Horse Creek Watershed
RLA and *RRISSC* Assessments

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Submitted by:

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Introduction

The *Watershed Assessment of River Stability and Sediment Supply (WARSSS)* is a three-phase methodology that assesses large watersheds with a practical, rapid screening component that integrates hillslope, hydrologic and channel processes. It is designed to identify the location, nature, extent and consequence of various past, as well as proposed, land use impacts. Before changes in land use management are implemented, it is of utmost importance to first understand the cause of impairment. The initial two phases of *WARSSS* involving the *Reconnaissance Level Assessment (RLA)* and the *Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC)* levels of the *Watershed Assessment of River Stability and Sediment Supply (WARSSS)* were conducted on the 186 mi^2 Horse Creek Watershed on the Pike National Forest, Colorado. The large Hayman wildfire in June, 2002, involved a large portion of the Horse Creek Watershed in addition to cumulative watershed impacts from roads, timber harvest and other land uses that potentially impact the water resources. This work was conducted under a contract between CUSP (Coalition for the Upper South Platte) and Wildland Hydrology, terminating by June 30, 2010. Results of the *RLA* and *RRISSC* assessments are used to recommend the high risk specific sub-watersheds and reaches to proceed to the final, most detailed *Prediction Level Assessment (PLA)* of *WARSSS*.

All references to figures, worksheets, tables and flowcharts beginning with "2-", "3-" or "4-" are unique to the *WARSSS* textbook (Rosgen, 2006) and were not changed for this report. Consecutively numbered figures, i.e., Figure 1, Figure 2, etc., are unique to this report.

Reconnaissance Level Assessment (RLA)

The *Reconnaissance Level Assessment* (*RLA*) is the first and most general phase of the three *WARSSS* assessment phases. Documentation of the step-wise procedures for specific tasks performed in the *RLA* and interpretations are described in *WARSSS*, Chapter 3 (Rosgen, 2006).

The *RLA* provides a broad overview of the Horse Creek Watershed while focusing on processes that may affect sediment supply and channel stability. The *RLA* identifies erosional or depositional processes and locations that are influenced by a variety of existing and past land use practices. This initial screening eliminates stable, low-risk slopes, sub-watersheds and river reaches from further analysis. By briefly evaluating a large assortment of processes, practices and places, the *RLA* reveals specific locations that require more detailed analyses at the *RRISSC* and *PLA* levels. This reduces the time and cost of the *WARSSS* assessment. Conducting a more detailed assessment of targeted sites is justified if the user consistently applies the *RLA* methodology and documents the initial results and recommendations. Even though field measurements are generally not required for this level, a site visit is necessary to verify aerial photograph interpretations, GIS resource data, and the valley and stream type mapping, as well as to confirm, reject or redirect the initial problem identification.

The *RLA* was conducted on the Horse Creek Watershed as shown in **Figure 1**. A total of 53, 3rd and 4th order sub-watersheds were assessed whose delineations are shown in **Figure 2**. The availability of the Hayman burn acreages and fire intensity, roads, timber stand changes and other resource data was provided by the USDA Forest Service, primarily through the GIS database and updates with recent high resolution aerial photographs. Dana Butler, Brian Banks and Denny Bohon, with assistance from Molly Purnell, are the primary Forest Service personnel involved from the Pike National Forest and provided the database and worksheet summaries for the *RLA* and *RRISSC* assessments under training and direction from Wildland Hydrology. Field checks were also conducted during this evaluation to validate ratings and stream types assigned to various sub-watersheds and associated risk and consequences of erosional/depositional processes.

In summary, this broad-level assessment method provides the following:

- A basis for selecting obvious sediment supply sources
- The location of stable slopes, sub-watersheds and stream channels not requiring additional assessments
- Verification of perceived problems
- Familiarity with the watershed being assessed, including preparation of maps and photographs to be used for later analysis
- The opportunity to identify sources and causes of problems not intuitively obvious, and a preliminary database for use in other applications

The *RLA* flowchart (**Flowchart 3-1**) illustrates the general assessment process using a sequence of numerical steps (Rosgen, 2006). The first *RLA* step assembled data sources needed recurrently in *WARSSS*. The Forest Service compiled all available information including resource inventory integrated into a GIS framework. The overlays were extremely valuable to determine spatially the extent and nature of land uses and fires to initially identify likely sediment sources.

In addition to the field experience of the Forest Service personnel, sources of potential sediment were reviewed based on previous research studies conducted by Colorado State University and the Intermountain Forest and Range Experiment Station in Moscow, Idaho. These existing studies were helpful in documenting observed erosional processes, primarily from wildfires and roads. Geographic information relating to the watershed played a major role in the *RLA* phase's initial focus on sediment sources. Because GIS was available, the *RLA* time requirement was reduced and new findings from the existing high resolution aerial photographs added mapping of road data and similar disturbances. Nevertheless, the *RLA* was completed within approximately one week (not counting field validation) with the assistance of GIS and the local experience of the Forest Service personnel involved. The information evaluated and collected is used throughout various phases of the *WARSSS* assessment and assists in the initial assessment of possible hillslope, hydrologic and channel processes that may affect sediment supply and river stability.

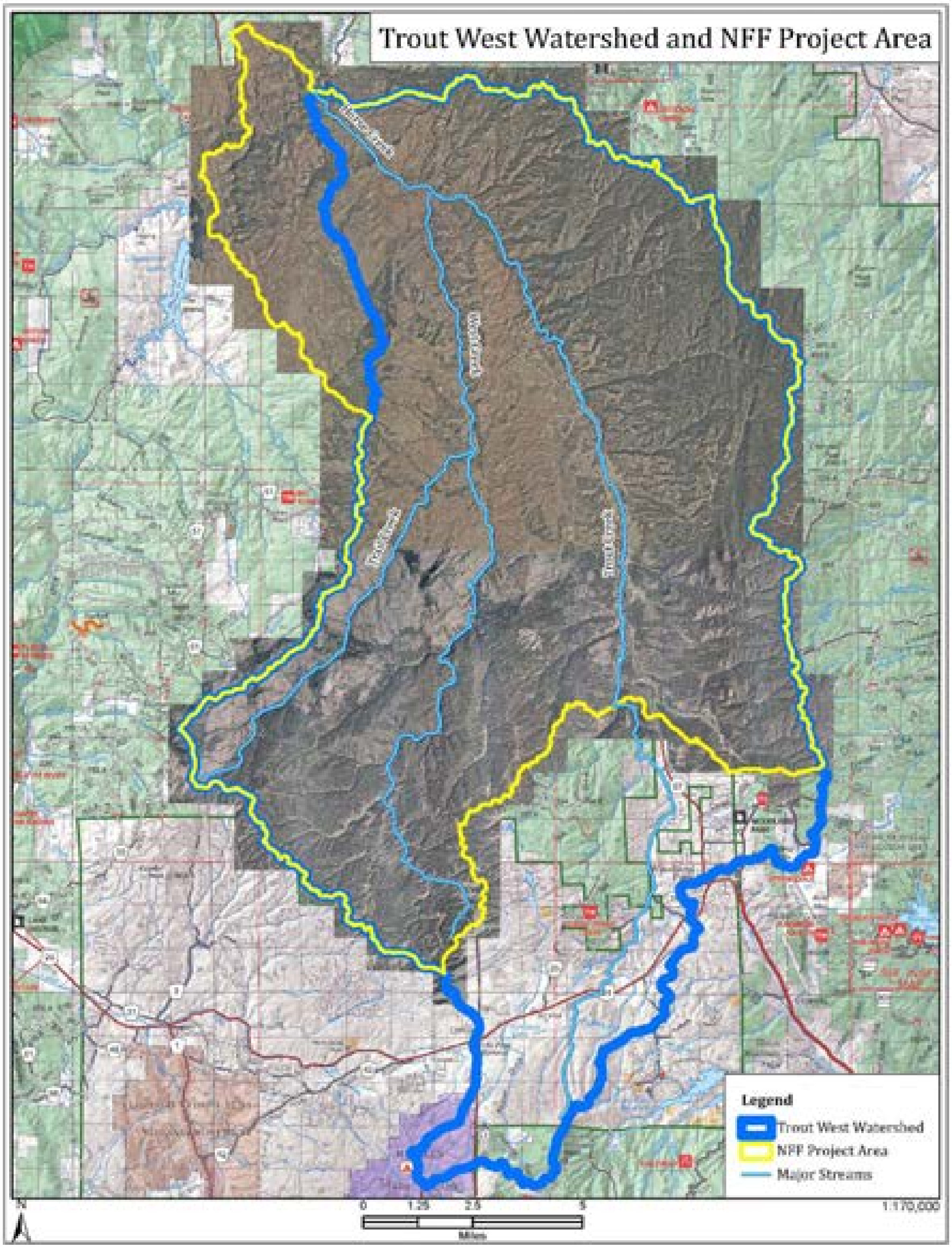


Figure 1. Horse Creek Watershed.

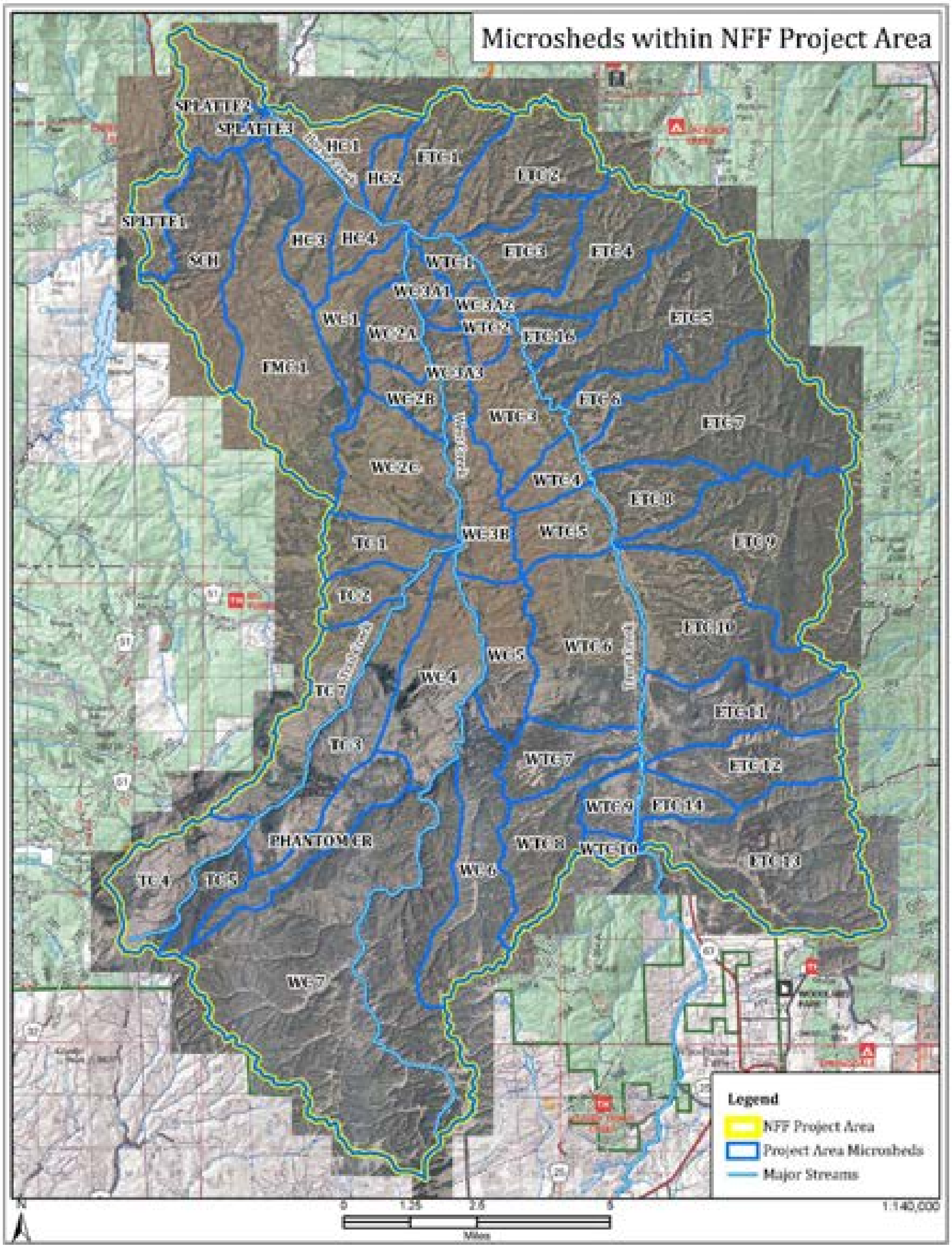
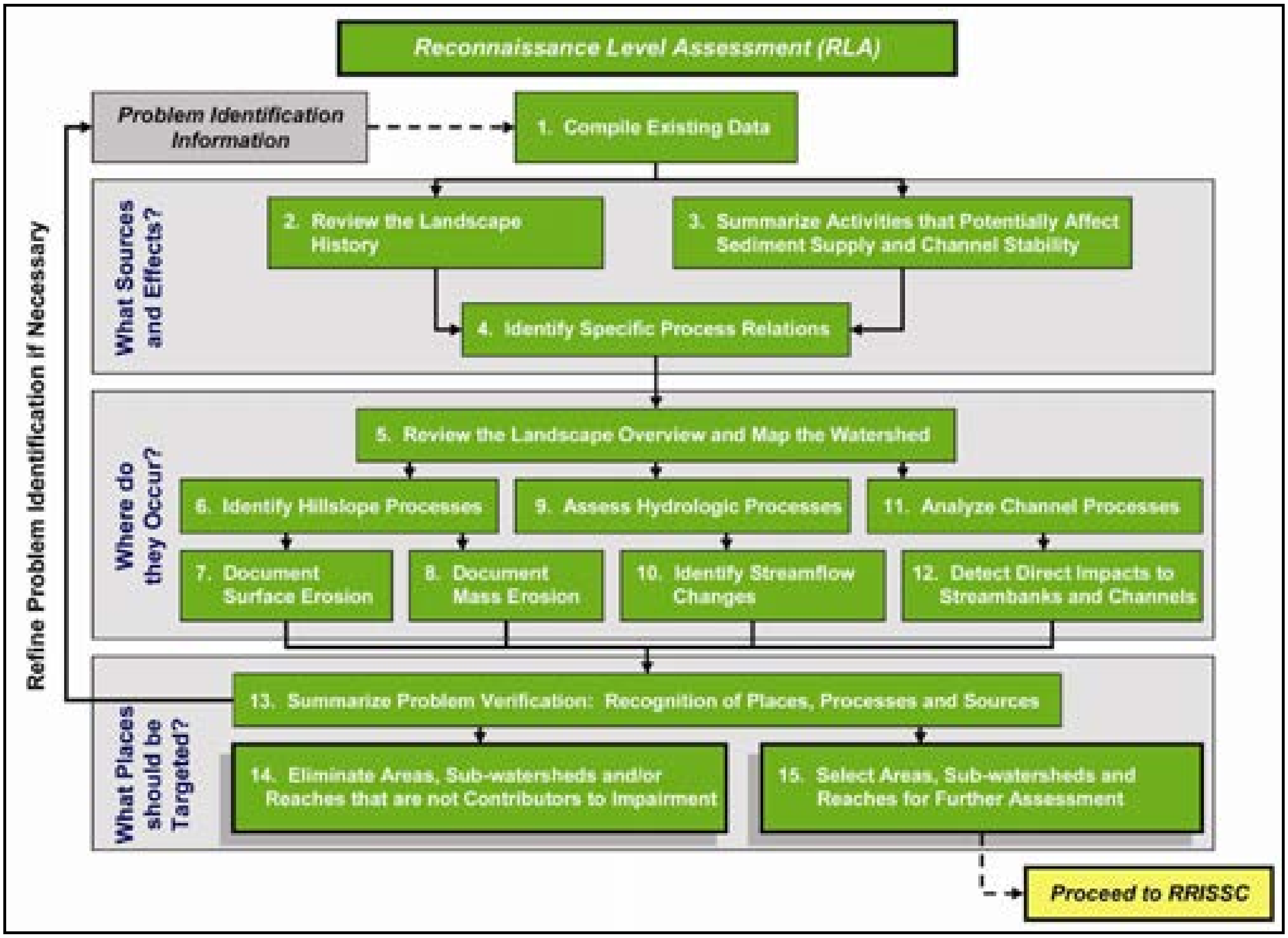


Figure 2. Sub-watershed delineation for the Horse Creek Watershed.



