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Risk Assessment of Post-wildfire Natural Hazards (revised)



Prepared for

**B.C. Ministry of Forests and Range
Southern Interior Forest Region**

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Dobson Engineering Ltd., Kelowna, B.C.
(with revisions by Southern Interior Forest Region staff)

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TABLE OF CONTENTS

INTRODUCTION	1
Table 1. Overview.....	2
Table 2. Detailed Procedure	3
 PHASE 1. DECISION TO UNDERTAKE ASSESSMENT AND IDENTIFICATION OF ELEMENTS AT RISK	4
Step 1 – Determine the elements at Risk.....	4
Step 2 – Is public safety or infrastructure at imminent threat (e.g. high or very high risk)? If yes, notify PEP.	4
Step 3 – For remaining elements identified as being at risk, proceed to Step 4. If no remaining elements at risk, complete report and end process.	4
Step 4 – Confirm land status for areas potentially affected by fire.....	4
Step 5 - Based on issues identified in Step 1, assemble Risk Assessment Team and appoint team leader.....	4
Step 6 - Finalize scope of assessment and establish project timeline.....	5
 PHASE 2. BACKGROUND PREPARATION	5
Step 1 – Assemble Mapping and Data	5
 PHASE 3 ASSESSMENTS.....	6
Phase 3A – Vegetation, Soil and Forest Floor.....	6
Step 1 - Vegetation Burn Severity.....	6
Table 3. Vegetation burn severity index after Curran <i>et al.</i> (2006).	6
Step 2 – Soil and Forest Floor Burn Severity	8
Soil and Forest Floor Burn Severity Assessment Form	10
Phase 3B – Hydrologic Assessment	11
Step 1 – Watershed Area.....	11
Step 2 – Burned Area.....	11
Step 3 – Change in Water Repellency	11
Step 4 – Change in Rainfall Runoff	12
Step 5 – Change in Peak Flows.....	12
Phase 3C – Hazardous Event Assessment	13
Step 1 – Watershed and Basin Characteristics.....	14
Step 2 - Streams.....	15
Step 3 - Slopes	16
Step 4 - Road/Trails.....	17
Step 5 - Likelihood of Occurrence of a Hazardous Event	18
Step 6 - Magnitude and Runout of a Hazardous Event.....	18
 PHASE 4. RISK ANALYSIS	19
 PHASE 5. REPORT	21
 PHASE 6. FOLLOW-UP	22
 LIMITATIONS.....	22

Introduction

This procedure has been prepared for the Southern Interior Forest Region (SIFR) to assess post-wildfire risks from natural hazards. It has been developed by professional staff from the SIFR through a facilitated process. The procedure is based on current information available from the US Forest Service BAER program, advice from US Forest Service staff familiar with post-wildfire risk assessments, and the knowledge and experience of SIFR staff. The procedure is a work-in-progress that has not yet been tested in the field.

Following a wildfire, the likelihood of the occurrence of severe erosion, landslides, gully processes, and floods can increase thereby increasing the risk to potential downslope values. The likelihood of a natural hazard event occurring within or downslope of a burned area depends on various factors including the area of the burn, the burn severity, extent of soil modifications, exposure to extreme weather events, and watershed/hydrological/geomorphic attributes. The resulting risk will depend on the downslope values present (temporal and spatial) and the time period for which the hazard exists.

The Southern Interior Forest Region has developed a draft Standard Operating Procedure for the Management of Increased Risk from Severe Surface Erosion, Landslide, Gully Processes, and Flood Events after Wildfires. The Standard Operating Procedure was developed to ensure that the increased risk from natural hazards following severe wildfires is systematically identified and appropriately communicated to stakeholders.

Under the Standard Operating Procedure wildfires will be screened to identify those wildfires that are located on, or directly above, moderate to steep slopes above human settlements, private property, or infrastructure. Those fires determined a moderate to high risk, will undergo assessment as described in these procedures.

The results of the Risk Assessment will be forwarded to the appropriate land managers and stakeholders to determine if risk control measures are required. The results of the Risk Assessment will also be used to determine where and when monitoring and additional research is required.

This section provides guidance for those undertaking a Risk Assessment. It is the intent that the risk assessment is carried out by professionals within the Ministry of Forests who are qualified in post-wildfire assessments. This is a field of expertise where there are currently a very limited number of professionals in BC who have experience in post-wildfire assessments and most of these individuals are Ministry of Forests staff. As stated previously the intent of the assessment is to determine IF there has been an increase in risk to public safety, private property or infrastructure from natural hazards following a wildfire. Because human life may be at risk it is important that in those instances that the determination of the increase in risk be completed quickly and accurately, hence the requirement for qualified professionals.

The product of the application of this procedure is a determination of the *change in risk* as a result of the wildfire. The actual process for the determination of the change in risk is detailed in Land Management Handbook 56 - *Landslide Risk Case Studies in Forest Development Planning and Operations* released by the Ministry of Forests in 2004.

Table 1 - *Overview*, provides a quick and simple overview of the procedure that involves six phases. Table 2 – *Detailed Procedure* provides a detailed outline of the procedure. The sections that follow Table 2 provide explanatory notes for each of the phases as guidance for the professionals conducting the assessment and what the expected outcomes are for each phase. Phase 1 addresses the issue of the elements at risk with a focus on the potential for a public safety issue. This may involve an overview assessment of the burned area from the air as well as ground reconnaissance. Phase 2 deals with assembling the background information such as maps, air photographs, reports etc. The outcomes from Phases 1 and 2 are also inputs to Phase 3. Phase 3, Parts 1 and 2 deal with what has changed in the catchment area upslope of the element(s) at risk including how the vegetation cover, forest floor and soils may have changed, and if the rainfall or snowmelt generated peak flow has increased. The outcome from Phase 3 Part 1 is part of the input to Phase 3, Parts 2 and 3. The outcome from Phase 3, Part 2 is part of the input to Phase 3, Part 3.

Phase 4 – *Risk Analysis*. This is the focus of the entire procedure. Has the risk for the elements of concern changed and what is the post-wildfire risk for specific natural hazards? The results of the hazardous events analysis completed in Phase 3 Part 3 are considered in conjunction with the predetermined consequences (public safety, etc) using the risk assessment procedure presented in LMH 56. The post-wildfire risk analysis procedure would normally end of Step 2 of the 6-step procedure (LHM 56, Figure 2, page 7) since the analysis is limited to the confirmation of risk based on the spatial nature of the hazards only.

Phase 5 – *Report*. A report will be completed for the Fire Zone Manager and District Manager. Communication of the results of the analysis will be communicated to the appropriate land managers and stakeholders so that they can determine if risk control measures are required.

Phase 6 – *Follow-up*. Professionals might determine during the assessment work that additional follow-up monitoring or research should be considered. The intent of this section is to provide the details for any follow-up work that may be recommended.

Table 1. Overview	
Phase	Component
1. Decision to undertake assessment and identification of elements at risk	Identify elements at risk. Public safety issue?
	Determine assessment scope and Assemble Risk Assessment Team
2. Background preparation	Assemble mapping and data
3. Assessments	Vegetation, soils and forest floor assessment
	Hydrologic assessment
	Hazardous Event Analysis
4. Risk Analysis	Risk Analysis
5. Report	Reporting to land managers and stakeholders
6. Follow-up	Follow-up assessments and monitoring

Risk Assessment

The risk assessment procedure is summarized in Table 2. The following sections provide additional explanations as guidance for the assessment team.

