most to least important. The numerical score given to the option based on meeting the criteria is presented at the bottom of each cell using the system explained in Table 10. The option's rating is then applied to the multiplier assigned in Table 11. The four criteria scores are then added together to determine the option's overall score. The overall score is out of a possible 30 points. The overall score is presented in the final column of the table.

7.3 RECOMMENDATION

Based on the ranking and scoring of the criteria, the third option, to adopt the InfoEx as an information-sharing tool received the highest score. Option two also scored relatively high as well. Since uncertainty was not represented in the scoring system both options are likely to be strong options for the WSSD.

The WSSD's external reputation and relationships with other InfoEx users are valuable aspects of a strategic action plan; therefore, option three remains the more accurate option for the department. Due to the WSSD's limited resource capacity, the flexible timeframe that option three offers by only inputting avalanche summaries into the InfoEx made it a valuable option. This option also ensures the WSSD maintains positive relationships with CAA members, a feature option two lacked.

The implementation of option three centres on the development of a strategic training plan for senior snow safety staff and an in-house electronic database to store avalanche observations. The training plan would focus on ensuring accurate and consistent data recording methods are being maintained.

TABLE 12 THE WEIGHING AND SCORING OF THE WSSD'S THREE OPTIONS TO ADDRESS ITS NEEDS FOR EFFECTIVE AVALANCHE CONTROL AND REPORTING PROCEDURES USING KUIPERS ET AL.'S CRITERIA

Option	1 Efficiency	2 Frugality	3 Effectiveness	4 Client Value	Overall Score
Status Quo Option	- Inconsistent data entry - Lack of electronic data storage - Inability to run reports Efficiency Score: 0 x 4 = 0	- $0.00 Frugality Score: 3 x 3 = 9	- Ensures positive relationships are maintained with CAA members - Current amount of time spent on computer Effectiveness Score: 1 x 2 = 2	- Arbitrary reporting - Subjective Client Value Score: 0 x 1 = 0	11
InfoEx as a Decision Support Tool	- Time consuming avalanche occurrence data entry by days end - Increased consistency for recording practices - Electronic data storage - Ability to run reports Efficiency Score: 2 x 4 = 8	- $0.00 Frugality Score: 3 x 3 = 9	- Potential to damage relationships with CAA members -More computer bound to meet daily InfoEx submission deadline Effectiveness Score: 2 x 2 = 4	- Consistency - Smart practice of info sharing Client Value Score: 2 x 1 = 2	23
InfoEx as an Information Sharing Tool	- Flexible time frame for electronic avalanche occurrence data entry - Increased consistency for recording practices - Electronic data storage - Ability to run reports Efficiency Score: 3 x 4 = 12	- $0.00 - Outsourcing the development of a higher level of database would be costly Frugality Score: 2 x 3 = 6	- Ensures positive relationships are maintained with CAA members - Current amount of time spent on computer Effectiveness Score: 3 x 2 = 6	- Consistency - Smart practice of info sharing but only summaries Client Value Score: 2 x 1 = 2	26

8.0 CONCLUSION

The purpose of this project has been to address the responsibilities of the Whitewater snow safety department to comply with the avalanche occurrence and observation reporting requirements established by the CAA through its Information Exchange program. Careful attention has been paid to ensure the internal avalanche control and reporting procedures will be maintained and developed to the highest level of safety standards. While determining the best way to integrate the new InfoEx program into existing practices at Whitewater, a needs assessment identified existing weaknesses in the department's control and reporting practices. The findings are based on a current state and future state analysis conducted using the department's historic avalanche data, smart practice review and consultation with other snow safety department managers. The findings of this research should provide the WSSD with a usable strategic action plan to address the outstanding issues identified in the needs assessment.

Further research on available funding options for snow safety operations would be of significant benefit as the WSSD is limited in its financial resource capacity. The development of a multifaceted electronic database reporting and storage system would encourage the use of more analytical tools to aid in snow science research and avalanche awareness capabilities. The time required by snow safety staff members for electronic avalanche data entry and reporting will diminish as technology advances the methods available to record such observations. Until funding for innovation is provided, the WSSD will be limited in its avalanche reporting capacity.