Flowchart 3-1. The *Reconnaissance Level Assessment* (*RLA*) step-wise sequence.

Erosional/Depositional Process Observations

A field review was conducted to observe and document various erosional/depositional processes within the Horse Creek Watershed. The purpose of this initial review was to document obvious processes responsible for high sediment supply and channel impairment. Previous research by Colorado State University and the Forest Service focuses on hillslope processes of surface erosion and roads as a result of the Hayman fire. The *WARSSS* assessment additionally evaluates a wide range of erosion and sediment sources, including hillslope, roads, channel sources and increased streamflow-related sediment. The subsequent ratings and risk prioritization addresses the erosional process and the land use activity related to various processes. One of the evident processes observed was erosion headcut gulleys (**Figure 3**). These channels are advancing headward due to increasing flood peaks due to wildfire, roads and other vegetation-altering silvicultural and riparian impact activities. The additional acceleration is caused by riparian vegetation loss due to high intensity burns. The headcuts create accelerated streambed and streambank erosion and a high sediment delivery as they exist on steeper slopes. The majority of high order streams are drained by low order; thus the cumulative effects can make considerable contributions to excess sediment supply in these erosive grussic granite soils.

Another process evident due to the recent fire in 2002 is the accelerated development of alluvial fans at the mouth of the tributaries (**Figure 4**). If these fans have sufficient room to "run out" onto floodplains or older fan deposits, they form a key function of sediment storage rather than routing the sediment from the uplands directly into the receiving trunk stream. The stream types of the stable form on actively building alluvial fans, such as that shown in **Figure 4,** are D4 (Rosgen, 1994, 1996). This stream type disperses energy and induces deposition onto the fan. Because of roads and drainageways cut by those trying to "drain" the fan, the unstable form has become G4 or F4b stream types that route the high sediment loads directly to the receiving trunk stream. These processes must be mitigated where they occur.

Stream crossing designs such as that shown in **Figure 5** promote an extremely high width/depth ratio and cause frequent flooding, fish migration barriers and river impairment. Improved designs for such crossings will be developed as part of the *PLA* to mitigate such causes of instability, loss of river function and high maintenance problems for the road.

A major problem also exists where the unimproved roads encroach on the mainstem channels causing fill erosion and direct sediment introduction to the channel (**Figure 6**). Floodplain connectivity is lost and greater shear stress is exerted on the channel boundary and road fill during runoff events. This continues to add to high sediment supply and instability. Road impacts are addressed in both the *RLA* and *RRISSC* levels of investigation. If these drainages rate *High* risk or greater, then such erosion rates must be quantified by location and process in the *PLA* phase.

Excess debris from the Hayman fire and floods promote excess sediment deposition and lateral migration (**Figure 7**). Debris and stream aggradation risk are evaluated in the *RLA* and *RRISSC* levels. Where vegetation and lack of encroachment from roads or lateral channel erosion exist, alluvial fans serve a valuable function (**Figure 8**). A recommendation often is to re-establish the alluvial fan and a braided (D4) stream type to regain the natural function of sediment storage rather than routing. The alluvial fan in **Figure 9**, however, is not functioning but rather is being headcut as the D4 is being converted to a G4 stream type (incising). Not only does this contribute excess sediment delivery to the receiving stream (Horse Creek), but the face or toe of the fan is being eroded from the entrenched F4 stream type of Horse Creek at this location. The *RLA* addresses this risk and this site will potentially be advanced to the *RRISSC* level to further evaluate this process.

The ditch lines and headcut extension of tributaries are being accelerated by the poor drainage problems of these high maintenance roads as shown in **Figure 10**. The erodible soils make road design and mitigation very important to potentially reduce sediment delivery from this source. The risk and impacts of roads are addressed at all levels in the *WARSSS* analysis. Additional problems result when the cross-road culvert drains become “shotguns” causing stream degradation and enlargement as shown in **Figure 11**. This stream was converted from a B4 to a highly unstable F4 stream type as a result of this poor design. A headcut gully (G4 stream type) is being developed into an alluvial fan as shown in **Figure 12** on an ephemeral tributary to Trail Creek. This fan is not functioning nor is the G4 stream type, which is highly unstable. Increased flood flow potential appears to be high, and when routed through G4 stream types, there is an exponential increase in delivered sediment due to the fire as well as road acreages. Streamflow increases as well as stream types are assessed for risk in the *RLA* and potentially will advance to the *RRISSC* level.

Mainstem erosion due to road fill encroachment and channel incision and streambank erosion is shown in main Horse Creek (**Figure 13**). The contributions to downstream sediment supply are accelerated due to these processes and are evaluated in this assessment process. Immediately upstream of the reach in Horse Creek, as shown in **Figure 13**, is the F4 stream type eroding the toe of the alluvial fan, which is deeply incised in depositional and erodible material (**Figure 14**). Surface erosion is accelerated on over-steepened slopes as influenced by road cuts, accelerated bank erosion or surface disturbance where more than 50% of the bare soil is exposed (**Figure 15**). These types of surface erosion processes are evaluated in this assessment. The stream migration of Trail Creek into the toe of an alluvial fan is also adding to increased sediment supply as shown in **Figure 16**. The stream is recovering from an F4 to a C4 stream type, is increasing its sinuosity and is decreasing width/depth ratio. Streambank stability is an issue and its risk is addressed during this assessment exercise. Ditch line sediment transport appears to be a concern and a consistent problem for high sediment supply sources, as shown in **Figure 17**, within the Trail Creek Watershed. A G4 stream type (gully) is advancing headward into an alluvial fan, showing a significant sediment supply consequence, as shown in **Figure 18**, located on an ephemeral tributary channel in the Trail Creek Watershed. Potential increases in streamflow and flood peaks make this process a very significant contribution to accelerated erosion and sediment supply.

Figure 3. Headcut gully (A4 to G4 stream type) on an ephemeral channel in Trail Creek Watershed.

Figure 4. Actively building alluvial fan depositing on floodplain associated with a D4 (braided) stream type.

Figure 5. Aggradation due to poor road crossing indicating very high width depth ratio, D4 stream type in Trail Creek.

Figure 6. Road fill erosion due to channel encroachment, F4 stream type.

Figure 7. Aggradation and excess organic debris, D4 stream type.

Figure 8. Natural buffer on active alluvial fan preventing sediment delivery into main trunk channel, D4 stream type.

Figure 9. Actively building alluvial fan on tributary to Horse Creek; note erosion of toe of the fan. Tributary G4 stream type incised in previous D4, mainstem reach of Horse Creek is an F4 stream type.

Figure 10. Sediment delivery from poor road drainage.

Figure 11. "Shotgun" culvert on tributary to Trail Creek converting a B4 to F4 stream type.

Figure 12. Gully erosion (G4 stream type) cut into an alluvial fan – tributary to Trail Creek.

Figure 13. Streambank erosion in entrenched Horse Creek, F4 stream type.

Figure 14. Channel degradation and streambank erosion against deposits and alluvial fan, Horse Creek, F4 stream type.

Figure 15. Surface erosion indicating rill erosion above road cut.

Figure 16. Streambank erosion against an alluvial fan, Trail Creek, indicating a meandering C4 conversion inside of a previous F4 stream type.

Figure 17. Sediment transported down the ditch line of a road in the Trail Creek Watershed.

Figure 18. Gully erosion downcutting in an alluvial fan, tributary to Trail Creek.

RLA Assessment Summary and Guidance Criteria

The *Direct* and *Indirect* potential influences of land use variables on stream channel stability and sediment supply were assessed based on a variety of land uses and impacts. This assessment is documented in **Table 3-1** as observed in the yellow highlighted potential influences. This generalized assessment was completed for the entire Horse Creek Watershed to determine specific inventory requirements using the GIS database to identify the nature and locations of potential impacts. This inventory sets the stage for the next assessment. The results indicated that silvicultural treatments, fires, roads and channelization due to roads are the primary uses and potential impacts to be evaluated (**Table 3-1**).

The next assessment task determined potential erosional process impacts based on a variety of variables influenced by land uses, fires, roads, etc., as shown in **Table 3-1**. The results of this subsequent broad assessment are shown in **Table 3-2**. This table is used to focus subsequent evaluations on gully erosion, streambank erosion, channel enlargement, aggradation, degradation, channel succession and potential sediment delivery based on streamflow changes due to wildfire, roads, and vegetation alterations among other variables. These are shown as highlighted items in **Table 3-2** for the typical land use impacts anticipated in the Horse Creek Watershed. The *Direct* and *Indirect* potential contributions of sediment are differentiated in the yellow highlighted categories. This assessment indicates that potential impacts are due to:

- Increased streamflow
- Riparian vegetation changes
- Surface disturbance
- Surface and sub-surface hydrology
- Direct channel impacts
- Loss of stream buffers (fire and roads)
- Altered dimension, pattern and profile of river channels
- Excess sediment supply
- Large woody debris
- Stream power change
- Floodplain encroachment

These variables are to be assessed in more detail by specific sub-drainages.

The *RLA* summary is provided in **Worksheets 3-1a, 3-1b** and **3-1c**, which document the guidance criteria and analysis summary for hillslope, hydrologic and channel processes to determine which areas and stream reaches may potentially require a more detailed assessment. These worksheets also document the location and justification for areas and river reaches not requiring further assessment. The completed worksheets are associated with 53 individual watersheds (**Figure 2**) within the Horse Creek Watershed (**Worksheets 3-1a, 3-1b** and **3-1c**). The guidance criteria utilized for these ratings are summarized for each process in **Table 3-3** through **Table 3-7** to determine if a particular Horse Creek sub-watershed should advance to the *RRISSC* or be placed in a lower risk category. These guidance criteria were evaluated for each sub-drainage within the Horse Creek Watershed and are summarized and highlighted in red by primary process in **Worksheets 3-1a**, **3-1b** and **3-1c**. The wildfire burn intensity was divided into *Low*, *Moderate* and *High* categories to assist in the potential impact ratings. As a result, ***27*** watersheds have sufficient risk to advance to additional risk evaluations, while ***26*** do not require additional assessment due their lower potential cumulative impacts. The aerial photo with the sub-drainages required to advance to the *RRISSC* is shown in **Figure 19**.

One of the sub-watersheds that rated *Low* risk and was excluded from further assessment was field tested. A large portion of the watershed was burned; thus hillslope erosion processes were evaluated as well as the stream types where increases in streamflow could potentially increase "channel source sediment." The ground cover on slopes over 50% gradient was approximately 65–75%. What little soil eroded due to surface erosion was deposited in a short distance. In other words, the delivered sediment to the drainageway was negligible as additional plants and surface debris on the slopes prevented delivered sediment to the adjacent stream channel. An E5 stream type had also evolved inside of an F5 stream type prior to the fire. A recent flood did not show significant damage due to the developed floodplain and well-vegetated low bank heights. Downstream of this reach was a B5 stream type, also very stable, showing little damage from a recent post-fire flood. The *RLA* assessment does not recommend proceeding with additional assessments in this and similar sub-watersheds. Based on these assessments, nearly half of the sub-watersheds do not need to advance for additional evaluation and potential mitigation/restoration. General resource management criteria for post-fire vegetation recovery and road maintenance are covered on the Forest Plan and "Best Management Practices (BMPs)" for hillslope processes. The drainage area of these sub-watersheds, however, will be evaluated as potential flow-related increases due to wildfire, stand changes and roads for use in more detailed mainstem drainage analysis of Horse Creek, Trail Creek, Trout Creek and West Creek.

Table 3-1. Direct and indirect potential influences (highlighted in yellow) of land use variables on stream channels and sediment supply for the Horse Creek Watershed.

	Potential Impacts											
Land Uses	(1) Streamflow Changes (Magnitude/ Timing/ Duration)	(2) Riparian Vegetation Change (Composition/ Density)	(3) Surface Disturbance (% Bare Ground/ Compaction)	(4) Surface/ Sub-surface Slope Hydrology	(5) Direct Channel Impacts that Destabilize Channel	(6) Clear Water Discharge	(7) Loss of Stream Buffers, Surface Filters, Ground Cover	(8) Altered Dimension, Pattern and Profile	(9) Excess Sediment Deposition/ Supply (All Sources)	(10) Large Woody Debris in Channel	(11) Stream Power Change (Energy Distribution)	(12) Floodplain Encroachment Channel Confinement (Lateral Containment)
Urban Development	D	D	D	D	D	D	D	D	I	D	D	D
Silvicultural	D	D	D	D	D		D	I	D	D	I	D
Agricultural	D	D	D	D	D		D	D	D	D	D	D
Channelization	D	D		D	D		D	D	D	D	D	D
Fires	D	D	D	D	I		D		D	D		
Flood control, clearing, vegetation removal, dredging, levees	I	D		D	D	I	D	D	I	D	D	D
Reservoir Storage, Hydropower	D	I		I	D	D		I	I/D	I	D	
Diversions, Depletions, (-) Imported (+)	D	I		I	D	D			I/D			
Grazing	I	D	D	D	D		D	D	D	D	D	
Roads	D		D	D	D		I	D	D	D	D	D
Mining	D	D	D	D	D		D	D	D	D	D	D
In-Channel mining		D		D	D		D	D	D	D	D	D
D = Direct Potential Impact		**I = Indirect Potential Impact**			**Blank = Little to no impact**							

Table 3-2. Relation of stream and channel variables to erosional processes (highlighted in yellow) for the Horse Creek Watershed.

	Potential Erosional Process Impacts								
Variables Influenced	Surface Erosion	Mass Erosion	Gully Erosion	Streambank Erosion	Channel Enlargement	Aggradation	Degradation	Channel Succession State	Sediment Delivery Efficiency
(1) Streamflow Changes (Magnitude/ Timing/ Duration)		**I**	**D**	**D**	**D**	**D**	**D**	**D**	**I**
(2) Riparian Vegetation Change (Composition/ Density)			**D**	**D**	**D**	**D**	**D**	**D**	**I**
(3) Surface Disturbance (% Bare Ground/ Compaction)	**D**	**I (Debris Torrents)**	**D (Rills-Gully)**	**I**	**I**	**I**	**I**	**I**	**D**
(4) Surface/ Sub-surface Slope Hydrology	**D**	**D**	**D**	**I**	**I**	**I**	**I**	**I**	**D**
(5) Direct Channel Impacts that Destabilize Channel			**D**	**D**	**D**	**D**	**D**	**D**	**I**
(6) Clear Water Discharge			**D**	**D**	**D**	**I**	**D**	**D**	
(7) Loss of Stream Buffers, Surface Filters, Ground Cover	**D**		**I**						**D**
(8) Altered Dimension, Pattern and Profile				**D**	**D**	**D**	**D**	**D**	
(9) Excess Sediment Deposition/ Supply				**D**	**D**	**D**	**D**	**D**	
(10) Large Woody Debris in Channel		**D**	**D**	**D**	**D**	**D**	**D**	**D**	
(11) Stream Power Change (Energy Redistribution)			**D**	**D**	**D**	**D**	**D**	**D**	
(12) Floodplain Encroachment Channel Confinement (Lateral Containment)		**I**	**I**	**D**	**D**	**D**		**I**	**D**

D = Direct Potential Contribution **I = Indirect Potential Contribution** **Blank = Little to No Influence**

Worksheet 3-1a. Evaluation and summary of guidance criteria for selection of Horse Creek sub-watersheds to proceed to *RRISSC* or to exclude from further assessment. Sub-watersheds/locations highlighted in yellow must advance to *RRISSC* due to the guidance criteria highlighted in red.