Table 2. Detailed Procedure				
Legend: RESP = Responsibility; WRC = Wildfire Risk Coordinator; RAT = Risk Assessment team; RATL = Risk Assessment Team Leader				
Phase	RESP	Step	Detail	
1. Identify Elements at Risk	WRC	1	Determine the elements at risk	
		2	Is public safety or infrastructure at imminent threat (e.g. high or very high risk)? If yes, notify Fire Zone Manager, District Manager and Provincial Emergency Program.	
		3	For remaining elements identified as being at risk, proceed to Step 4. If no remaining elements at risk, complete report and end process.	
	WRC & RATL	4	Confirm land status for areas potentially affected by fire.	
		5	Based on issues identified in Step 1, assemble Risk Assessment Team and appoint team leader.	
		6	Finalize scope of assessment and establish project timeline.	
2. Background Preparation	RAT	Assemble information		
			- TRIM maps	
			- Forest cover maps	
			- recent fire maps	
			- recent air/ortho photos	
			- PEM/TEM maps	
			- terrain/terrain stability maps	
			- geology/soils maps	
			- cadastral maps	
			- climate data	
			- hydrometric data	
- fire information, maps, photographs [from Protection]				
3. Assessments				
– 3A – Vegetation, soil and forest floor		How has the vegetation cover, forest floor and soil changed within the area of concern as a result of the fire?		
		1	Vegetation Burn Severity Assessment	Prepare vegetation burn severity map (from aerial overview, field traverses and/or any information available from Incident Command or the fire suppression teams) indicating areas of unburned, low, medium or high vegetation burn severity.
		2	Soil and Forest Floor Burn Severity Assessment	On-site assessments of soil and forest floor hydrological and structural characteristics. Sample site selection based on vegetation burn severity map and professional understanding of water repellency to enable reasonable extrapolation of results to area of concern.
– 3B – Hydrologic Assessment	RAT	Has the probable peak flow, from rainfall or snowmelt, increased as a result of the fire?		
		1	Catchment area	Review burned area maps and air/ortho photos and determine catchment area (ha or km ²) above elements at risk.
		2	Burned area	Determine % of catchment area burned upstream/upslope of elements at risk.
		3	Change in water repellency	Using the results from the water repellency assessment determine % of burned area upstream/upslope of the elements at risk that has increased water repellency.
		4	Change in rainfall runoff	Is there sufficient catchment area upslope of the elements at risk with increased water repellency to increase rainfall and/or snowmelt generated peak flows? Yes/no?
		5	Change in peak flows	Rain – What is the post-fire rainfall generated peak flow hazard? [low, greater than low?]
				Snow – Will the post-fire snowmelt generated peak flow increase? [Yes/no] What is the post-fire snowmelt generated peak flow hazard? [unchanged, increased]
		– 3C – Hazardous Event Analysis		What is the likelihood of a hazardous event being triggered by a rainfall generated peak flow within and/or downslope from the burned area?
1	Watershed/Basin Characteristics			Review the fan to confirm the hydrogeomorphic characteristics of watershed/sub-basin.
2	Streams			(a) Identify all streams and non-channelized hollows. (b) Delineate reach breaks based on channel gradient and confinement, and lump similar streams/reaches together where possible. (c) Identify stream channel morphology in confined reaches steeper than 15%. (i.e. average cross sectional area, bedload type and volume etc). (d) Identify channel constrictions and or impediments to flow in confined reaches steeper than 15%.
3	Slopes			(a) Identify slopes greater than 30% that are connected and/or partially connected to the confined reaches steeper than 15%. (b) Estimate the percent coverage of these slopes with ash and burned soil. (c) Can the rainfall generated peak flow destabilize unstable slopes connected and/or partially connected to the confined reaches steeper than 15%? (d) Can the rainfall generated peak flow destabilize the adjacent slopes at channel constrictions?
4	Roads/Trails			Identify roads/trail that cross the confined reaches steeper than 15% and determine if the drainage structure and/or road prism can contain the rainfall generated peak flow?
5	Likelihood of Occurrence of a Hazardous Event			Estimate the likelihood of occurrence a hazardous event based on the output from Steps 1 to 4.
6	Magnitude and Runout of a Hazardous Event			Estimate the magnitude and runout of the hazardous event and determine if the elements are at risk.
4. Risk Analysis	RAT & RATL			Determine how the flood, erosion/sedimentation, debris flow, debris flood and landslide risks to the elements at risk have changed as a result of the fire
		- Using the results of the hydrologic analysis Phase 3 Part 2, and analysis of floods, etc Phase 3, Part 3 as input to the risk analysis procedure from Land Management Handbook 56, determine the risks to the element(s) at risk		
5. Report	RAT & RATL	Communicate change in risk(s) to the elements at risk as a result of the fire to Fire Zone Manager, District Manager and stakeholders		
6. Follow-up	RATL	Provide a summary of additional follow up work that may be required		

Phase 1. Decision to Undertake Assessment and Identification of Elements at Risk

Step 1 – Determine the elements at Risk

Purpose: The purpose of this step is to identify the elements at risk. The elements at risk may have already been identified during the previous overview phase, if so then the information should be confirmed.

Procedure: The elements at risk may be identified from the office if there is adequate local knowledge of the area of concern. Additional information may be available through the Incident Command for the fire. If necessary an overview flight may be required.

Step 2 – Is public safety or infrastructure at imminent threat (e.g. high or very high risk)? If yes, notify PEP.

Purpose: The priority of the risk assessment is the determination if there is an imminent threat to public safety or infrastructure.

Procedure: If there is an imminent threat to human life or infrastructure, i.e. a high or very high risk, then the office of the Provincial Emergency Program shall be notified immediately [1-800-663-3456].

Step 3 – For remaining elements identified as being at risk, proceed to Step 4. If no remaining elements at risk, complete report and end process.

Purpose: In addition to imminent threats to public safety and infrastructure, the risk analysis also considers risks to public safety and infrastructure where there is not an imminent threat, as well as risks to private lands.

Procedure: As previously stated in the Standard Operating Procedure, the risk assessment is limited to public safety, private property and infrastructure. It must be determined if there are risks to any or all of these elements as a result of the fire. If it is confirmed that there is no public safety issue and there are no other elements at risk, then the risk assessment should end at this point. It will be necessary to provide a written report that summarizes the actions undertaken and the basis for the decision that no further action is required. The report should be submitted to the Fire Zone Manager and District Manager.

Step 4 – Confirm land status for areas potentially affected by fire.

Purpose: Confirmation of the land status for the areas potentially affected by the fire should be a priority.

Procedure: This may involve review of the cadastral maps for the areas as well as searching the title on BC Online at www.bconline.gov.bc.ca to determine the ownership of private lands.

Step 5 - Based on issues identified in Step 1, assemble Risk Assessment Team and appoint team leader.

Purpose: The details of the assessment and the composition of the Risk Assessment Team are based on the scope of the project.

Post-wildfire Risk Assessment Procedure

Procedure: Scoping the project should include confirming the land status for the areas that may be affected. It also involves consideration of the initial approximation of the types of assessments required (Steps 1 and 3). The make up of the Risk Assessment Team should be based on the types of assessments and hazards that have been identified, the number of elements at risk at the magnitude of the affected area that may have to be assessed. For very small areas or where there may be limited elements at risk, the team could be limited to one professional. However, for larger areas and more complex situations, the team may include soils specialists, hydrologists and geotechnical engineers or geoscientists. The requirement for dedicated GIS support is essential and may be overlooked during the project start-up. The decision on the composition of the team should be made through consultation with other professionals familiar with the procedure and the area. After the team has been assembled, a team leader must be appointed.