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Appendix 1 Interview Questions

Background

1. Can you briefly describe to me what your duties and responsibilities are in your role with the resort?

2. How long have you been in this role with the organization?

Operation

3. Can you describe how your snow safety department conducts and records avalanche control?

a. If you do not conduct and/or record avalanche control work can you please explain your rationale behind this decision?

4. Are you able to/do you run historic reports using your current system?

5. Are you able to provide me with a copy of your current control work forms please?

For operations with separate patrol/avalanche work

6. Do you have an equal percentage of applicants seeking employment for avalanche control as for First Aid?

InfoEx

7. How did you and your staff find the adjustment to using the InfoEx to record avalanche work?

8. Will you use the InfoEx in lieu of your previous recording method?

9. Did you identify any gaps or additions to the data required to fill in the InfoEx compared to your previous system?

10. What are your likes and dislikes about the program?

Implementation/Conclusion

11. Is there anything you would like to see the CAA add to their database to ensure smart practices are being applied?

12. Is there anything you would like to add to a previous response or with regards to the topic that I did not ask you about?

APPENDIX 2 DATA ANALYSIS VARIABLES

- Number and location of any size 2.5 (or greater) avalanches
- Number, and location of any natural avalanche that occur within operational hours cross-referenced with zone closure information
- Number and location of size 2 (or greater) avalanches (naturally and artificially released) that occur following 24-hour new snowfall readings within the parameters of:
  - 0cm
  - 1-9cm
  - 10-19cm
  - 20+cm
- Number, location and size of natural avalanches that occur following a control route

APPENDIX 3 ANDERSON'S 15 STEPS FOR THEMATIC CONTENT ANALYSIS

The following 15 points are from Rosemarie Anderson's paper titled *Thematic Content Analysis (TCA) Descriptive Presentation of Qualitative Data* (2007).

1. Before beginning a Thematic Content Analysis (TCA), make multiple copies of interview transcript (or other extant text, including post-interview notes) as relevant and stipulated in your Methods chapter.

2. Mark with a Highlighter (real or electronic) all descriptions that are relevant to the topic of inquiry. Criteria for "relevant" descriptions should be included in your Methods chapter.

3. From the highlighted areas, mark each distinct unit of meaning. Meaning units are separated by a break or change in meaning. Err on the side of too many units. However, be sure to retain all information relevant to understanding a meaning unit within the meaning unit. Otherwise, relevant information will be disconnected from source as the TCA continues. Units may vary in text length.

4. Cut out units and put similar units together in a pile. (On a Word file, copy and paste on to another document.) Code each unit, for example. 1-16 for interview # 1, page 16 (or by text line)

5. Label each pile as initial categories (themes) using key words or phrases copied from highlighted texts. Use your own categories sparingly. Revise categories as you continue to code data.

6. If obvious information is missing from text, identify categories that are missing, for example, "no affect."

7. Go through the entire interview transcript identifying distinct units, grouping and regrouping similar and dissimilar units, and re-labeling categories as you go along. Use your own categories/themes sparingly, retaining words copied from the meaning units being described.

8. Read through all meaning units per category and redistribute units as appropriate. Re-label categories as appropriate. Collapse or subdivide categories as appropriate.

9. After a few days, reread the original interview transcript or text without looking at your units or categories.

10. Return to meaning units and categories made on the first pass, and reconsider each unit and category. Redistribute units as appropriate, considering carefully whether your units are too small or too large. Re-label as appropriate. Collapse or subdivide categories as appropriate considering carefully whether your categories are too small or too large.

11. Look over your categories as a whole. Consider whether you have too many categories (or less likely, too few) to render meaning to your highlighted texts given your topic. If so, return to # 10.