Sub-watershed/ Reach Location ID		Step 7: Surface Erosion		Step 8: Mass Erosion		Step 10: Streamflow Change			Step 11: Channel Processes		Step 12: Direct Channel Impacts		Step 15
	Burn	Circle Selected Guidance Criteria Number (Table 3-3)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-4)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-5)*	Roads	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-6)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-7)*	Reason for Exclusion	Check Location Selected for Advance-ment to *RRISSC***
WC 3b	Moderate	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)	(6)		(1) (2) (3) (4) (5) (6)		(1) (2)		Y
WC 3a1	Low/Un	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
WC 3a2	Low/Moderate	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
WC 3a3	Low/Un	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
WC 2a	Mod/High	(1) (2) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
WC 2b	Mosaic	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5) (6)	ND	(2)		N
WC 2c	Mod/High	(3)		(1) (2) (3) (4) (5)	ND	(1) (3)	(6)		(1) (2) (3) (4) (5) (6)		(2)		Y
ETC 1	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 2	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 3	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 4	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 5	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 6	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 7	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 8	Unburned	(3)		(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(6)		(1) (2)	ND	N
ETC 9	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 10	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 11	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N

Worksheet 3-1b. Evaluation and summary of guidance criteria for selection of Horse Creek sub-watersheds to proceed to *RRISSC* or to exclude from further assessment. Sub-watersheds/locations highlighted in yellow must advance to *RRISSC* due to the guidance criteria highlighted in red.

Sub-watershed/ Reach Location ID	Burn	Step 7: Surface Erosion		Step 8: Mass Erosion		Step 10: Streamflow Change			Step 11: Channel Processes		Step 12: Direct Channel Impacts		Step 15
		Circle Selected Guidance Criteria Number (Table 3-3)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-4)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-5)*	Roads	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-6)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-7)*	Reason for Exclusion	Check Location Selected for Advance-ment to *RRISSC***
ETC 12	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 13	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 14	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
ETC 16	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
FMC 1	**High**	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3) (5)			(1) (2) (3) (4) (5) (6)		(2)		Y
HC 1	**High**	(1) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
HC 2	**Moderate**	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)			(3) (4) (5)		(2)		Y
HC 3	**High**	(1) (2) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
HC 4	**High**	(1) (2) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5) (6)		(2)		Y
PHANTOM CR	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
SCH	**High**	(1) (2) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)	(6)		(1) (2) (3) (4) (5)		(2)		Y
SPLATTE1	**Mosaic**	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
SPLATTE2	**Mosaic**	(1) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
SPLATTE3	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
TC 1	**Mosaic**	(3)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5) (6)		(2)		Y
TC 2	**Mosaic**	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
TC 3	**Moderate**	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)	(6)		(1) (2) (3) (4) (5) (6)		(2)		Y
TC 4	**Moderate**	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(3)	(6)		(1) (4) (5)		(2)		Y

Worksheet 3-1c. Evaluation and summary of guidance criteria for selection of Horse Creek sub-watersheds to proceed to *RRISSC* or to exclude from further assessment. Sub-watersheds/locations highlighted in yellow must advance to *RRISSC* due to the guidance criteria highlighted in red.

Sub-watershed/ Reach Location ID		Step 7: Surface Erosion		Step 8: Mass Erosion		Step 10: Streamflow Change			Step 11: Channel Processes		Step 12: Direct Channel Impacts		Step 15
	Burn	Circle Selected Guidance Criteria Number (Table 3-3)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-4)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-5)*	Roads	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-6)*	Reason for Exclusion	Circle Selected Guidance Criteria Number (Table 3-7)*	Reason for Exclusion	Check Location Selected for Advance-ment to *RRISSC***
TC 5	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
TC 7	Mosaic	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)			(4) (5) (6)		(2)		Y
WC 1	High	(1) (2) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
WC 4	High	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(3)			(4) (5)		(2)		Y
WC 5	High	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (3)			(4) (5) (6)		(2)		Y
WC 6	Unburned	(3)		(1) (2) (3) (4) (5)	ND	(5)			(6)		(1) (2)	ND	Y
WC 7	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(5)			(6)		(1) (2)	ND	Y
WTC 1	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
WTC 2	High	(1) (2) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
WTC 3	High	(1) (4)		(1) (2) (3) (4) (5)	ND	(1) (3)			(1) (2) (3) (4) (5)		(2)		Y
WTC 4	Mosaic	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(4) (6)		(1) (2)	ND	Y
WTC 5	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
WTC 6	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
WTC 7	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
WTC 8	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(5)			(6)		(1) (2)	ND	Y
WTC 9	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(1) (2) (3) (4) (5) (6)	ND	(1) (2)	ND	N
WTC 10	Unburned	(1) (2) (3) (4)	ND	(1) (2) (3) (4) (5)	ND	(1) (2) (3) (4) (5)	(6)	ND	(6)		(1) (2)	ND	Y

*Criteria based on overall review of the list in Table 3-1 and Table 3-2.

**Locations that meet one or more selection criteria should proceed to the *RRISSC* assessment level.

Table 3-3. Guidance criteria for advancement to the *RRISSC* assessment based on surface erosion.

Surface Erosion Guidance Criteria for Advancement to *RRISSC*
1. If surface erosion is evident on steep, dissected slopes. 2. If surface erosion is evident on unstable soils at lower slope positions in close proximity to drainageways. 3. If activities such as skid trails are continuous down-slope indicating a high potential of surface erosion converted to sediment delivery to a drainageway. 4. If surface disturbance activities occur on rill-dominated slopes.

Table 3-4. Guidance criteria for advancement to the *RRISSC* assessment for mass erosion.

Mass Erosion Guidance Criteria for Advancement to *RRISSC*
1. If evidence exists of recent (within last 10 years) slump/earthflow and/or debris flow/debris avalanche activity. 2. If slide activity is located on steep, concave, continuous slopes. 3. If there is a high percentage of vegetation clearing in proximity to landslide prone terrain. 4. If the location of slide activity is in or adjacent to drainageways. 5. If evidence exists of slump/earthflow and or debris flow/debris avalanche caused by road location.

Table 3-5. Guidance criteria for advancement to the *RRISSC* assessment for potential streamflow changes.

Streamflow Change Guidance Criteria for Advancement to *RRISSC*
1. If rural (non-urban) watersheds have a percentage of bare ground, hydrologic modification due to change in vegetative type and clearcutting timber stands that exceed 30% of first- to third-order watershed areas in the presence of A3–A6, C, D, E, F and G stream types. 2. If urban watersheds have impervious conditions that exceed 10% of second- to third-order watershed area in the presence of A3–A6, C, D, E, F and G stream types. No hydrologic recovery is recognized. 3. *Time-trend of vegetation (rural or non-urban)*. If the vegetative conversions occurred within the last 15–20 years for rain-dominated or temperate climates, or 80 years or less for snowmelt-dominated montane and/or sub-alpine climatic regions, there likely has not been sufficient time for hydrologic recovery. These recovery times are based on re-vegetating sites and the time necessary to regain pre-treatment evapo-transpiration, snow deposition patterns and other similar processes reflecting consumptive water loss. 4. *Diversions, imported water, water depletion and/or return flows*. If the recipient or depleted stream types are alluvial and susceptible to degradation, aggradation, streambank erosion or enlargement (stream types A3–A6, C, D, E, F and G). 5. *Reservoirs*. All reservoirs located on alluvial channel types or those incised in landslide debris, glacial tills, etc. need to be assessed at the *RRISSC* or *PLA* level. This is due to the complexity of potential impacts, the nature of the stream type, the variation in the operational hydrology of the reservoir, potential ramping flows due to power generation (rapid raise and lowering of flow stage), timing of releases with downstream unregulated tributaries and clear water discharge effects. Temperature and other water quality parameters may also need to be assessed. 6. *Roads*. If roads are located in the lower one-third of slope position on moderate to steep slopes (sub-surface flow interception). Road densities over 10% of watershed area of first- and second-order watersheds. Roads traversing highly dissected slopes or with multiple stream crossings. Drainageway crossings associated with floodplain fill blockages, and base-level changes above and/or below culverts and/or bridges.

Table 3-6. Guidance criteria for advancement to the *RRISSC* assessment for channel processes.

Channel Process Guidance Criteria for Advancement to *RRISSC*
1. If there are potential increases in streamflow within the sub-watershed associated with A3–A6, C, D, E, F or G stream types. 2. If there appear to be stream types that are of the unstable form for a given valley type, i.e., G and F types in valley types II, IX, and X, then proceeding to the *RRISSC* assessment level is recommended. The observer is reminded to compare reference to existing conditions to determine if the existing stream type is appropriate for the valley type being studied. For example, if a D stream type was mapped in a valley type IX (glacial outwash valley), it would be indicative of the stable form for that valley type. However, if a D stream type was mapped in valley types II, IV, VI, VIII or X, it would not represent the typical stable form and should be flagged to require the *RRISSC* assessment. 3. If the current stream type departs from the stable form as indicated in the potential channel evolution or successional stage of channel adjustment relations, then proceed to the *RRISSC* assessment level. 4. If aerial photographs or site visits reveal the following channel-destabilizing processes: a. aggradation (excess deposition, wide/shallow) b. degradation (incision, floodplain abandonment) c. lateral accretion (excess bank erosion) d. avulsion (abandonment of previous channels) e. enlargement f. meandering to braided channels 5. If time-trend aerial photography analysis indicates little recovery of apparent channel condition associated with the magnitude, extent and/or obvious consequence of channel change. 6. If road drainage, stream crossings or lack of floodplain drains (through-fill crossings) cause adverse channel adjustment.

Table 3-7. Guidance criteria for advancement to the *RRISSC* assessment due to direct channel impacts.

Direct Channel Impact Guidance Criteria for Advancement to *RRISSC*
1. If the stream's dimension, pattern and profile have been altered due to direct impacts from various sources, then the influence of time of disturbance on channel recovery must be determined at a more advanced level of assessment. 2. If evidence exists of riparian vegetation alteration from woody plants to a grass/forb community or annuals.

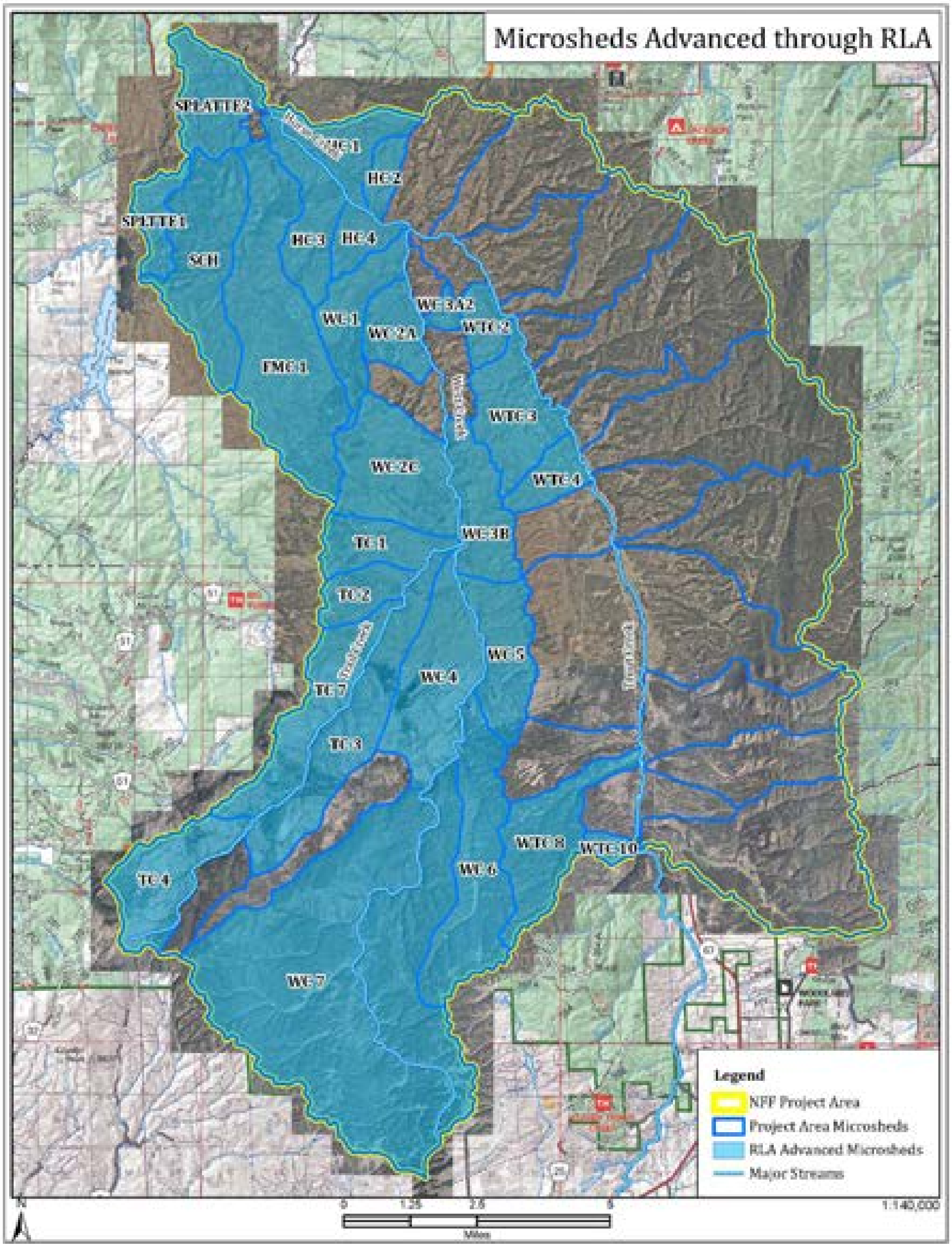
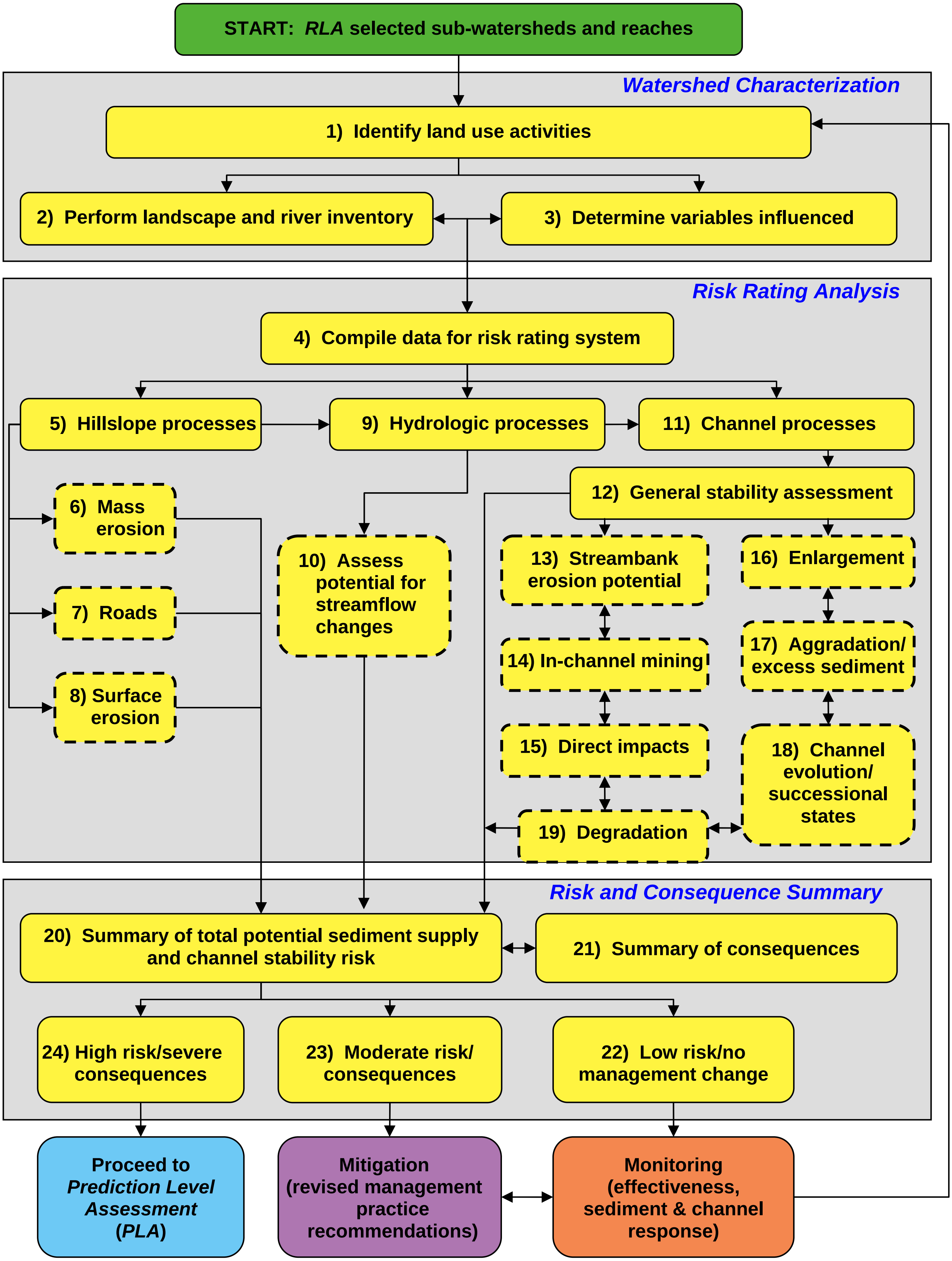


Figure 19. High risk sub-watersheds as determined from *RLA* to advance to the *RRISSC* level of assessment.

Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC)

The *RRISSC* phase of *WARSSS* uses a risk rating system that analyzes the type and extent of land uses, the erosion potential of the landscape and channels, and the relationship of potential sediment sources to hillslope, hydrologic and channel processes. These rapid assessment methods are designed to isolate those land and stream systems with poor conditions and other variables that may be observed in a consistent, objective and reproducible manner. The *RRISSC* involves specific hillslope, hydrologic and channel processes assessments to create a summary risk rating by specific location. These ratings determine if a given sub-watershed or river reach is tagged for a further, more detailed assessment in *PLA*, requires management action changes or monitoring, or can be excluded from further assessment. Documentation of the step-wise procedures for specific tasks performed in the *RRISSC* and interpretations are shown in **Flowchart 4-1** and are described in *WARSSS*, Chapter 4 (Rosgen, 2006).

Due to the findings of the *RLA*, the Trail Creek Watershed was selected for a more detailed *RRISSC* assessment as well as the mainstem streams of Horse Creek, West Creek and Trout Creek and Trail Creek. The Trail Creek Watershed sub-drainages ("microsheds") showing the worst or highest risk sub-drainages determined from the *RLA* are shown in **Figure 20**. The risk ratings for each major land use and processes for the high risk multiple sub-watersheds are shown and discussed by primary erosional/depositional processes. The summary worksheets for each erosional/depositional process assessment are separated by the high risk sub-drainages and mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek; separate worksheets are designated for the main trunk stream assessments. The overall final ratings and recommendations of the high risk sub-drainages of Trail Creek and the mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek are documented in an overall summary form to determine the potential necessity to advance to the *Prediction Level Assessment (PLA)*. The relationship among land uses, process influences, consequences and assessment methods used for the following assessments is based in general on the information contained in **Table 4-3**.



Flowchart 4-1. Procedural sequence of analysis for the *RRISSC* assessment.

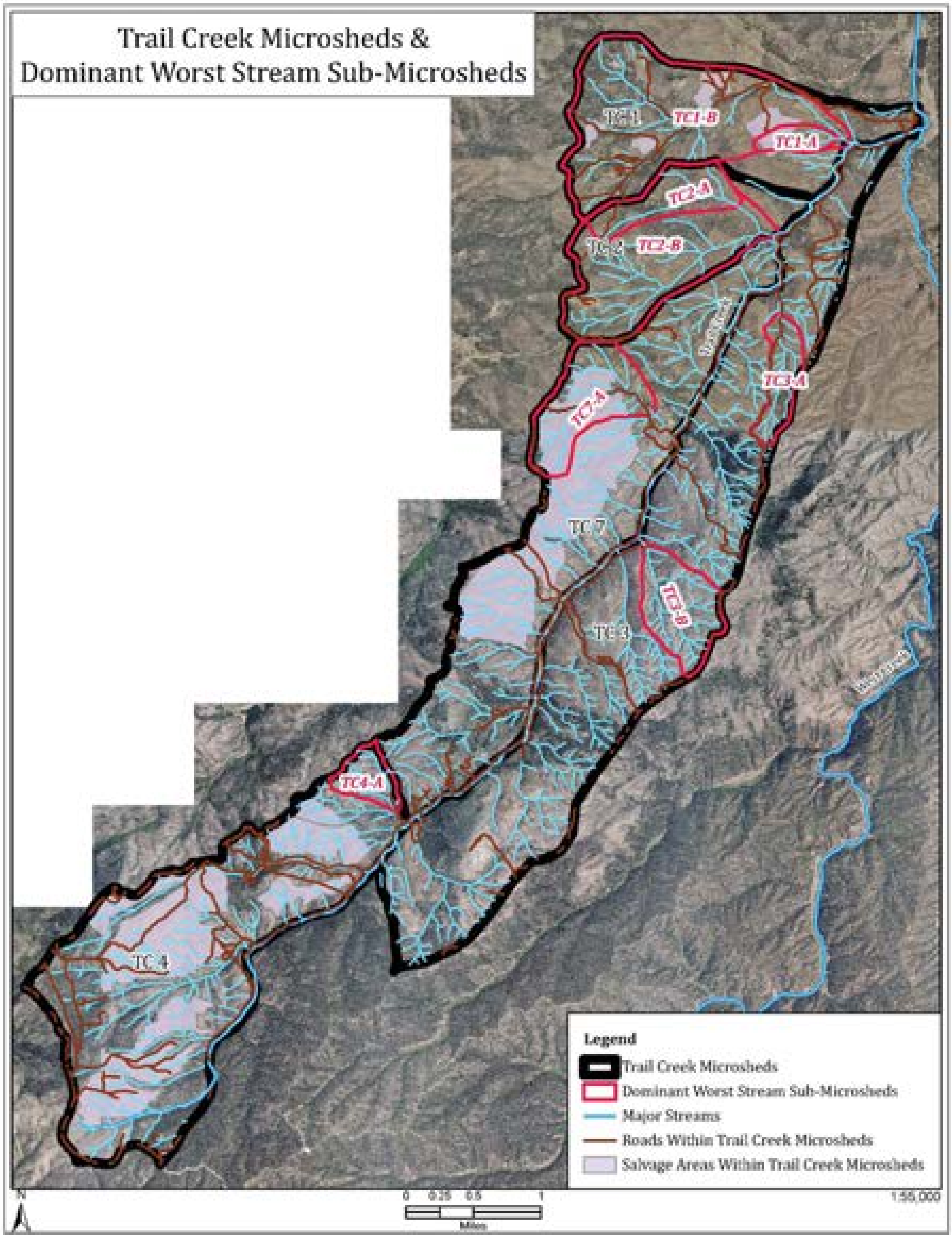


Figure 20. Highest risk sub-watersheds in the Trail Creek Watershed as determined in *RLA*.

Table 4-3. Relationship among land uses/activities, process influences, consequences and assessment methods.

Potential change from Land uses/activities	Processes influenced	Potential consequences	*RRISSC* prediction method
Streamflow decrease in magnitude, duration and altered timing due to reservoirs or diversions	Shear stress ↓ Stream power ↓ Sediment transport competency and capacity ↓	Excess sediment deposition Aggradation Accelerated bank erosion Widening channel Successional state	**Worksheet 4-11** **Worksheet 4-11** **Worksheet 4-7** **Worksheet 4-10** **Table 4-5**
Streamflow discharge increase due to high % impervious and storm water drains from urban development. Clear water discharge "ramping flows" from reservoir releases	Shear stress ↑ Stream power ↑ Sediment transport capacity ↑	Degradation Channel enlargement Bank erosion Channel succession shift Increased sediment load (supply)	**Worksheet 4-12** **Worksheet 4-10** **Worksheet 4-7** **Table 4-5** **Worksheet 4-11**
Streamflow increase from vegetative alteration, clearcutting, land clearing and roads	Shear stress ↑ Stream power ↑ Magnitude of flow ↑ Duration of flows ↑	Channel enlargement Bank erosion Degradation Channel succession shift Increased sediment load (supply) Surface erosion	**Worksheet 4-10** **Worksheet 4-7** **Worksheet 4-12** **Table 4-5** **Worksheet 4-11** **Worksheet 4-5**
Riparian vegetation alteration (% of channel length by stream type)	Bank erodibility ↑ Sediment transport capacity↓ Stream power ↓ Shear stress ↓	Bank erosion Aggradation Enlargement Channel succession shift	**Worksheet 4-7** **Worksheet 4-11** **Worksheet 4-10** **Table 4-5**
Surface disturbances (% of ground cover) and roads	Surface runoff ↑ Sub-surface flow interception (roads) ↑ Deposition ↑ Sediment transport capacity (aggradation) ↓ Excess scour (degradation)↑	Surface erosion delivered to stream Road source sediment Gully erosion Aggradation Degradation Streambank erosion	**Worksheet 4-5** **Worksheet 4-4** **Worksheets 4-7, 9, 10, 12** **Worksheet 4-11** **Worksheet 4-12** **Worksheet 4-7**
Water yield – harvest and roads – add to soil water influencing slope stability	Surface/sub-surface hydrology ↑ Soil saturation ↑ Internal strength by roots ↓ Slope equilibrium ↓	Mass erosion: - slump earthflow ↑ - debris torrent ↑ - sediment supply delivered to channel ↑ Aggradation ↑ Channel succession shift Enlargement ↑ Surface erosion ↑	**Table 4-4** **Worksheet 4-3** **Worksheet 4-11** **Table 4-5** **Worksheet 4-10** **Worksheet 4-5**
Direct channel impacts Channelization Levees Straightening Dredging	Shear stress ↑↓ Stream power ↑↓ Width ↑ Confinement ↑ Incision ↑	Gully erosion ↑ Bank erosion ↑ Channel enlargement ↑ Degradation ↑ Aggradation ↑ Channel succession shift	**Worksheets 4-7, 9, 10, 12** **Worksheet 4-7** **Worksheet 4-10** **Worksheet 4-12** **Worksheet 4-11** **Table 4-5**
Channel clearing, cleaning, grubbing, large woody debris removal	Stream power ↑ Shear stress ↑ Sediment transport capacity ↓ Competence ↑ Degradation ↑ Energy dissipation ↓	Sediment deposition ↑ Degradation ↑ Bank erosion ↑ Channel enlargement ↑ Sediment supply ↑ Aggradation ↑	**Worksheet 4-11** **Worksheet 4-12** **Worksheet 4-7** **Worksheet 4-10** **Worksheet 4-11** **Worksheet 4-11**

Note: Potential consequences column is directly related to *RRISSC* prediction method column; for example, potential excess sediment deposition is assessed in **Worksheet 4-11**.

Stream Classification

The majority of the stream types were broadly classified from aerial photo interpretations and several classifications were validated by field visits. Stream classification delineation is based on the criteria shown in **Figure 2-14** (Rosgen, 2006). Stream classification within the high risk Trail Creek sub-drainages are shown for TC1-A and TC1-B in **Figure 21**. The predominance of G (gully) stream types make any increase in streamflow an exponential increase in sediment supply. This is true for G and F stream types due to the accelerated bed and streambank erosion processes associated with these stream types. The same conditions are true for sub-watersheds TC2-A and TC2-B in **Figure 22**. The mainstem of Trail Creek varies from G to F to D, all of which promote excessive sediment deposition and accelerated streambank erosion processes. The stream types located in sub-watersheds TC2-A and TC2-B and the mainstem of Trail creek also show "weak-link stream types" of G, F and D. The same stream types dominate sub-watersheds TC3-A, TC3-B and TC7-A (**Figure 23**). The acreages of fire salvage logging are also shown in TC7-A. Skid roads in such stream types generally create high potential for accelerated sediment supply if they parallel the drainage network. **Figure 24** also shows the predominance of G stream types in sub-watershed TC4-A and F stream types in the mainstem Trail Creek. Stream classification on the mainstem Horse Creek and selected tributaries is shown in **Figure 25**, and the West Creek and selected tributaries stream classification is shown in **Figure 26**. **Figure 27** depicts the classification for the mainstem Trout Creek.

A summary of data collected for the F4b, G4/A4 and D4b stream types is shown in **Worksheets 4-1a**, **4-1b** and **4-1c**, respectively. A more detailed stream classification delineation will be determined on-site for selected streams advancing to the *PLA*.

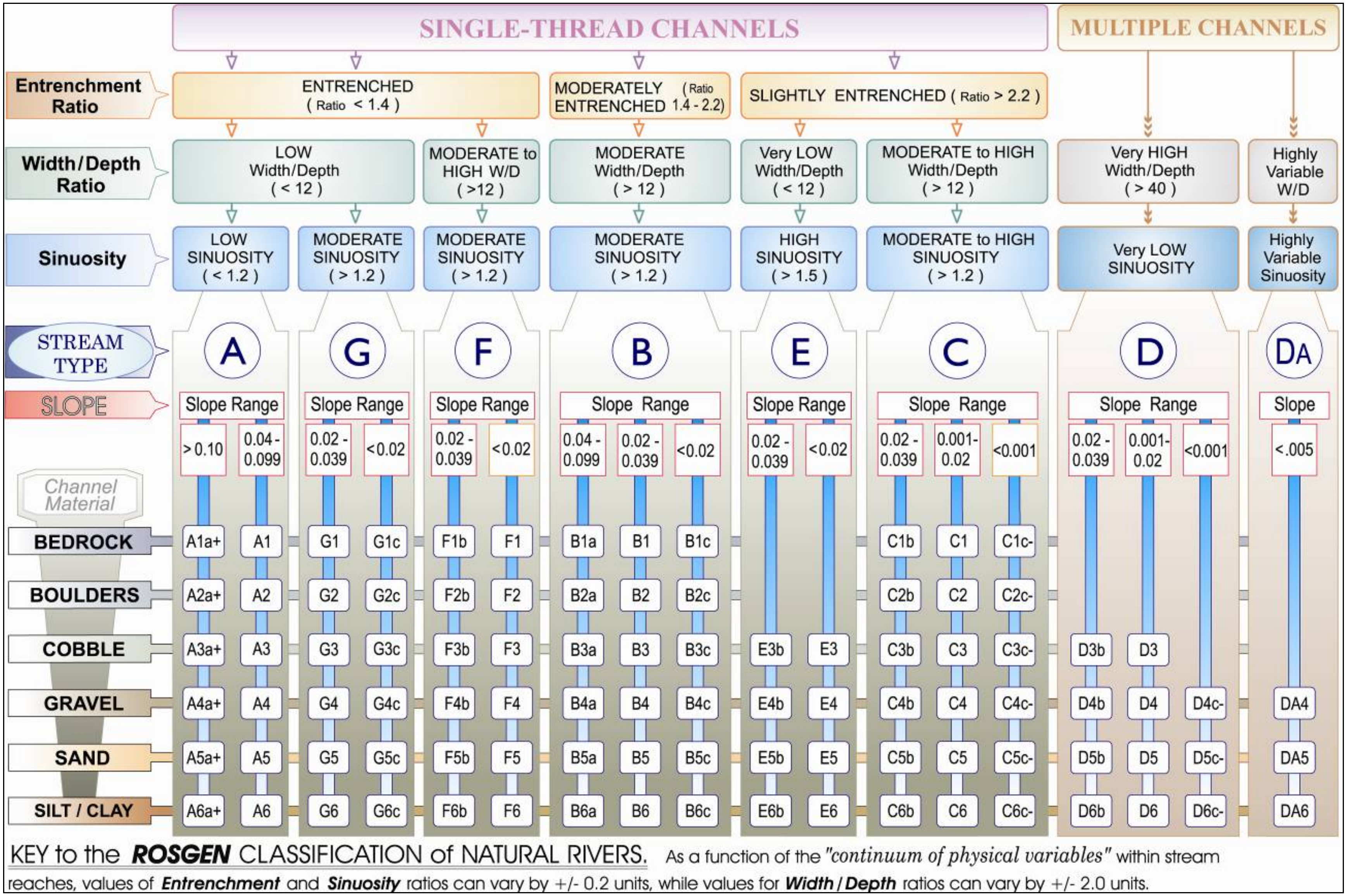


Figure 2-14. Stream classification key for natural rivers (Rosgen, 1994, 1996, 2006).