Step 6 - Finalize scope of assessment and establish project timeline

Purpose: The Risk Assessment Team must review the project scope as initially determined in Step 5.

Procedure: The assembled Risk Assessment Team should review and agree on the project scope before proceeding. Once the scope has been confirmed, the team should decide on the appropriate timeline to complete the assessment. The urgency to complete the assessment will be a function of whether or not there is an imminent threat to public safety or infrastructure. For those situations where there is not an imminent threat, it should be the intent of the team to complete the assessment as quickly as is practical.

Phase 2. Background Preparation

Step 1 – Assemble Mapping and Data

Purpose: Before proceeding with the assessment the team needs to assemble the mapping and background data for the area of concern that will support the assessment work.

Procedure: Maps of the area of concern are essential for the assessments. For efficiency, the first option should be to secure much of the mapping and GIS files from the Incident Command for the fire. The team needs to decide on a suitable map scale and the extent of the area that needs to be included on the maps. At this time the Project Map, a base map of the area of concern, will be produced. The map scale should be set appropriate to the size of the project area. The additional types of mapping and background data that may be available include (but is not limited to) the following:

- TRIM maps
- Forest cover maps
- Recent fire maps
- Recent air/ortho photos
- PEM/TEM maps
- Terrain reports and maps
- Geology/soils reports and maps
- Cadastral maps
- Climate data [AES, Fire weather, local]
- Hydrometric data

Phase 3 Assessments

Phase 3A – Vegetation, Soil and Forest Floor

The intent of this phase is to assess how the vegetation, soil and forest floor within the area of concern have changed as a result of the wildfire. The impact of these changes on erosion potential and watershed hydrological characteristics will then be used in completing the hydrologic and hazardous event assessments.

Step 1 - Vegetation Burn Severity

Purpose: To characterize the reduction in vegetation cover (due to effects on moisture storage, erosion protection and snow accumulation), and the potential for needle cast (which can store moisture and provide erosion protection). With respect to longer-term effects on watershed response and possible watershed rehabilitation efforts, an indication of the lethality of the fire on the vegetation and its ability to recover is also useful.

Procedure: Assess vegetation burn severity according to the index below using an aerial overview, field traverses and any information available from Incident Command or the fire suppression teams.

Vegetation Burn Severity Index

Class	Vegetation Characteristics
Unburned	Vegetation in natural unburned state
Low	Canopy unburned, trunks partially burned, understory lightly or patchily burned
Medium	Trees burned and dead, scorched needles remain, understory burned
High	Trees blackened and dead, needles consumed, understory burned

Table 3. Vegetation burn severity index after Curran *et al.* (2006).

Output: The result of the vegetation burn severity assessment should be a layer (sketch or GIS) on the Project Map indicating the distribution of different vegetation burn severity classes and a summary of the percentage of each class within the area of concern.

Note: An alternative to visual assessments may be available in the future using remote sensing satellite imagery. Currently, no source of interpreted, remote sensing data is available within the short time frame required for these assessments.

Example: Figure 1 illustrates a burn severity map that was produced during a trial of the current procedure, for the Kuskonook Fire, near Creston BC. It shows an example of an area of concern (the Kuskonook Creek watershed) and the element(s) at risk. Summary data for each of the three classes (low-unburned, medium, high) within the area of concern are provided for this example watershed. Figure 2 illustrates a vegetation burn severity map derived from satellite imagery for the Kuskonook Fire, based on methods used by the US Forest Service and US Geological Survey.

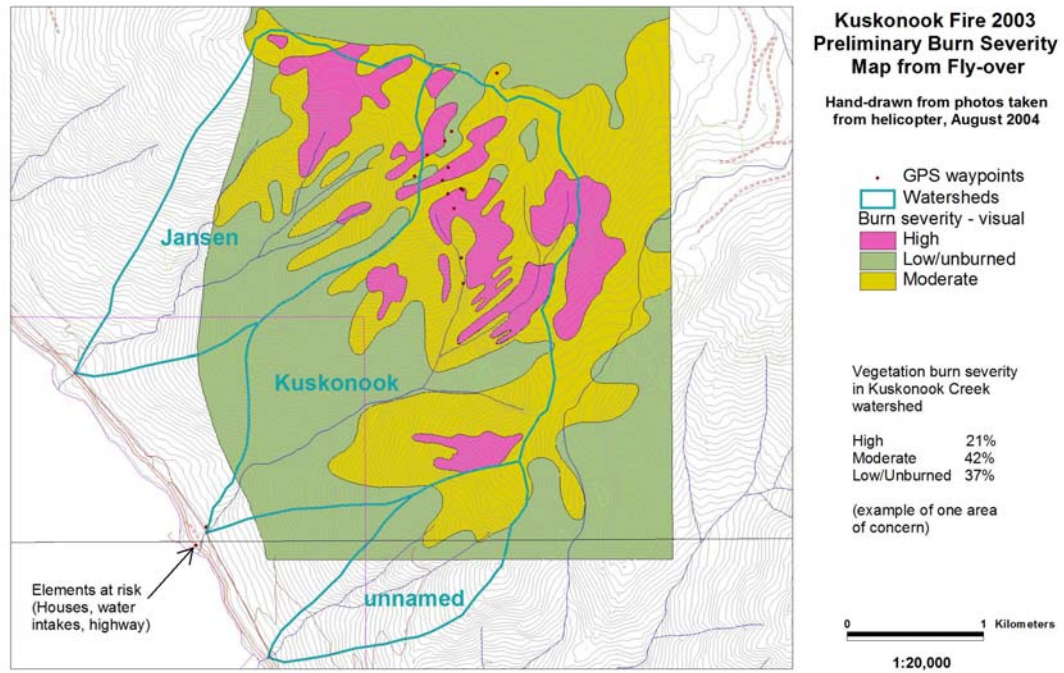


Figure 1. Preliminary burn severity map of part of the Kuskonook Fire, made from photos taken during an aerial overview.

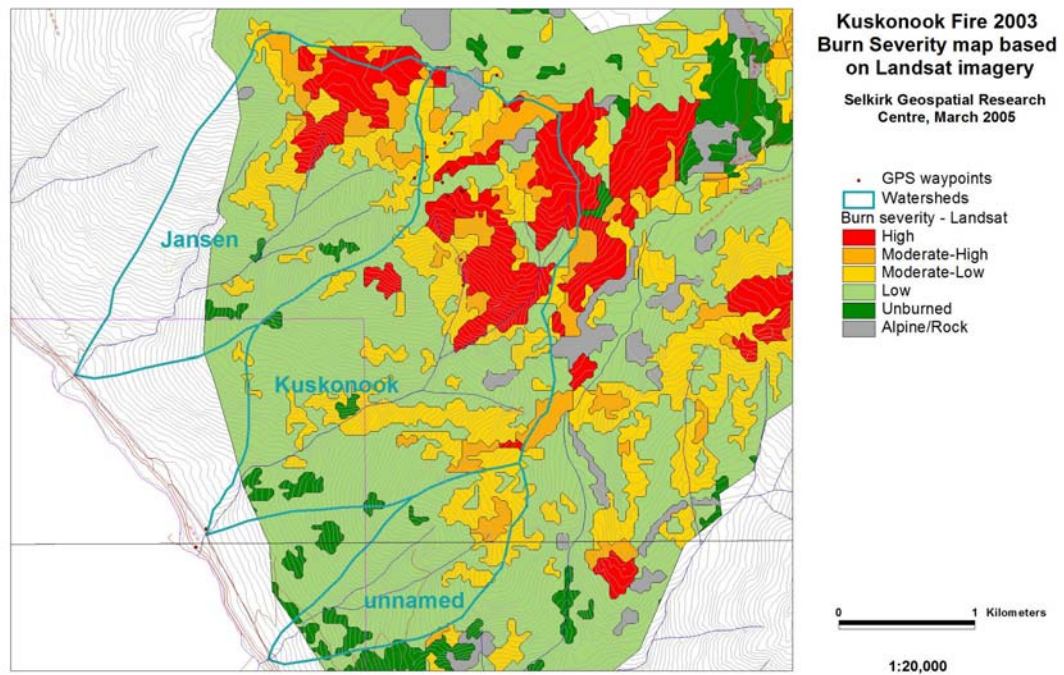


Figure 2. Burn severity map derived from Landsat 5 satellite images (R. Magai, Selkirk College).