12. For each additional interview transcript (or other texts), use the Thematic Content Analysis (TCA) as above.

13. When all TCAs are complete, read each TCA separately. Then, while retaining meaning units, combine categories/themes for all interview transcripts and notes. Collapse or subdivide categories as appropriate. Re-label categories as appropriate. Err on the side of having too many categories. Err on the side of retaining labels for categories that are identical or similar to the words in the interview transcripts.

14. After a few days, reread your total categories as a whole. Consider whether you have too many (or too few) categories to make overall sense of the interview transcripts given your topic.

15. Redo all the instructions above until you are satisfied that the categories reflect the interview transcripts as a whole. Once you are satisfied, your categories are themes and you are done with the TCA for this study.

APPENDIX 4 TOTAL NUMBER OF AVALANCHES IN ZONE C AND B BY SIZE

TABLE 13 TOTAL NUMBER OF AVALANCHES IN ZONE C BY SIZE

Size	Number
0	1
1	2073
1.5	895
2	657
2.5	58
3	2
No Result	12
Total	3698

TABLE 14 TOTAL NUMBER OF AVALANCHES IN ZONE B BY SIZE

Size	Number
0	1
1	1973
1.5	554
2	234
2.5	2
No Result	15
Total	2779

APPENDIX 5 NATURAL AVALANCHE OCCURRENCES DURING HOURS OF OPERATION AND OPEN AVALANCHE TERRAIN

TABLE 15. NATURAL AVALANCHE OCCURRENCES DURING HOURS OF OPERATION AND AVALANCHE TERRAIN OPEN

Date	Time	Size	Location	Closure Information
06-03-08	1435	1.5	B5	Closed at 1530
06-03-21	1520	1	C5	Open all day
06-12-23	1200	1	C1e	Open all day
06-12-23	1200	1	C1f	Open all day
06-12-23	1200	1	C2	Open all day
06-12-23	1200	1	C3b	Open all day
06-12-23	1200	1	C4b	Open all day
06-12-23	1200	1	C5	Open all day
06-12-23	1200	1	C7b	Open all day
09-01-27	1400	1	C1f	Open all day
10-01-11	850	1	B6a	Closed at 1500
11-03-17	830	1	B3	Open all day

APPENDIX 6 AVALANCHE INCIDENTS THAT COULD NOT BE ENTERED INTO THE INFOEX DATABASE DUE TO INABILITY TO RECORD SIZE 0 RESULTS

TABLE 16 AVALANCHE INCIDENTS THAT COULD NOT BE ENTERED INTO THE INFOEX DATABASE DUE TO INABILITY TO RECORD SIZE 0 RESULTS

Date	Location	Trigger	# of Charges	Results/Size
99-01-15	C1g	Xe	1	Nr
99-01-15	C4b	Xe	1	Nr
99-01-15	C7b	Xe	1	Nr
99-01-31	C1g	Xe	1	Nr
00-01-10	C4a	Xe	1	Nr
01-12-09	B6a	Xe	1	Nr
01-12-11	B6a	Xe	2	Nr
01-12-17	C4a	Xe	1	Nr
01-12-17	C6b	Xe	1	Nr
02-01-10	B6a	Xe	3	Nr
02-01-27	B6b	Xe	1	Nr
02-02-07	B10	Sc	0	Nr
02-12-29	B6a	Xe	2	Nr
03-03-24	B6b	Xe	1	Nr
03-12-07	B7d	Xe	1	Nr
03-12-07	B8c	Xe	1	Nr
03-12-17	C6b	Xe	1	Nr
04-03-19	B6	Xe	1	Nr
04-03-26	B7b	Sc	0	Nr
04-12-10	C1c	Xe	1	Nr
06-03-02	B6a	Xe	1	Nr
07-01-08	B5b	Xe	1	Nr
08-01-06	B4	Xe	2	Nr
09-01-11	C7b	Xe	1	Nr
09-01-14	C1e	Xe	1	Nr
09-01-14	C1f	Xe	1	Nr