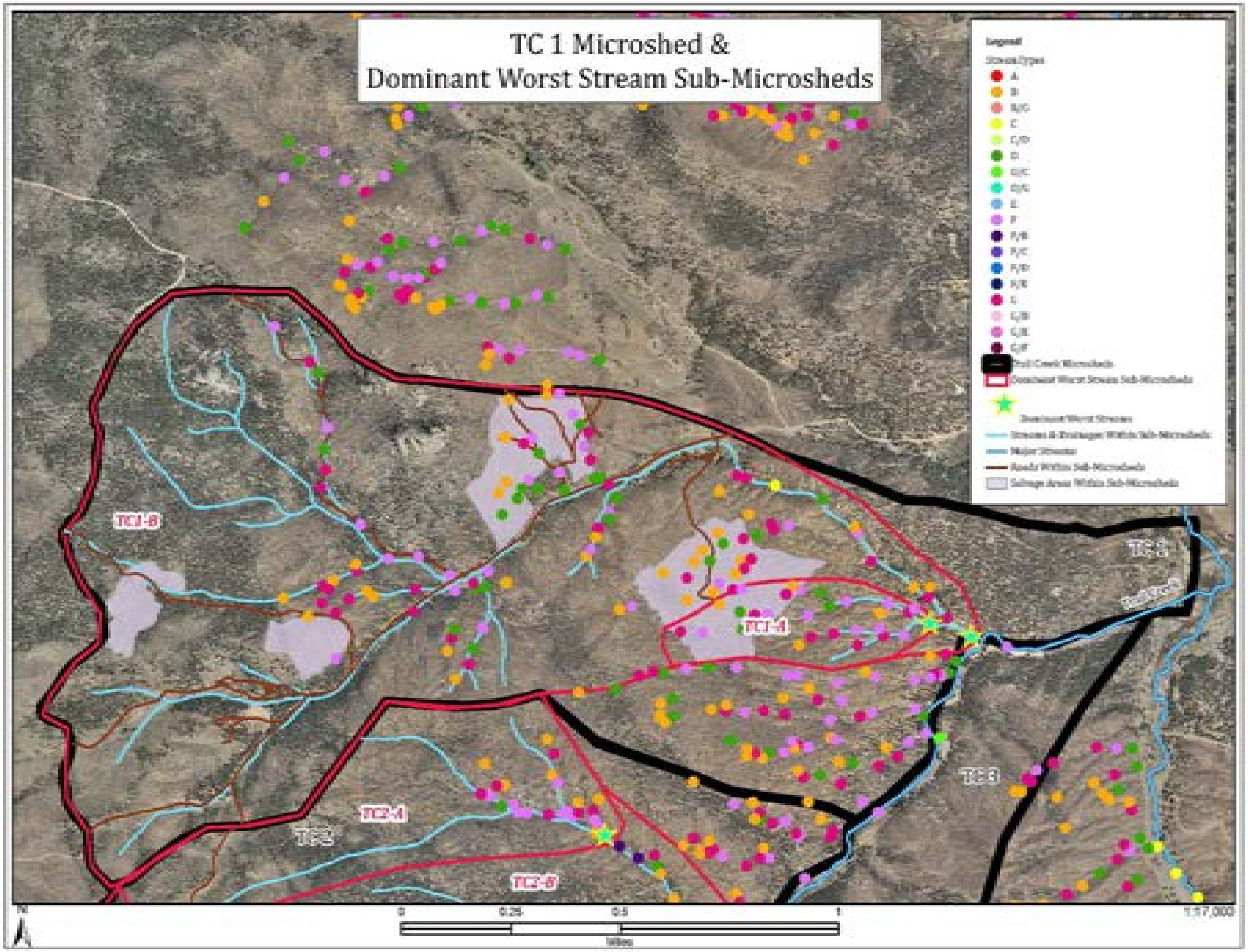


Figure 21. Stream classification and fire salvage logged areas in the high risk Trail Creek sub-watersheds TC1-A and TC1-B.

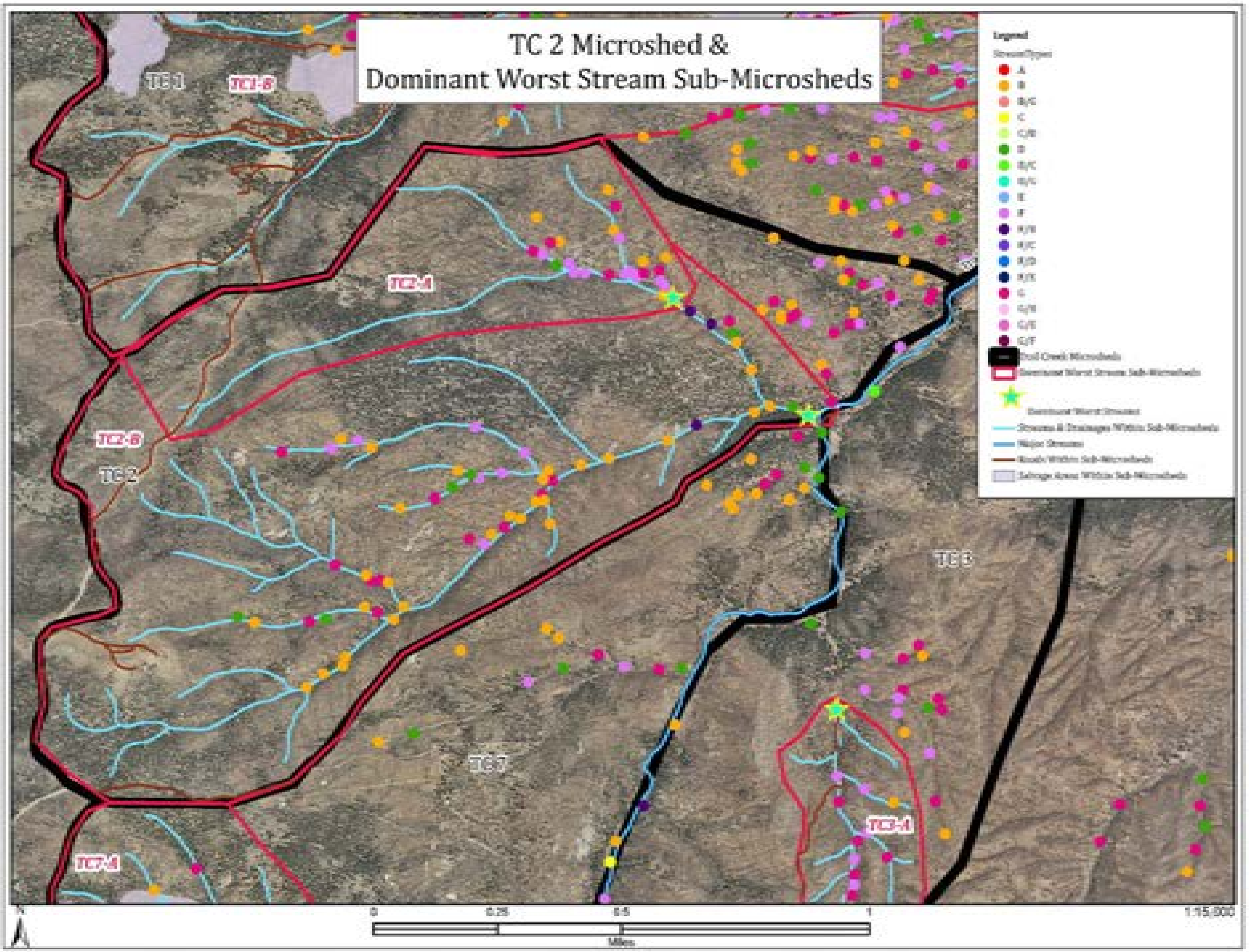


Figure 22. Stream classification in Trail Creek sub-watersheds TC2-A and TC2-B.

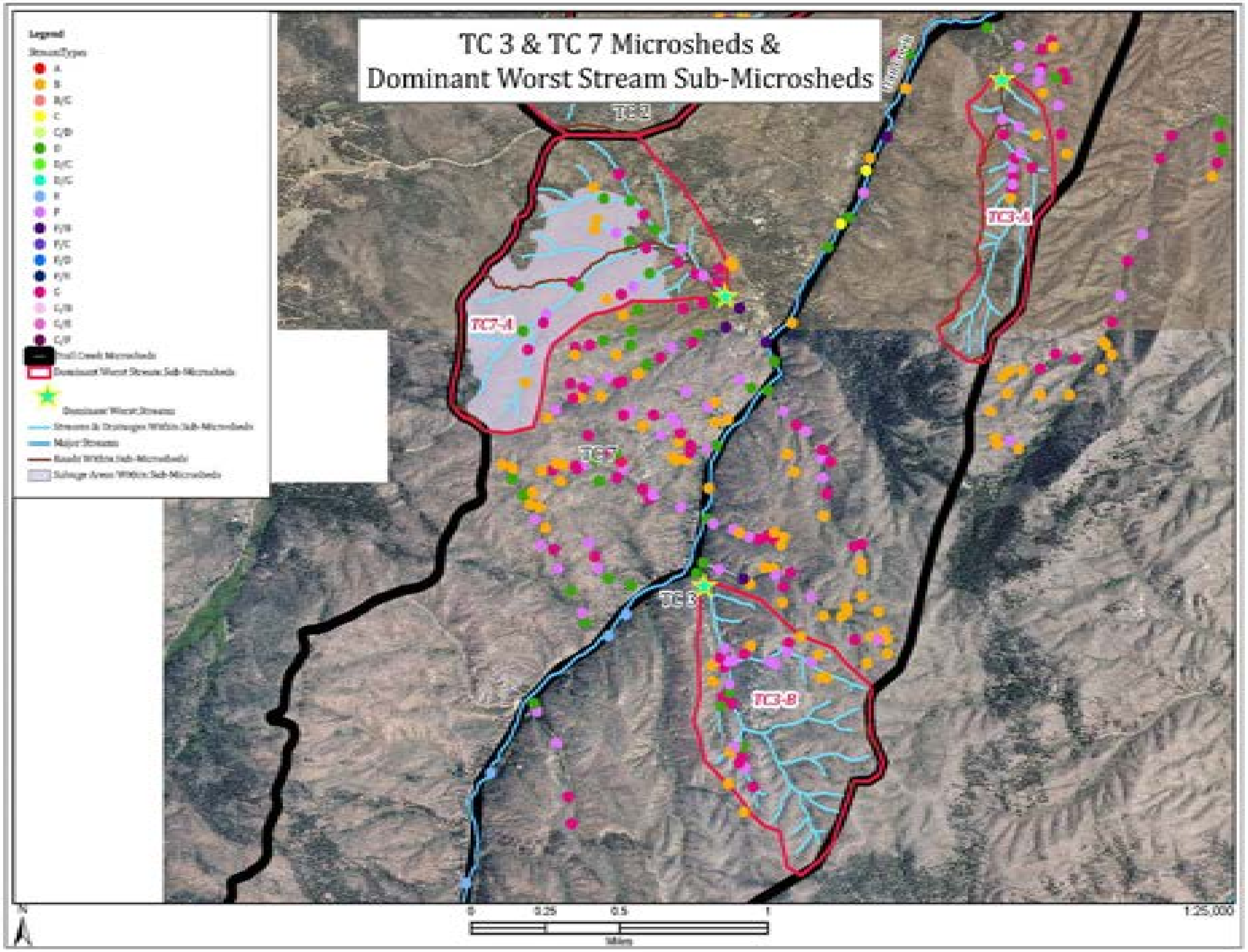


Figure 23. Stream classification and fire salvage logged areas in the high risk Trail Creek sub-watersheds TC3-A , TC3-B, TC7 and TC7-A as well as the mainstem Trail Creek.

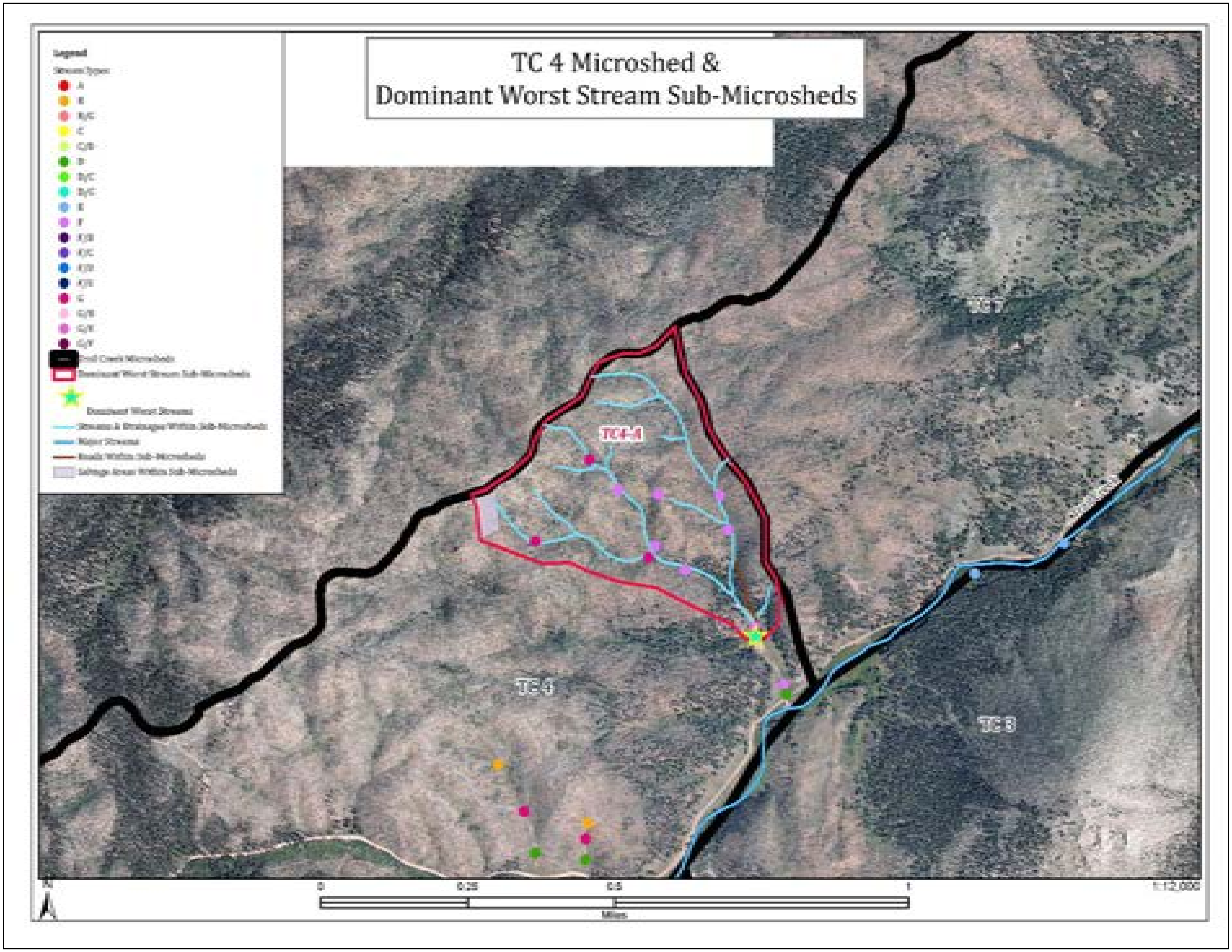


Figure 24. Stream classification showing predominantly G (gully) stream types in the high risk Trail Creek sub-watershed TC4-A and F stream type in the mainstem Trail Creek.