Post-wildfire Risk Assessment Procedure

Step 2 – Soil and Forest Floor Burn Severity

Purpose: To assess the key mineral soil hydrological and structural characteristics, and depth and type of forest floor (litter and duff layer) within the area of concern. The level of detail should be sufficient to enable the assessor to provide a reasonable estimate of soil erodibility and hydrological characteristics across the area of concern for the hydrologic and hazardous event assessments.

Procedure: Using the attached field form (Soil and forest floor burn severity assessment) to record results and conduct assessments.

The number of assessment strata required will be influenced by the variation in soil type and depth, terrain types, vegetation cover, forest floor cover, topography, slope position, slope morphology and gradient, aspect, burn history, rainfall history and current vegetation burn severity. All these factors may influence the occurrence of soil water repellency directly through the provision of hydrophobic substances or indirectly by their effect on soil moisture at the time of the fire. Assessment strata will be dictated by professional judgment as to whether the variation in one or more of these factors would be sufficient to influence repellency. The assessment should enable a reasonable estimate of forest floor and soil characteristics for the hydrological and slope hazard analyses that follow.

As a minimum, three test sites should be selected within a stratum of each of the vegetation burn severity areas (unburned, low, medium, high). The number of sample plots will increase with greater variation in water repellency characteristics.

Site, Soil and Vegetation Characteristics: For each stratum, summary data of site and soil characteristics such as terrain type, BEC characteristics, aspect, slope, pre-fire forest cover, vegetation burn severity and any other important information should be collected. Also note any evidence of recent, post-fire overland flow or soil erosion.

Forest Floor Burn Severity Assessment: Determine average depth of the forest floor layer and approximate percentage cover of remaining forest floor. Also determine the condition of remaining large woody debris (unburned, charred, consumed) and estimate its percentage cover. If forest floor type varies within the area of concern to the point that moisture storage capacity and erosion protection will vary markedly for a similar depth, record forest floor type. If needles scorched during the fire have fallen to the ground, estimate the percentage of ground covered by them.

Mineral Soil Assessment: Assess and record texture and coarse fragment content of the surface soil layers. Assess changes (visual / touch), compared to unburned areas, in soil structure; these are often associated with a change in the colour or coherence of the mineral soil. Record the depth of any layer of structural loss. It is important to note that this layer will often be wettable, although not all wettable layers have altered soil structure. Note ash colour and depth, and the percentage of exposed mineral soil. Note the depth to live roots in the mineral soil; presence or absence of fibrous roots and fungal mycelium in the soil may also be noted as these provide additional information on soil erodibility or depth of heating.

Water Repellency Assessment: To assess if water repellency is present use a short duration water drop penetration test (WDPT). The WDPT involves determining the length of time for a drop of water, applied to a mineral soil layer, to penetrate the surface of that layer. Determine if water repellency is present at the surface or at what depth it occurs. The occurrence of wettable layers (water drops infiltrate the layer within 3 – 5 seconds) should be recorded. Moisture content of the soil should be noted as this will influence water repellency. This stage of the investigation is very rapid.

If water repellency is found, conduct a more detailed assessment on the water repellent layer as follows:

- To assess horizontal extent: excavate, or remove the forest floor, from a line of approximately 50 cm length within the repellent layer. Apply water drops along the length of the line. Drops remaining beyond 30 seconds indicate water repellent conditions. Estimate the proportion of the line that is water repellent. This proportion represents an estimate of the extent of water repellency.
- To assess persistence: a longer duration WDPT is required.
- To assess the thickness of the repellent layer: conduct further excavation and short duration WDPT to assess the thickness of the repellent layer.
- To assess infiltration into the mineral soil surface: use the mini-disk infiltrometer at 3 to 5 points per test site. Carefully remove the remaining forest floor before determining infiltration. The suction rate on the infiltrometer should be set near to zero (0.5 cm). Record time to the appearance of the first bubble and volume infiltrating in one minute.

Outputs: The Soil and Forest Floor Burn Severity Assessment will have one layer compiled on the Project Map. There will be polygons characterized by three properties:

- duff depth;
- altered mineral soils; and
- water repellent soils (subdivided by persistence and depth, if necessary).

Summary data should also be provided that indicate the percentage of the area of concern within each stratum. The strata are not specified further here, as they will vary with the fire and watershed.

Example: The typical soil and forest floor burn severity map that might be produced would be superimposed onto a topographic map and the vegetation burn severity map produced earlier in the procedure. Summary data for the percentage of the area of concern within each category should be given. As a simplified example only, a map might have 3 different areas; (1) wettable with duff layer (patchy (50%), mean depth 10 cm), no structural changes; (2) repellent from surface to 2 cm depth, all persistence measurements >1 hour, near continuous repellency (90%), patchy duff of mean depth 5 cm; no readily observable structural change; (3) no duff layer, wettable surface soil (2 cm depth) with loss of structure (easily erodible), repellent layer from 2-4 cm, persistence median 2 hr (SE 1 hour), near continuous (90%).

Soil and Forest Floor Burn Severity Assessment Form

Fire _____ Date _____ Crew _____
 Stratum _____ GPS _____
 Plot _____ Representative Area _____

Site, Soil and Vegetation Characteristics

1. Terrain type _____
2. BEC _____
3. Aspect _____
4. Slope angle _____
5. Pre-fire forest cover _____
6. Vegetation burn severity _____
7. Other (overland flow, rills, sediments). _____

Forest Floor Burn Severity Assessment

1. Average depth of forest floor _____ cm percentage cover _____
2. Condition of large wood debris (charred, consumed etc) _____
3. % cover of woody debris _____
4. % cover of needle cast _____

Mineral Soil Assessment

1. Surface soil texture and colour _____
2. Surface coarse fragment content _____
3. Ash colour and depth _____
4. % mineral soil exposure _____
5. Depth in mineral soil to live roots or rhizomes _____

Water Repellency Assessment

Soil moisture condition (dry, moist, wet): _____

Short duration WDPT

- Thickness of any wettable surface soil layer _____
- Depth at which repellent soil is found (e.g. 0-3 cm below surface) _____

1. Horizontal Extent:

Length of line:

Number of points:

Proportion repellent (estimated horizontal extent) _____

2. Persistence: On repellent layer, conduct full WDPT at 3 to 5 locations (record times)

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3. Thickness: conduct further excavation and short duration WDPT.

4. Infiltration: using the mini-disk infiltrometer at 3 to 5 locations at each plot

- Time to first bubble

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- Volume infiltrating in one minute (mm/min)

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Phase 3B – Hydrologic Assessment

The intent of this phase of the assessment is to determine if the rainfall and snowmelt generated peak flows have increased as a result of the wildfire. This is largely an office exercise with the exception of Step 5 – Change in Peak Flows where the capacity of the channel must be ascertained in the field. The results of the Hydrologic Assessment will be considered in the Hazardous Event Assessment to determine what the post-wildfire potential is for flooding, debris floods, debris flows and landslides.