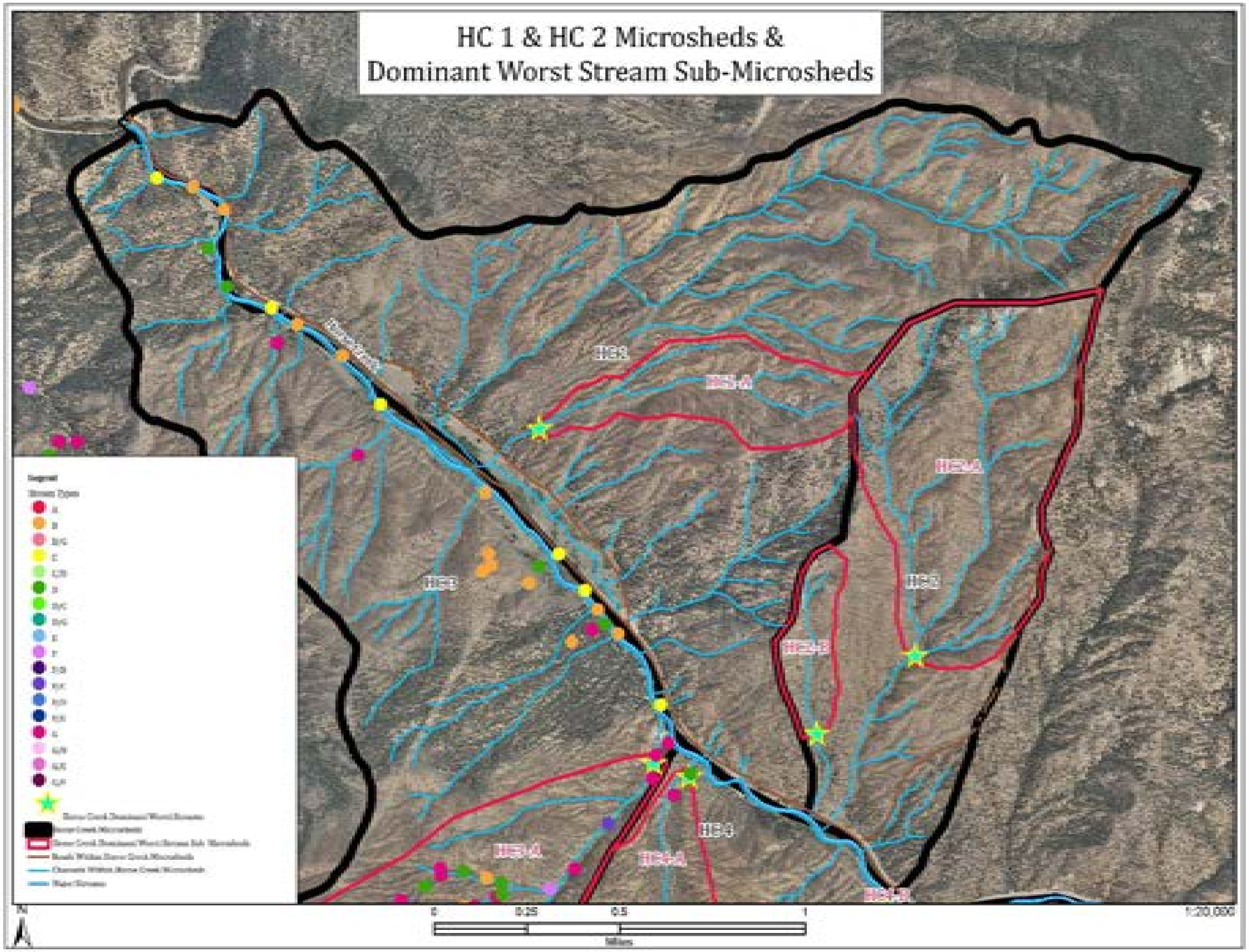


Figure 25. Stream classification on mainstem Horse Creek and selected tributaries.

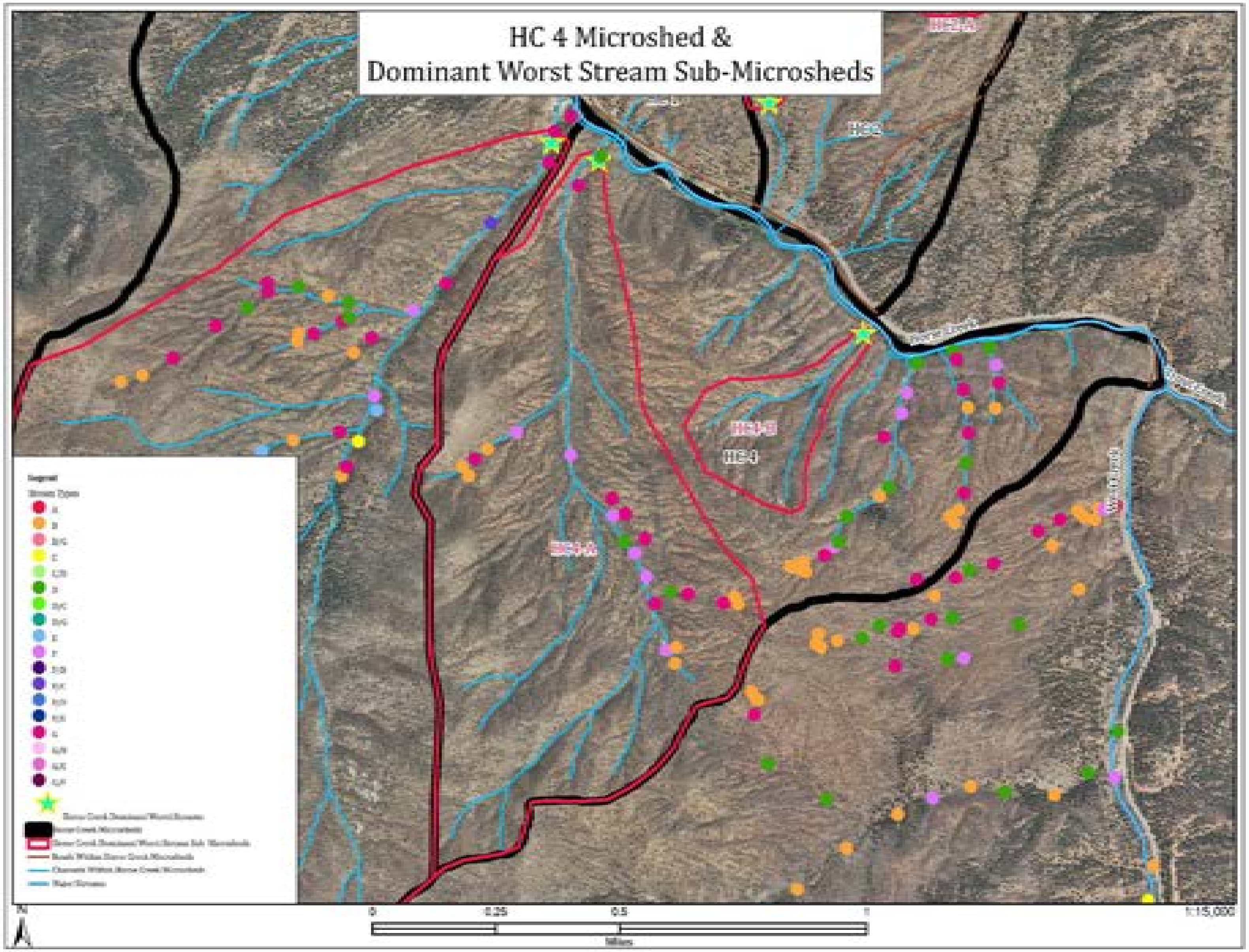


Figure 26. Stream classification for West Creek and selected tributaries.

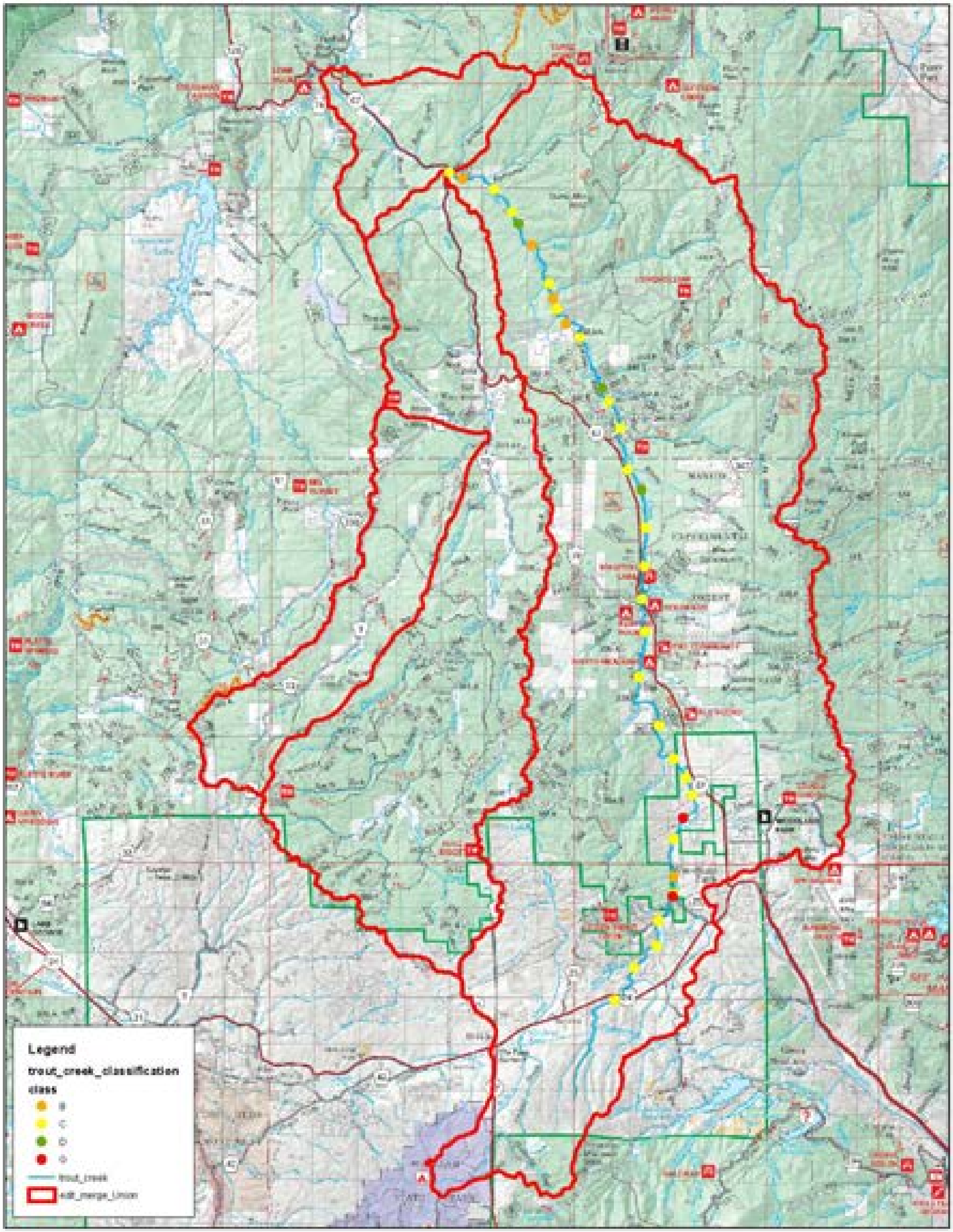


Figure 27. Stream classification for mainstem Trout Creek.

Worksheet 4-1a. Level II stream classification for the F4b stream type.

Stream:	**Trail Creek Sub Watershed - TC1A**					
Basin:	**Trail Creek**	Drainage Area:	**61**	acres	**0.095**	mi^2
Location:	**Pike National Forest - near West Creek, Colorado**					
Twp.&Rge:	**T10S R70W**	Sec.&Qtr.: **36**				
Cross-Section Monuments (Lat./Long.):	**X 485193.00 Y 4331741.01**				Date:	**6/10/2010**
Observers:	**Butler, Purnell**				Valley Type:	**III**

Parameter	Value	Units
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**23.5**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**2.3**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**54.05**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**8.7**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**2.7**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**35**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.49**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**4**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.043**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.07**	

Stream Type → **F4b** ← (See **Figure 2-14**)

Worksheet 4-1b. Level II stream classification for the G4/A4 stream type.

Stream:	**Trail Creek Sub Watershed - G Validation**					
Basin:	**Trail Creek**	Drainage Area:	**110**	acres	**0.17**	mi^2
Location:	**Pike National Forest - near West Creek, Colorado**					
Twp.&Rge:	**T11S** **R70W**	Sec.&Qtr.: **14**				
Cross-Section Monuments (Lat./Long.):	**X 483202.33** **Y 4327945.46**				Date:	**6/10/2010**
Observers:	**Butler, Purnell**				Valley Type:	**III**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**10**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.86**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**17**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.14**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**2**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**17.5**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.75**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**8**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.09**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.2**	

Stream Type **G4/A4** (See **Figure 2-14**)

Worksheet 4-1c. Level II stream classification for the D4b stream type.

Stream:	**Trail Creek Sub Watershed - TC1B**				
Basin:	**Trail Creek**	Drainage Area:	**975** acres	**1.52**	mi^2
Location:	**Pike National Forest - near West Creek, Colorado**				
Twp.&Rge:	**T10S R70W**	Sec.&Qtr.:	**36**		
Cross-Section Monuments (Lat./Long.):	**X 485235.39 Y 4331731.32**			Date:	**6/10/2010**
Observers:	**Butler, Purnell**			Valley Type:	**III**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**55.6**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.5**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**83.4**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**37**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.8**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**82.5**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.48**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**4**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.074**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**n/a**	

Stream Type	**D4b**	(See **Figure 2-14**)

Mass Erosion Risk

Using the relations in **Figure 4-1** and **Figure 4-2**, the mass erosion for both slump/earthflow and debris flows are rated in **Worksheet 4-3a** for the Trail Creek high risk sub-drainages. The summary of the mass wasting ratings are depicted for each high risk Trail Creek sub-drainage in **Worksheet 4-3a**. The ratings are *Moderate* risk due to lower gradient slopes where this process was observed, which justifies advancement to the *PLA*. However, the ratings for Trail Creek and other mainstem streams (**Worksheet 4-3b**) indicate a *Very High* risk. The reasons for this are three-fold: 1) the over-steepened (rejuvenated) slopes cut by the channel have accelerated mass wasting processes, 2) the roads constructed adjacent to the stream have also over-steepened slopes causing mass wasting onto the road surface, ditch lines and eventually to the stream, and 3) the lower slope position of the mass wasting in proximity to the stream indicated a *Very High* risk. These accelerated erosional processes will need to be mitigated by counter-buttressing slump slopes and by constructing toe protection from laterally eroding channels. Such mitigation will be specifically prescribed following the *PLA* inventory.

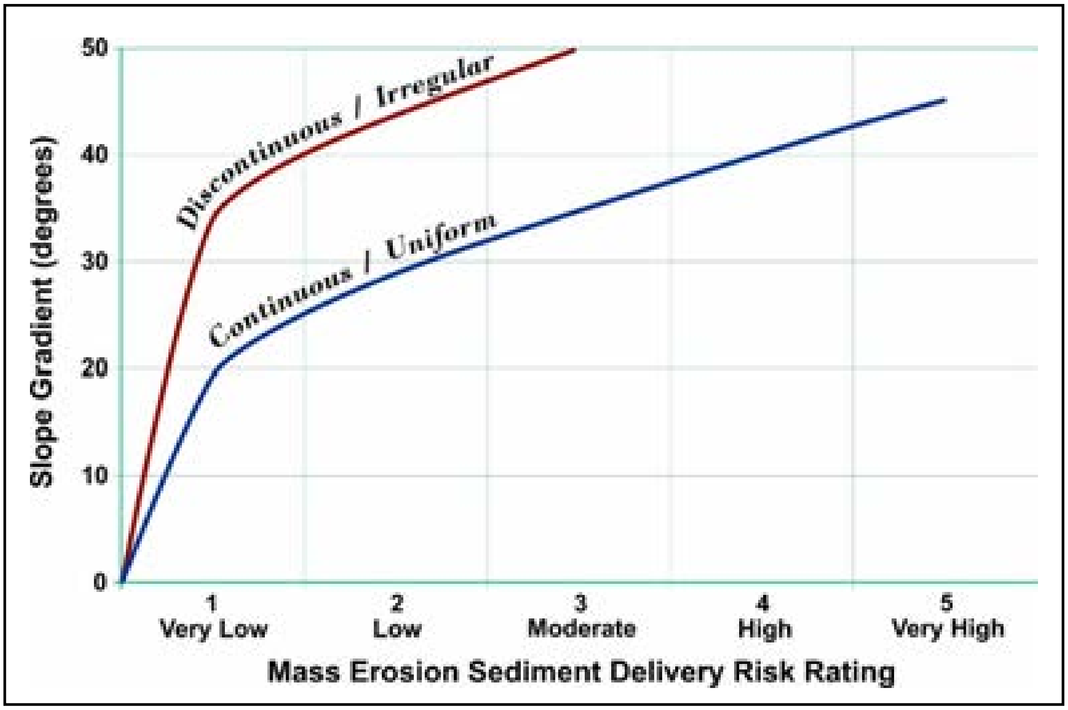


Figure 4-1. Mass erosion sediment delivery risk based on slope gradient (degrees) by slope shape.

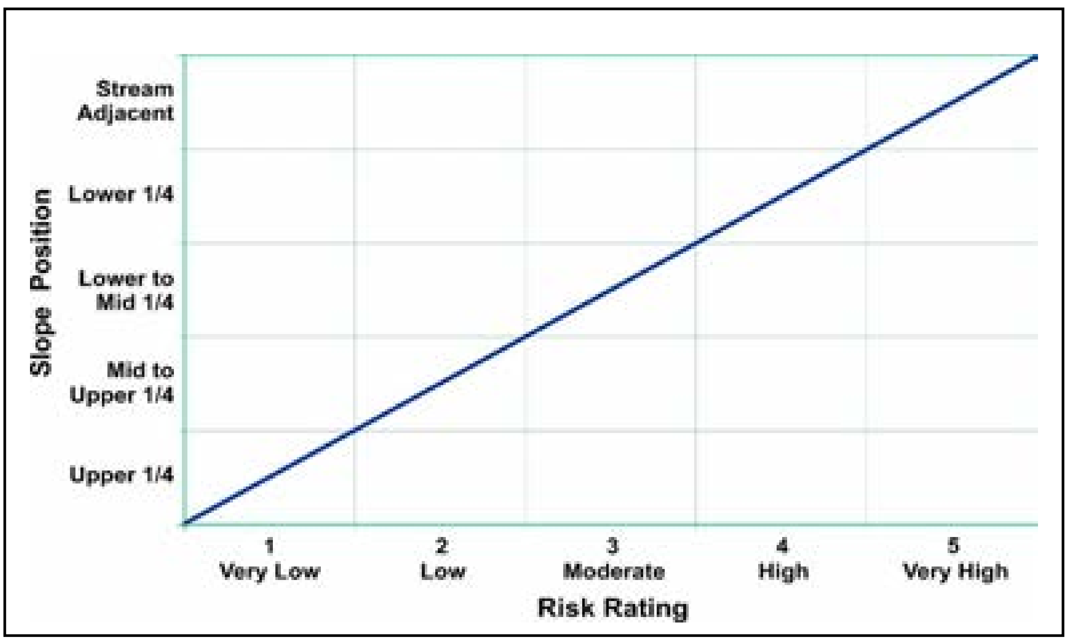


Figure 4-2. Mass erosion sediment delivery risk based on slope position.

Worksheet 4-3a. Risk rating worksheet for mass erosion sediment delivery for the sub-watersheds.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Microsheds advanced from *RLA* in Trail Creek Watershed	**Slope Gradient** (Degrees)	**Slope Shape** (Discontinuous or Continuous)	**Risk Rating:** Slope Gradient by Slope Shape **(Figure 4-1)**	**Slope Position** (Lower 1/4, Mid to Lower 1/4, Mid to Upper 1/4, Upper 1/4 or Stream Adjacent)	**Risk Rating:** Slope Position (**Figure 4-2**)	**Total Risk Rating Points by Sub-watershed ∑[(4)+(6)]**	**Overall Mass Erosion Risk Rating** (use column (7) points; insert adjective and numerical risk rating) **VL(1) = 2–3, L(2) = 3–4 M(3) = 5–6, H(4) = 7–8 VH(5) = 9–10**
TC 1	**11.31**	**Continuous**	**VL (1)**	**Stream Adjacent**	**VH (5)**	**6**	**M (3)**
TC 2	**9.09**	**Continuous**	**VL (1)**	**Stream Adjacent**	**VH (5)**	**6**	**M (3)**
TC 3	**13.50**	**Continuous**	**VL (1)**	**Stream Adjacent**	**VH (5)**	**6**	**M (3)**
TC 4	**9.09**	**Continuous**	**VL (1)**	**Stream Adjacent**	**VH (5)**	**6**	**M (3)**
TC 7	**10.20**	**Continuous**	**VL (1)**	**Stream Adjacent**	**VH (5)**	**6**	**M (3)**

No reason to advance to *RRISSC* for mass erosion based on *RLA*, but using rock type/geology criteria from **Table 4-4**, *Moderate* risk resulted

At the microshed level, the sediment delivery potential to the ephemeral crenulations is at an elevated risk due to vegetation changes that continuous and stream adjacent were selected

Worksheet 4-3b. Risk rating worksheet for mass erosion sediment delivery for the main trunk streams.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sub-watershed Location (I.D.)	**Slope Gradient** (Degrees) At road cuts where slumps are occuring	**Slope Shape** (Discontinuous or Continuous)	**Risk Rating:** Slope Gradient by Slope Shape **(Figure 4-1)**	**Slope Position** (Lower 1/4, Mid to Lower 1/4, Mid to Upper 1/4, Upper 1/4 or Stream Adjacent)	**Risk Rating:** Slope Position (**Figure 4-2**)	**Total Risk Rating Points by Sub-watershed ∑[(4)+(6)]**	**Overall Mass Erosion Risk Rating** (use column (7) points; insert adjective and numerical risk rating) **VL(1) = 2–3, L(2) = 3–4 M(3) = 5–6, H(4) = 7–8 VH(5) = 9–10**
Trail Creek	**80**	**Continuous**	**VH (5)**	**Stream Adjacent**	**VH (5)**	**10**	**VH (5)**
West Creek	**80**	**Continuous**	**VH (5)**	**Stream Adjacent**	**VH (5)**	**10**	**VH (5)**
Trout Creek	**80**	**Continuous**	**VH (5)**	**Stream Adjacent**	**VH (5)**	**10**	**VH (5)**
Horse Creek	**80**	**Continuous**	**VH (5)**	**Stream Adjacent**	**VH (5)**	**10**	**VH (5)**

Potential Sediment Delivery Risk from Roads

The risk ratings from potential sediment delivery from roads is based on risk rating relations based on the road impact index (acres of road divided by acres of sub-drainage multiplied by the number of stream crossings) as depicted in **Figure 4-3**. The potential delivery of sediment from roads is additionally rated by the relations in **Figure 4-4**, **Figure 4-5** and **Figure 4-6**. The results of these ratings are depicted in detail for the high risk Trail Creek sub-drainages in **Worksheet 4-4a**. TC1 is the only sub-drainage that rated *High* and is recommended for road assessment detail at the *PLA* level. The mainstem reaches, however, all rated *Very High* risk due to the proximity of the road fill to the channel and the large number of stream crossings that increased the road impact index (**Worksheet 4-3b**). Road recovery potential is poor because the majority of the roads are not well maintained and the cut banks, ditch lines and road fills have poor vegetative recovery and are contributing sand and fine gravel to the adjacent stream channels. It is recommended to proceed to the *PLA* on all of the major tributaries due to the road impacts. Specific mitigation by changes in road drainage, revegetation and stabilization measures will be needed to offset this very high sediment supply source.

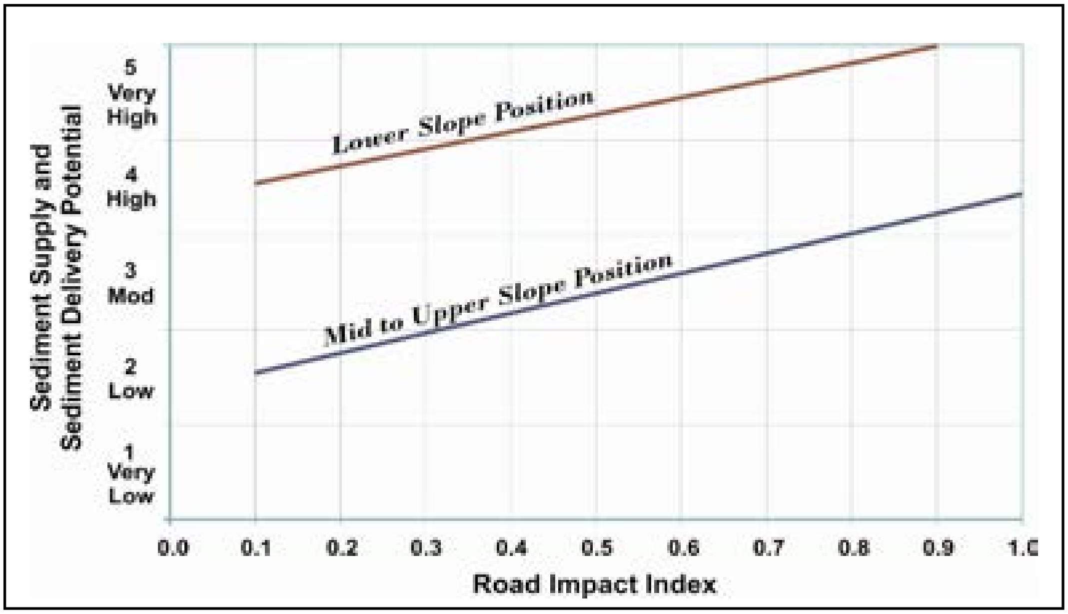


Figure 4-3. Road sediment delivery risk based on road impact index by slope position. Figure modified from Rosgen (2001) based on measured delivered road sediment to debris basins in Horse Creek Watershed, Idaho and Fool Creek, Colorado using experimental watershed data from USDA Forest Service.

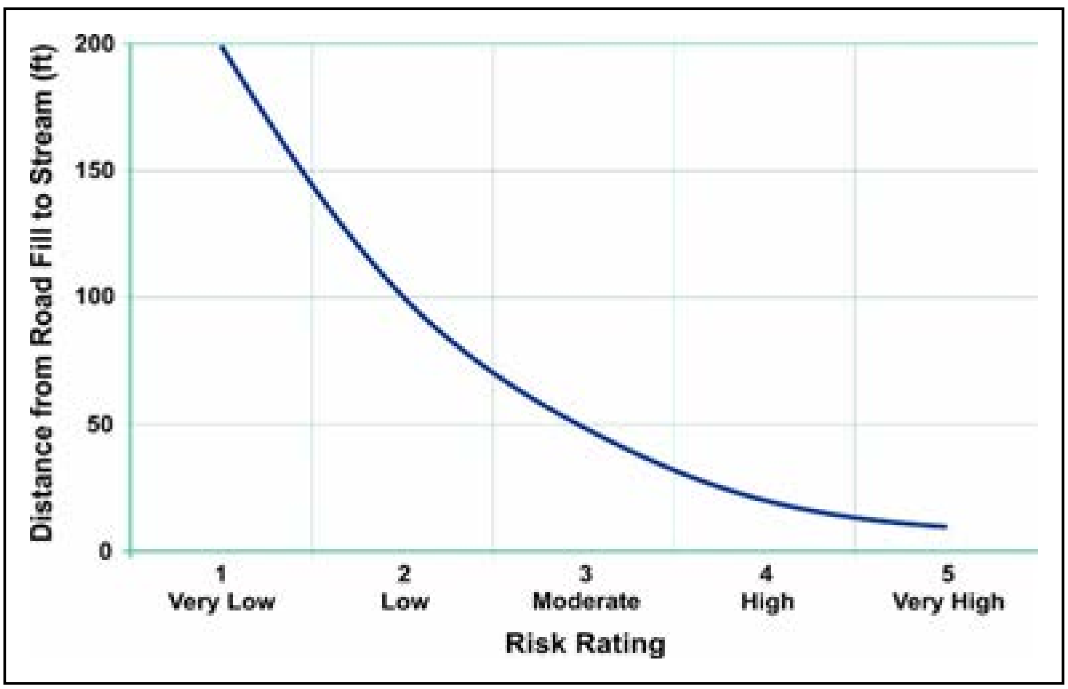


Figure 4-4. Road sediment delivery risk based on distance from road fill to stream (ft).

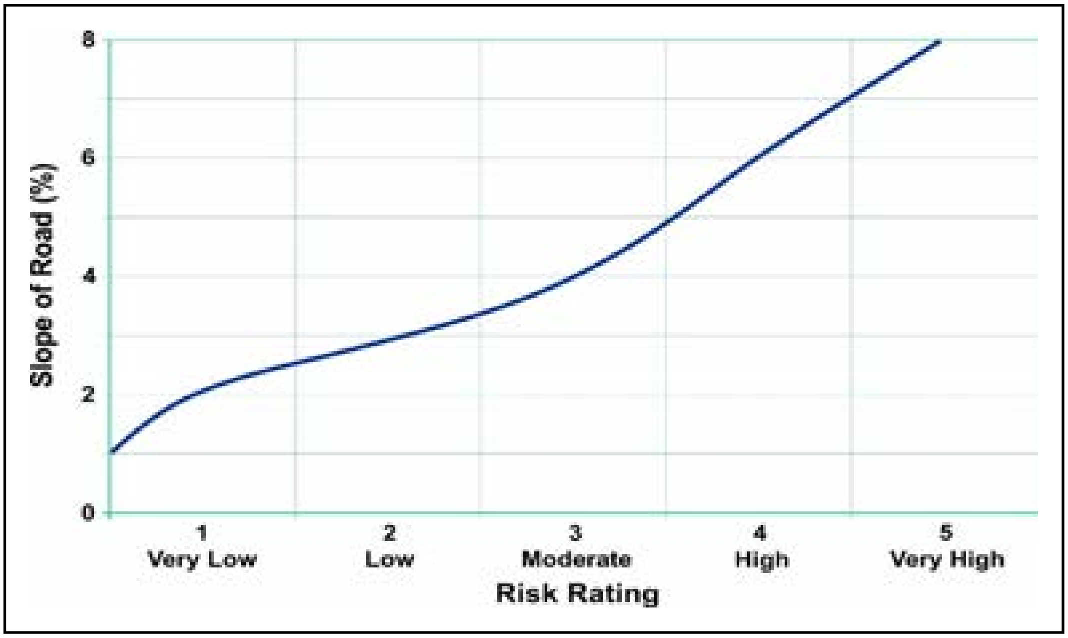


Figure 4-5. Road sediment delivery risk based on slope of road (%).