Step 1 – Watershed Area

Purpose: To define the watershed area above an element, or elements, at risk.

Procedure: The watershed area is defined as the drainage area that has the potential to affect the hydrology upslope of the element at risk. Depending upon the extent of the wildfire, the watershed area may include only a portion of the total area burned. Confirm and outline on a map the approximate watershed area from topographic maps, aerial photographs and field observations. Watershed areas should be defined for each element at risk and will form the basis for the Vegetation, Soil and Forest Floor Assessment and the Hazardous Events Assessment.

Output: The watershed area boundary line will be one layer compiled on the Project Map. The watershed area will be determined in hectares.

Step 2 – Burned Area

Purpose: To define the burned area within the watershed area.

Procedure: The burned area is defined as the area of the watershed that is burned. The burned area may have been initially defined during overview flights conducted in Phase 1, or may be approximated using fire maps, fire photographs and field observations. Determine what percentage the burned area is of the watershed area.

Output: The burned area boundary line will be one layer compiled on the Project Map. The burned area will be determined in hectares.

Step 3 – Change in Water Repellency

Purpose: To determine if the wildfire has changed the soil characteristics and increased the water repellency of the soil.

Procedure: The water repellency within the burned area is determined in the Soil and Forest Floor Burn Severity Assessment. For the hydrologic assessment it is necessary to know if and how the wildfire has changed the water repellency. It may be that soils were naturally water repellent prior to the wildfire, or that as a result of the wildfire a hydrophobic condition was created in the soil that significantly increased the water repellency. The result of the Soil and Forest Floor Burn Severity Assessment is a map that identifies areas of concern with altered infiltration and erosional characteristics, based on the occurrence of repellency and structural changes to the soil.

[[I didn't like your re-wording, Tim – I changed it back to a bit closer to Don's original. Also I think there's no way you can distinguish the potential for "overland flow" from "enhanced preferential flow" so I combined them. (PJ)

(your wording) The result of the Soil and Forest Floor Burn Severity Assessment is a map that integrates the properties of duff depth, altered mineral soils, and water repellent soils. From this information the areas where overland flow, enhanced preferential flow or erosion have the potential to occur will be identified. How is this done?]]

Outputs: The change in water repellency assessment will have one layer compiled on the Project Map. There will be polygons characterized by two properties:

- potential for overland flow or enhanced preferential flow; and
- potential for erosion.

Step 4 – Change in Rainfall Runoff

Purpose: To estimate what the change in rainfall runoff might be based on the change in water repellency.

Procedure: The change in rainfall runoff will be a qualitative estimate based on the extent of burned area within a watershed and the extent to which water repellency has been changed.

Typical infiltration rates for the BC interior exceed most one-hour rainstorms, but if the rainfall during a rainstorm event exceeds the infiltration rate of the soils there will be runoff. Following the fires in 2003 there were a number of instances where there were sufficient changes in soil condition that runoff (and resulting flooding, debris floods, debris flows and landslides) did occur at a number of fires (including Okanagan Mountain Park, Cedar Hills, Strawberry Hill, Ingersoll, Kuskonook and Lamb Creek Fires. In the absence of local infiltration rate data, a simple field test is to pour a liter of water on the soil at representative sites within the burned area as well as similar areas outside the burned area. The difference in the runoff characteristics can be used to estimate the potential change in rainfall runoff within the burned area.

Other factor in this assessment are the stream network density within and below the burned area, and storage opportunities such as lakes and wetlands. In areas with high drainage densities, and few storage sites, there is an increased potential for elevated rainfall runoff.

[[I made a few changes here (PJ)]]

Output: A qualitative assessment of the potential for increased rainfall runoff from the watershed area. Rating values could be presented as “low”, “moderate” or “high”.

[[A map or a qualitative decision? These are poor rating values?]]

Not a map; just a L, M, or H for each drainage basin. (PJ)]

Step 5 – Change in Peak Flows

Purpose: To determine if there may be an increase in either the rainfall or snowmelt generated peak flows as a result of the changes in the burned area using the results from Change in Rainfall Runoff. Depending on the location and extent of the wildfire, the reduction in forest cover may increase the water yield as a result of increased snow accumulation, decreased evapotranspiration and increased melt rates related to increased solar energy.

Procedure: There are two peak flow issues to be addressed, peak flows generated by rainstorms and those generated by snowmelt. In the short-term, it is more likely that changes in peak flows as a result of rainstorms will be of concern. Over the longer-term changes in snowmelt generated peak flows may be more of an issue.

Rainfall Peak Flows: The results from the change in rainfall runoff assessment will be used to determine the potential changes in rainstorm generated peak flows. The concern will be whether or not the channel has the capacity to safely convey the estimated peak flows past the elements at risk or not. An estimate of the channel capacity will be made at key locations, such as culverts, bridges, and confined or unconfined segments of

Post-wildfire Risk Assessment Procedure

channel. This assessment should be completed in conjunction with the Slope Hazard Assessment (Phase 3C, Step 3) as rainstorm generated peak flows may be accompanied by debris floods or debris flows.

[[I don't think so, we may have a hydro not a geo doing this step, so we need a channel capacity number for the SHA. 9OK, minor change here – PJ]]

Output: An estimate of the rainstorm generated peak flow, and estimates of the capacity of the channel in m² at key locations.

Snowmelt Peak Flows: The change in snowmelt generated peak flows is a function of the location and extent of burned area within the watershed. For most interior watersheds peak flows are typically generated from snowmelt in the upper elevations of the watershed or snow accumulation zone.

To estimate the potential for increased snowmelt generated peak flows assess the extent of burned area in the snow accumulation zone. Rough estimates of the snow accumulation zones in the SIFR are: 100% of the watershed for the northwest Chilcotin Plateau area, the upper 40% of the watershed for the Okanagan, and the upper 60% of the watershed for the remainder of the southern interior. Use the same procedures to estimate the increase in snowmelt generated peak flows after a wildfire as would be used assess clear-cut logging.

Output: The results of the assessment of the potential for a change in the snowmelt generated peaks flows could be presented as a percentage increase in peak flow, similar to the results of assessments of the hydrologic impacts of logging.

Discussion: Until there are models available to estimate streamflow in ungauged basins, and changes in peak flow, the results of this assessment will be qualitative, not quantitative. The decision on whether or not there will be a “significant” increase in the rainfall runoff from the watershed area will be based on consideration of the nature and extent of the changes to the vegetation and soil resulting from the fire.

[[Tim – you removed a lot of material from this section. (and I removed another sentence that didn't make sense) Do you want to put some of it back in the “discussion” section, or should it be moved to the other (background) report ? (PJ, 2007-07-31)]]

Phase 3C – Hazardous Event Assessment

[[I still have a lot of problems with this section, but I don't have time to go through it in detail right now.

For now, I've just copied in Tim's revision without any changes.
(PJ 2007-07-31)]]

The intent of this phase of the assessment is to determine the likelihood of a hazardous event being triggered (by a post-wildfire, rainfall generated peak flow) within or downslope from the burned area. A hazardous event is defined as a flood, a debris flood, a debris flow, or a landslide. The hazardous event assessment may be carried out using quantitative or qualitative methods, depending on the type and scope of the analysis.

It is suggested that initially a qualitative approach be used to complete this part of the procedure. The ratings may be expressed using the terms “very high”, “high”, “moderate”, “low”, and “very low” likelihood of a specific hazardous event occurring over a specified time period. This period would be defined as the time it takes for the

Post-wildfire Risk Assessment Procedure

rainfall generated peak flow to be returned to background levels (generally 3 to 5 years if water repellent soils are present). These terms can have different meanings to different individuals and therefore should be defined to avoid ambiguity.

A quantitative assessment could be completed if risk mitigation measures are proposed. It is recommended that quantitative results be rounded to a single decimal point as any more one may imply a greater degree of accuracy than is present.

Step 1 – Watershed and Basin Characteristics

Purpose: To confirm the hydrogeomorphic nature of the burned watershed and, if possible, the historic response to previous wildfires.

It is important to note that this part of the assessment may in some cases be a simple task. Professional judgment may determine that it is obvious what the hazardous event is that could be triggered by the rainfall generated peak flow and what the runoff of this event could be. For example, the characteristics of the Kuskonook Creek watershed indicate that it is subject to debris flows, and the runoff from a large debris flow could reach the distal margin of the fan. If this is the case, the team member could go straight to the risk analysis.

Procedure: In the office, examine MOF forest cover maps to locate historic wildfires. Review these areas on recent and older air photographs to (determine if there was any landslide, debris flow, debris flood, or flood response to the wildfire) evaluate the historic response to wildfire. For each watershed, calculate the area in hectares, and the range of elevation (relief) in metres. Calculate the Melton ratio, an index of watershed ruggedness, defined as the relief divided by the square root of watershed area. This is, in effect, an index of average watershed slope. As an initial screening tool, catchments with Melton ratios of <0.3, 0.3 - 0.6, and >0.6 are likely to be subject to water floods, debris floods, and debris flows, respectively (Wilford et al, 2004)².

With the review of previous wildfire response and the direction provided by the Melton ratios, it is necessary to observe field characteristics of the watersheds and alluvial fans. In the watersheds this will include identification and confirmation of any elements at risk, review of the initiation, transport and depositional zones from earlier potential post-wildfire events. Initiation zones may provide indications of whether the event was caused naturally after the wildfire or if there was human influence. Transport and depositional zones within the watershed may have levees, debris lobes or other indicators key to identification of the event type.

On the alluvial fans, a review of the depositional characteristics of the fan to confirm whether it is affected by floods, debris floods or debris flows. This can include identification of debris flow deposits in the sediments present on the fan, the presence of debris lobes, levees and relic channels. Wilford et al (2004) discuss several criteria for identifying debris flow and debris flood deposits in the field. Where the risk to the identified elements is high to very high, trenches could be excavated on the fan to determine the presence and date of previous hazardous events that may have occurred following earlier wildfires. Dendrochronology studies could also be completed on the mature trees growing on the fan to date earlier hazardous events.

Output: This will provide confirmation of the hazardous event(s) that have been generated within the watershed. This could include an estimate on the magnitude and runoff from previous hazardous events. A map showing the aerial extent of these events in the watershed and on the fan, and the location of the current elements at risk will be produced. A discussion on whether previous wildfires have triggered hazardous events within or downslope from the affected slopes in watershed will be included.

Step 2 - Streams

Purpose: To determine the amount of in channel sediment that could potentially be mobilized during an event. To locate zones where the channel capacity could be exceeded during an event and could cause bank and slope destabilization.

Procedure: Identify streams and non-channelized hollows within and downslope from the burned area. Previous studies conclude that the overland flow generated by short duration/high intensity rainfall events on slopes burned to a moderate to high severity is collected and concentrated in these features. Areas of high-density drainage can also indicate rapid, pre-fire erosion responses and relatively high amounts of surface runoff. Once identified, these drainage features should be divided into reach breaks based on channel confinement and gradient. The confined reach breaks suggested are 0 to 15%, 15 to 40% and greater than 40% (Van Dine, 1996). For this procedure, it has been assumed that confined reaches greater than 40% are likely to be initiation zones for debris flows and sometimes debris floods, while confined reaches between 15 and 40% are more likely to be initiation zones for debris floods and generally transport zones for debris flows. Confined and unconfined reaches less than 15% are more likely to be deposition zones for both of these hazards. Depositional zones identified in this step form part of the input used for estimating the runout of the hazardous event. This is primarily an office based exercise and should be completed using TRIM data, air photos, orthophotos or GIS algorithms. This part of the procedure can be done manually, however on larger wildfires it maybe more efficient to use a GIS analysis. Information gathered should be added as a layer to the Project Map.

Field verification of the reach segments will assess the channel morphology in confined reaches where the channel is steeper than 15%, and debris flows or floods could initiate. This includes a visual estimate on the presence, volume (generally in m³ per lineal m) and type of bedload. This assessment of the bedload will provide an estimate on the volume of material that could be mobilized by the hazardous event and is an input into the determination of the magnitude of a hazardous event. Erosion estimates following a wildfire suggest an 80% increase in available erodible sediment (Martin and Moody 2002) in stream channels and non-channelized channels (**not open slope, but not channelized??**).

The presence of channel constrictions and determine if the rainfall generated peak flow could exceed the capacity of the channel and cause erosion and destabilization of the adjacent slopes.

A review of the average bankfull capacity should be completed in the confined streams/reaches with channel gradients steeper than 15% at: (i) channel constrictions; (ii) adjacent to unstable slopes; and (iii) next to sidewalls where the surficial material could be easily eroded. It is important to assess what could happen at these locations if the bankfull capacity is exceeded (i.e. where would the flow go and what could it do).

If the rainfall generated peak flow exceeds the channel capacity at these locations, additional material could be entrained by the flow (through erosion) and/or from secondary hazardous events that could be triggered (i.e. gully sidewall failures, etc).

The output from this step directs the fieldwork for Step 3 below. Steps 3 (c) and (d) would be done concurrently with Step 2.

A review of the bankfull capacity in the stream reaches present on the fan should also be completed to determine if the rainfall generated peak flow (associated with a flood

Post-wildfire Risk Assessment Procedure

event) could be contained. If the channel will be overwhelmed, an assessment of what elements are at risk from a flooding event should be undertaken. The output from this step can be inserted into the risk analysis (for flood events only).

Output: The output from (a) and (b) is a map and tables that identify streams and non-channelized hollows present on or downslope from the burned area. The reaches in these drainage features should be divided into the following categories: - confined reaches from 0 to 15%, 15 to 40% and greater than 40% and unconfined reaches less than 15%. Streams/reaches with similar characteristics should be noted on this map. A focused fieldwork plan is generated for Step 2 (c) and for Step 3 (a), (b), (c) and (d).

The outputs from (c) include (1) an estimate on the volume of bedload material that could be mobilized by a hazardous event and/or the rainfall generated peak flow in the stream channels/non-channelized hollows; (2) the identification of areas where the bankfull capacity could be exceeded and secondary hazardous events could be triggered; and (3) an estimate on the likelihood that a flood could occur (i.e. exceed the bankfull capacity in the stream channel(s) on the fan) and affect the elements at risk.

Step 3 - Slopes

Purpose: To identify steeper or unstable slopes that have a moderate or high burn severity (a combination of moderate or high vegetation burn severity and moderate or high soil and forest floor burn severity). The connectivity of these slopes to critical stream channel reaches and the potential for an event to initiate on these slopes and enter the creek will be assessed. **Identification of pre-wildfire unstable or potentially unstable slopes, especially those with partial or direct connectivity to the channel, will be completed. The potential for event initiation from these slopes will be evaluated. (ARE THESE SLOPES BURNED? UNBURNED? DOES IT MATTER?)**

Procedure: In the office, using GIS methods when possible, identify slopes steeper than 30% and that have moderate or high burn severity. An estimate of the extent of the burned areas present on these slopes would then be field checked to determine the presence and pervasiveness of the burned soil layer. This burned soil layer on slopes steeper than 30% could be mobilized by overland flow occurring after a short duration / high intensity rainfall event. If these slopes are connected to or partially connected to the channel, the entrained material could increase the density of the streamflow and could trigger a debris flow or debris flood in the channel. The greater the volume of this material that can be delivered to the stream channel, the higher the likelihood that a debris flow or debris flood could be triggered. The intersection of these steeper burned slopes and the stream channel where the gradient is in excess of 15% will be determined.

The identification of the unstable and potentially unstable slopes can be completed in the office using information such as terrain stability mapping, terrain stability assessment reports and air photographs. These polygons should be overlain on the Project Map and compared with the stream channel gradient and stream confinement layers. An assessment of the stability of the slopes that are partially or directly connected to the stream channel should be completed in the field. This assessment should focus on infiltration induced processes on the open slopes and the potential for bank erosion along the channel margins where the channel gradient is steeper than 15%. If there is the likelihood of a landslide being triggered on these slopes, an estimate on the volume of the material that could be delivered to the stream channel should be undertaken.

Stream reaches with channel constrictions, impediments to flow or where bankfull capacity could be exceeded during a peak flow event will be confirmed in the field. Bank or floodplain erosion could lead to slope undercutting and destabilization and increase the likelihood of a landslide. Unstable or potentially unstable slopes adjacent to

Post-wildfire Risk Assessment Procedure

these critical channel reaches are especially vulnerable to significant erosion should rainfall generated peak flows occur. A hazardous event may be triggered by these processes or the additional material introduced to the channel may increase the magnitude of an event triggered upstream. If there is a moderate or high likelihood of a landslide being triggered by bank or floodplain erosion, an estimate of the volume of sediment that could be delivered to the stream should be completed.

Output: The products of this assessment will be one of four layers on the Project Map. The first layer is one that depicts the location of slopes steeper than 30% that have moderate or high burn severity. The second layer will show where the steeper burned slopes (>30%) intersect the steep gradient channel sections (>15%). The third layer will depict the locations where unstable and potentially unstable slopes intersect steeper or confined channel reaches. The fourth layer will show critical stream reach locations where peak flows could cause bank or floodplain erosion and slope undercutting. Estimates of the volume of sediment that could be delivered to the stream channel from slope initiated or from stream undercutting initiated events should be provided.

Step 4 - Road/Trails

Purpose: to identify roads and trails that cross confined stream channels steeper than 15%. Empirical evidence suggests that rainfall generated stream flows can overwhelm the capacity of drainage structures on road/trail crossings on gullied/gully-like streams. This can cause the saturation of the road subgrade and generate hydrostatic pressures that can cause failure of the road prism. If the channel confinement and gradient at these locations exceed the threshold levels, a debris flow could initiate. In addition, stream flow that overtops the road prism can cause severe erosion of the road subgrade adding material to the entrained bedload. Stream flow that overtops the road can also be re-directed down the alignment and can trigger a fill slope failure and/or landslide on adjacent slopes. Also, cross-drain culverts on roads below severely burned slopes may be inadequate to handle increased flows or eroded sediment, and drainage diversions and/or landslides can result.

Procedure: Roads and trails that cross confined stream channels steeper than 15% should be identified using air photos, orthophotos, TRIM data, fire maps, overview flights etc. Once these locations have been identified, an assessment on the ability of the site to safely pass the rainfall generated peak flow (calculated from a previous step) should be undertaken.

If the road/trail crossing/drainage structure will be overwhelmed by the increased stream flow, an estimate on the likelihood of occurrence of hazardous event should be completed. The hazardous event(s) could include failure of the road prism at the crossing (i.e. through erosion or the build up of hydrostatic pressures), a fill slope failure on adjacent slopes or landslide occurrence on the adjacent slopes. An estimate on the magnitude and runout of these hazardous events should be undertaken. It is important to note that these events could trigger secondary hazards such as a debris flow or debris flood.

Drainage structures on roads below slopes steeper than 30% that are burned to a moderate to high severity should be reviewed, and inadequacies noted. [[slope criteria are from step 3 above]]

Output: A map will be generated in this step that notes that the location of all roads and stream crossings that meet the above criteria. An assessment on the possible outcome(s) at the sites where the road prism/drainage structure(s) may be overwhelmed, and roads with inadequate cross drainage, should be provided.

Post-wildfire Risk Assessment Procedure

Preliminary mitigation measures can also be recommended at this stage to reduce the likelihood of a hazardous event.

Step 5 - Likelihood of Occurrence of a Hazardous Event

Purpose: using the output from Phase 3, Part 3 Steps 1 to 4, an estimate on the likelihood of occurrence of a hazardous event should be determined. Until additional research is completed on wildfires in the SIFR, it is recommended that the initial hazard ratings be expressed qualitatively as low and greater than low.

A quantitative approach may be undertaken if risk mitigation measures are proposed, however this is beyond the scope of this procedure.

Procedure: Sound professional judgment (based on relevant experience) is needed to combine the outputs from the previous steps to estimate the likelihood of occurrence of a hazardous event. Burned slopes that are coupled with stream reaches where the likelihood of a hazardous event being triggered is greater than low should be identified. It is suggested that watershed/sub-basin divides be used to identify hazardous areas rather than polygons within these areas.

Output: A hazard map that shows the parts of the watershed, sub-basins, streams that have a low or greater than likelihood of hazardous event occurring.

Regression models have been developed by the USGS to combine relevant data to provide an estimate on the probability of a hazardous event occurring. Additional research needs to be undertaken on hazardous events that have been triggered from wildfires within the SIFR for these models to be developed.

Step 6 - Magnitude and Runout of a Hazardous Event

Purpose: to provide an estimate on the magnitude and runout of a hazardous event. The magnitude of a hazardous event can be described as a total volume transported beyond an area or point of interest or peak discharge at a specific location (Jakob et al 2005)¹. If the total volume method is used, it is suggested that the magnitude be divided into ranges such as less than 500 m³, 500 to 5,000 m³ and greater than 5,000 m³. A single number implies a greater level of accuracy than may be able to be determined.

Procedure: As stated for this procedure, confined stream reaches steeper than 40% are possible initiation zones for debris flows and sometimes debris floods and confined reaches that vary from 15% to 40% are transport zones for debris flows and possible initiation zones for debris floods. If the estimated likelihood of occurrence of these hazardous events is greater than low, the total volume of the event can be estimated by summing the entrained volume along the path of the hazardous event (Fannin et al (2001)²).

Sediment production from burned watersheds and/or sub-basins can possibly could be estimated using the WEPP model (<http://forest.moscowsl.wsu.edu/fswepp/>). This model can provide a good representation of pre and post fire sediment production (and an estimate on the magnitude of a hazardous event). This model is based on US data and needs to be calibrated for Canadian conditions.

¹ Jakob., M, H. Weatherly, Debris flow hazard and risk assessment, Jones Creek, Washington., Proceedings, Landslide Risk Management workshop, Vancouver, British Columbia, Balkema, Rotterdam, pp 533 to 541.

² Fannin, R.J., M. Wise., An empirical-statistical model for debris flow travel distance. Can. Geotech. J. 38: 982-994.

The runout of a potential hazardous event can be initially estimated using the criteria described in Phase 3, Part 3, Step 2; that is, confined stream reaches less than 15% and unconfined reaches less than 15% should be considered depositional areas for hazardous events.

More detailed modeling of the runout could be undertaken if required. This could include methods described in Van Dine (1985)³, Benda et al (1990)⁴, Fannin et al (1993)⁵, Millard (1999)⁶, Fannin et al (2001), Corominas (1996)⁷ and Finlay et al (1999)⁸. It is unlikely, however, that detailed modeling of debris flow runout would be undertaken as part of this risk assessment procedure. Where the risk is judged to be high, recommendations should be made for more detailed assessments, including modeling if appropriate.

Output: An estimate on the magnitude of hazardous event that has a greater than low likelihood of occurrence should be provided in the ranges described above. An estimate on the probable runout of this event should be provided. The estimated runout should be detailed on the hazard map derived in the previous step.

The estimate on the runout is used to determine if an element is at risk from a potential hazardous event (i.e. if the event occurs will the runout reach the element at risk).

Further research needs to be undertaken on burned slopes within the SIFR that have triggered hazardous events to further refine the thresholds for deposition that are used in estimating the runout of these events.

Phase 4. Risk Analysis

Determine how the flood, erosion/sedimentation, debris flow, debris flood and landslide risks to the elements at risk have changed as a result of the fire.

The post-fire risk analysis procedure follows the recognition that some level of hazard and risk exists that may need to be managed, along with the identification of the elements present that could be at risk. The Ministry of Forests has determined that this procedure will assess the risk to the following elements: -

1. Public Safety; this includes people residing in structures and buildings, users of infrastructure such as highways and train lines and drinking water quality.
2. Infrastructure, such as hydro and telephone/cable lines, roads and highways, gas and oil pipelines and rail lines.
3. Private property.

³ Van Dine, D.F. (1985) Debris flows and debris torrents in the Southern Canadian Cordillera. Can. Geotech. Journal V22. pp. 44-68.

⁴ Benda, L.E. and Cundy, T.W. (1990) predicting deposition of debris flows in mountain channels. Can. Geotech. Journal V27. pp. 409-417.

⁵ Fannin, R.J. and Rollerson, T.P. (1993) Debris flows: some physical characteristics and behavior. Can. Geotech. Journal V30. pp. 71-81.

⁶ Millard, T.M. (1999) Debris flow initiation in Coastal BC gullies. Forest Research Branch. Technical Report TR-002.

⁷ Corominas, J. (1996) The angle of reach as a mobility index for small and large landslides. Can. Geotech. Journal V33. pp. 260-271.

⁸ Finlay, P.J., Mostyn, G.R. and Fell, R. (1999). Landslide risk assessment: prediction of travel distance. Can. Geotech. Journal V36. pp. 556-562.

Post-wildfire Risk Assessment Procedure

The outcome of this procedure is not to determine if the risk to these elements is acceptable, it is to present the level of risk so that it can be communicated to the appropriate decision makers to assess whether mitigative measures should be undertaken.

The basic underpinning of this part of the procedure is presented in Land Management Handbook 56 (Landslide Risk Case Studies in Forest Development Planning and Operations) [Wise, Moore and Van Dine – Editors, 2004].

Figure 3, adapted from Land Management Handbook 56, shows six steps in the decision-making framework for risk analysis management. After each step, a decision must be made: go forward to the next step, go backward to the previous step, or take action. The process is iterative, and it is not unusual in slope hazard risk management projects for a stakeholder to revisit previous steps. The analysis presented in this procedure stops at the completion of Step 3 in this figure. The information gathered up to this point is then conveyed to the appropriate decision makers to determine whether further risk evaluation and mitigation is required.

It is important in risk analysis and management to initiate communication with stakeholders early on in the process, particularly if there is a significant risk to public safety. The risk estimates should be communicated in clear and direct terms to the affected stakeholders and presented in a manner that allows for simple comparison with established thresholds of acceptable or tolerable risk.

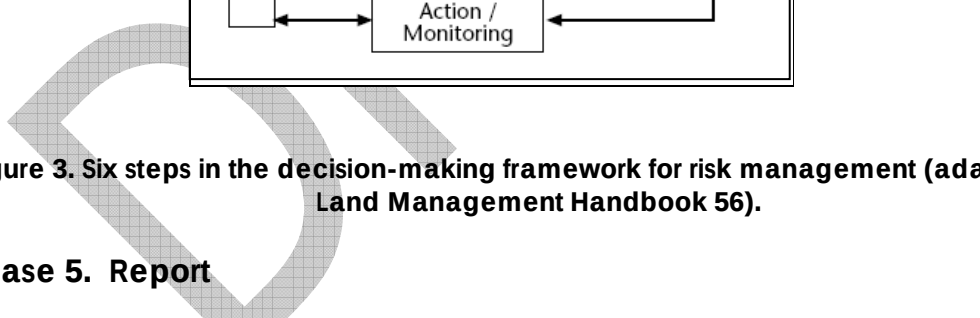
The analysis of the risk associated with the post-wildfire slope and hydrologic hazards discussed in this procedure involves estimating the probability of the event occurring and the consequence of such an occurrence. The probability of occurrence (qualitatively referred to as likelihood) is an estimate of the chance of the event occurring. The estimation of this probability has been presented in previous sections.

Consequence is the effect, or expected effect, of the hazard on a specific element. That is, if the event occurs will it reach the site that the element is occupying (i.e. the spatial effect) and if it does, is the site occupied by the element (i.e. the temporal effect) and if it is occupied, what is the exposure of the element to the hazard (i.e. the vulnerability).

For the purpose of this procedure, the risk analysis should be completed up to the stage of determining whether there will be a spatial interaction with the element at risk only (also known as a partial risk analysis). This is suggested due to: -

- (i) The level of uncertainty associated with assessing the probability of the hazard occurring; and
- (ii) The possibility that the fire could be extinguished (or brought under control) by a rainstorm that triggers the hazard of concern. Time is of the essence in completing the assessment.

For a detailed explanation of the risk procedure refer to Land Management Handbook 56, *Landslide Risk Case Studies in Forest Development Planning and Operations* released by the Ministry of Forests in 2004 - [www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh56.htm].



Phase 5. Report

100

Output: A brief written report including appropriate maps.

Phase 6. Follow-up

Purpose: Identification of any follow-up work identified by the Risk Assessment Team during the assessment work that is not urgent but should be considered over the longer-term.

Procedure: It may be that during the assessment work that the members of the Risk Assessment Team identify concerns that they believe should be considered but that are beyond the scope of the risk assessment. For example, there may be an increased risk of increased peak flows from snowmelt. Although this may be a longer-term concern, the team may recommend that there should be additional research into the magnitude of this issue using short-term snow courses. In another situation the team may decide that there is a need for some ongoing monitoring of a potentially unstable slope.

Regardless of the issue, this step of the procedure provides the opportunity for the team to prepare a report for the land managers consideration that identifies any follow-up issues and provides a rationale supporting the recommendation as well as a business plan including estimated costs and timelines. It would be the land manager's responsibility, based on the information provided, to decide if additional work would be approved.

Limitations

This procedure has been developed by the SIFR post-wildfire working group and is based on the most recent BAER procedure developed by the US Forest Service, advice from specialists in the US Forest Service, Rocky Mountain Research Station, Moscow, Idaho, and the knowledge and experience of SIFR staff. This procedure has not yet been applied to actual fires. It should be considered as a work-in-progress until it has been field verified. The procedure is not intended to be prescriptive, but rather a guide to be used by professionals with familiarity and some level of experience in undertaking post-wildfire assessments, and to provide a framework for conducting assessments in a consistent manner.

-----End-----