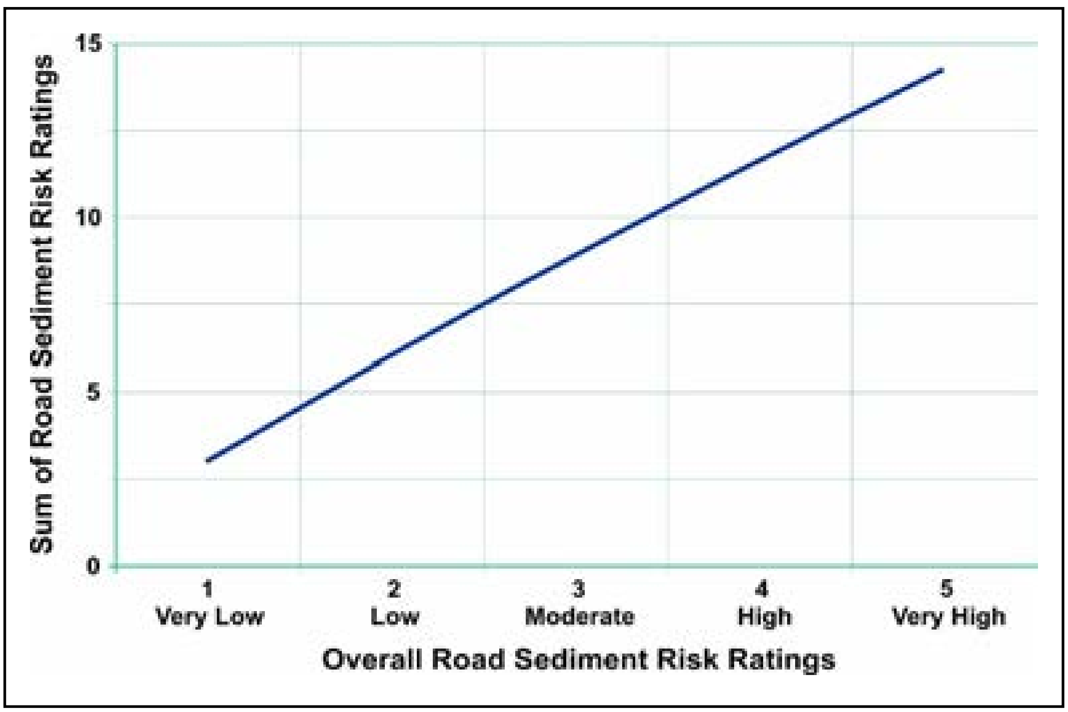


Figure 4-6. Overall road sediment delivery risk based on the sum of individual sediment risk ratings.

Worksheet 4-4a. Risk rating worksheet for potential sediment delivery from roads for the sub-watersheds.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)				(15)	(16)	(17)
Microsheds advanced from RLA in Trail Creek Watershed	**Acres of Sub-watershed** (200–5000 acres)	**Acres Disturbance of Road** (Include Cut Bank, Fill Slope, Road Surface)	**Number of Stream Crossings**	**Calculate Road Impact Index** **[(3)/(2)X(4)]** *If Crossings = 0, Multiply by 1.	**Slope Position** (Lower or Mid-Upper)	**Risk Rating:** Road Impact Index (5) by Slope Position **(Fig. 4-3)**	**Distance of Road Fill to Stream** (ft)	**Risk Rating:** Distance of Road Fill to Stream (ft) **(Fig. 4-4)**	**Slope of Road** (%)	**Risk Rating:** Slope of Road (%) **(Fig. 4-5)**	**Total Individual Risk Rating Points** **∑[(7)+(9)+(11)]**	**Overall Risk Rating for Potential Sediment from Roads (Fig. 4-6)**	**Adjustments for Construction, Design and Age of Road**				**Risk Rating Adjustments for Mass Erosion Potential Slump/ Earthflow*** (Table 4-4, Figs. 4-1, 4-2)**	**Debris Torrent/ Avalanche:** If Erosion Risk and Sediment Delivery Potential is *High*, Raise Final Road Risk Rating to *Very High* **(Table 4-4, Figs. 4-1, 4-2)**	**Final Risk Rating of Potential Sediment from Roads**
													Age of Road: If > 7 yrs and Sediment Delivery Potential = *Low*, Reduce One Risk Category*	**Road Surfacing:** If Gravel/ Asphalt, then Reduce One Risk Category**	**Ditch Line:** If Surfacing Out-sloped, Reduce One Risk Category	**Vegetative Condition of Cut Banks, Road Fills:** If > 50% Ground Cover, Reduce One Risk Category			
TC 1	**1202**	**15.4**	**19**	**0.243**	**Lower**	**H (4)**	**25**	**H (4)**	**6%**	**H (4)**	**12**	**H (4)**					**M (3)**		**H (4)**
TC 2	**854**	**2.6**	**1**	**0.003**	**Mid-Upper**	**L (2)**	**200**	**VL (1)**	**1%**	**VL (1)**	**4**	**VL (1)**					**M (3)**		**L (2)**
TC 3	**3024**	**23.6**	**48**	**0.374**	**Mid-Upper**	**M (3)**	**50**	**M (3)**	**6%**	**H (4)**	**10**	**M (3)**					**M (3)**		**M (3)**
TC 4	**2229**	**31.9**	**45**	**0.644**	**Lower**	**VH (5)**	**125**	**L (2)**	**3%**	**L (2)**	**9**	**M (3)**					**M (3)**		**M (3)**
TC 7	**2153**	**13.3**	**24**	**0.148**	**Lower**	**H (4)**	**140**	**L (2)**	**6%**	**H (4)**	**10**	**M (3)**					**M (3)**		**M (3)**

***Unless: Road has not recovered; poor maintenance; poor vegetative cover on cut bank and fill slopes - ditch line is still leading water into stream.**

****Unless: Road cut bank, fills and ditch line continue to provide sediment source to stream.**

*****If risk is *high* for potential sediment delivery of mass erosion (Worksheet 4-3), then adjust overall risk up one category.**

Chose Lower slope position as the dominant position and to maximize risk

Looked at all roads and made judgement call on distance from road to acknowledge hydrologic connectivityand lack of road maintenance

Road slope, utilized contours to determine dominant road slope only of sediment contributing roads - if many places where drainage and road coincide slope bumped up to high

TC1 - Chose 25 ft as Distance from Road Fill to Stream (75% within 25 feet) dominant average distance in the watershed

TC2 - Chose 200 ft as Distance from Road Fill to Stream (about 15%) of road is within 25 feet of stream (not too great of road sediment delivery risk)

TC7 - Chose 50 ft (about 50% of roads deliver sediment, a moderate risk)

TC4 - Chose 125 ft distance resulting in a Low risk

TC3 - Chose 50 feet - roads pose a moderate risk of delivering sediment

Worksheet 4-4b. Risk rating worksheet for potential sediment delivery from roads for the main trunk streams.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)				(15)	(16)	(17)
Sub-watershed Location (I.D.)	**Corridor Acres of Sub-watershed** (200–5000 acres)	**Acres Disturbance of Road** (Include Cut Bank, Fill Slope, Road Surface) 20 feet width for trail creek road	**Number of Stream Crossings**	**Calculate Road Impact Index [(3)/(2)X(4)]** *If Crossings = 0, Multiply by 1.	**Slope Position** (Lower or Mid-Upper)	**Risk Rating:** Road Impact Index (5) by Slope Position **(Fig. 4-3)**	**Distance of Road Fill to Stream** (ft)	**Risk Rating:** Distance of Road Fill to Stream (ft) **(Fig. 4-4)**	**Slope of Road** (%)	**Risk Rating:** Slope of Road (%) **(Fig. 4-5)**	**Total Individual Risk Rating Points ∑[(7)+(9)+(11)]**	**Overall Risk Rating for Potential Sediment from Roads (Fig. 4-6)**	**Adjustments for Construction, Design and Age of Road**				**Risk Rating Adjustments for Mass Erosion Potential Slump/ Earthflow*** (Table 4-4, Figs. 4-1, 4-2)**	**Debris Torrent/ Avalanche:** If Erosion Risk and Sediment Delivery Potential is *High*, Raise Final Road Risk Rating to *Very High* **(Table 4-4, Figs. 4-1, 4-2)**	**Final Risk Rating of Potential Sediment from Roads**
													Age of Road: If > 7 yrs and Sediment Delivery Potential = *Low*, Reduce One Risk Category*	**Road Surfacing:** If Gravel/ Asphalt, then Reduce One Risk Category**	**Ditch Line:** If Surfacing Out-sloped, Reduce One Risk Category	**Vegetative Condition of Cut Banks, Road Fills:** If > 50% Ground Cover, Reduce One Risk Category			
Trail Creek	**223**	**24.8**	**20**	**2.22**	**Lower**	**VH (5)**	**10**	**VH (5)**	**1%**	**VL (1)**	**11**	**H (4)**	**0**	**0**	**0**	**0**	**VH (5)**		**VH (5)**
West Creek	**484**	**33.9**	**42**	**2.94**	**Lower**	**VH (5)**	**10**	**VH (5)**	**1%**	**VL (1)**	**11**	**H (4)**	**0**	**0**	**0**	**0**	**VH (5)**		**VH (5)**
Trout Creek	**843**	**9.4**	**31**	**0.35**	**Lower**	**VH (5)**	**10**	**VH (5)**	**1%**	**VL (1)**	**11**	**H (4)**	**0**	**0**	**0**	**0**	**VH (5)**		**VH (5)**
Horse Creek	**85**	**6.8**	**5**	**0.40**	**Lower**	**VH (5)**	**10**	**VH (5)**	**1%**	**VL (1)**	**11**	**H (4)**	**0**	**0**	**0**	**0**	**VH (5)**		**VH (5)**

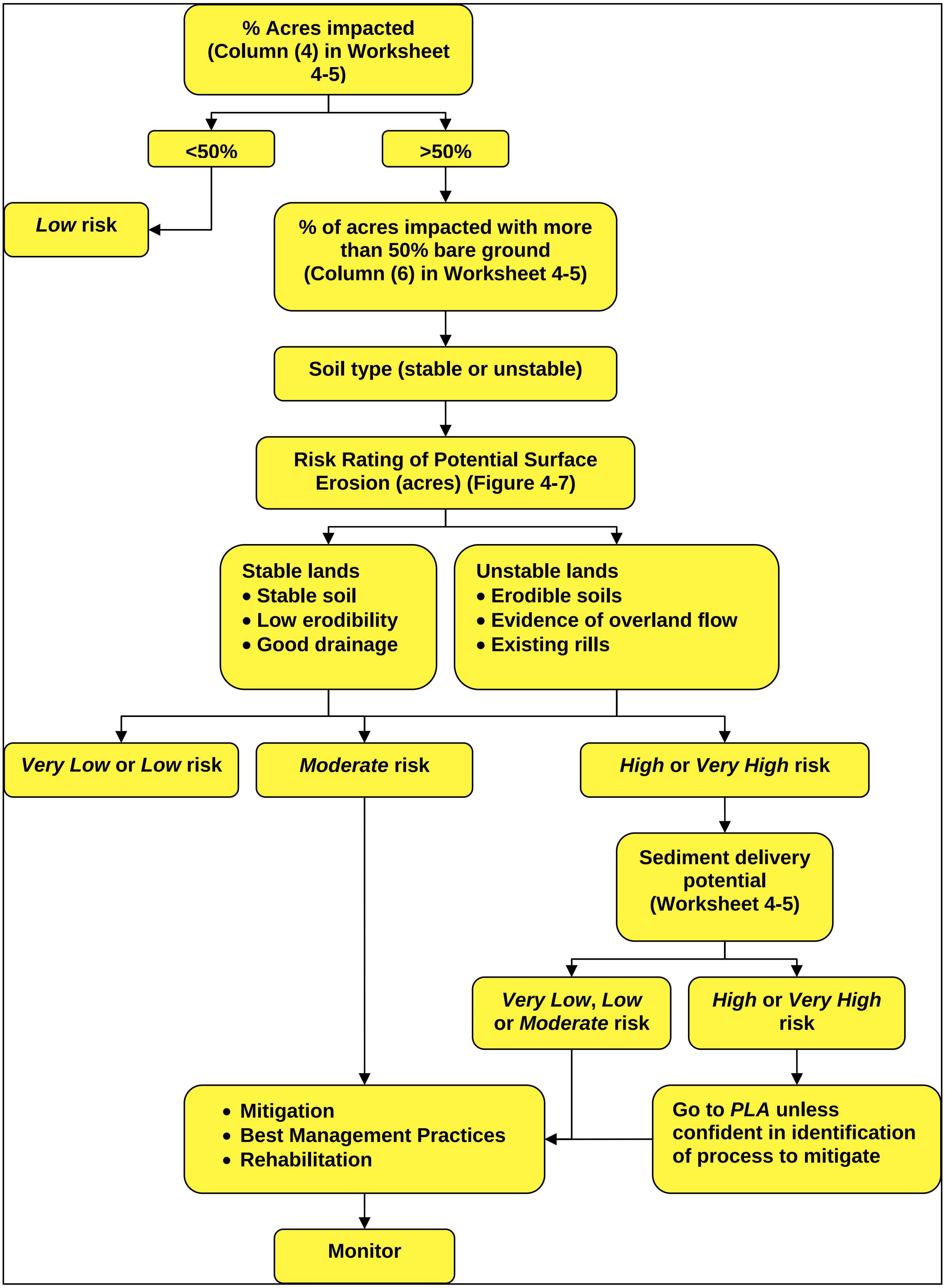
***Unless: Road has not recovered; poor maintenance; poor vegetative cover on cut bank and fill slopes - ditch line is still leading water into stream.**

****Unless: Road cut bank, fills and ditch line continue to provide sediment source to stream.**

*****If risk is *high* for potential sediment delivery of mass erosion (Worksheet 4-3), then adjust overall risk up one category.**

Surface Erosion Risk

The criteria for the potential delivered sediment from surface erosion are based not only on the erodibility of the soils and ground cover density, but also on the potential delivery of sediment (i.e., soil loss does not equal sediment delivered to a stream channel). The approach for this assessment is depicted in **Flowchart 4-2**, and specific criteria for this process are shown in **Figure 4-7** through **Figure 4-13**. Of the ratings completed for the high risk Trail Creek sub-drainages in **Worksheet 4-5a**, all were *High* risk; however, only 10% of their area or less were rated as such. Advancement of this process to the *PLA* is recommended but only these acres would be involved in assessment for restoration or stabilization. The mainstem reaches evaluated in **Worksheet 4-5b** also rated *Very High* risk for approximately 10% of the area, which also requires advancing to the *PLA*, but mapping specific, localized areas where the sediment delivery potential was the highest.



Flowchart 4-2. Specific land use activities relating to surface erosion potential and delivered sediment from surface disturbance.

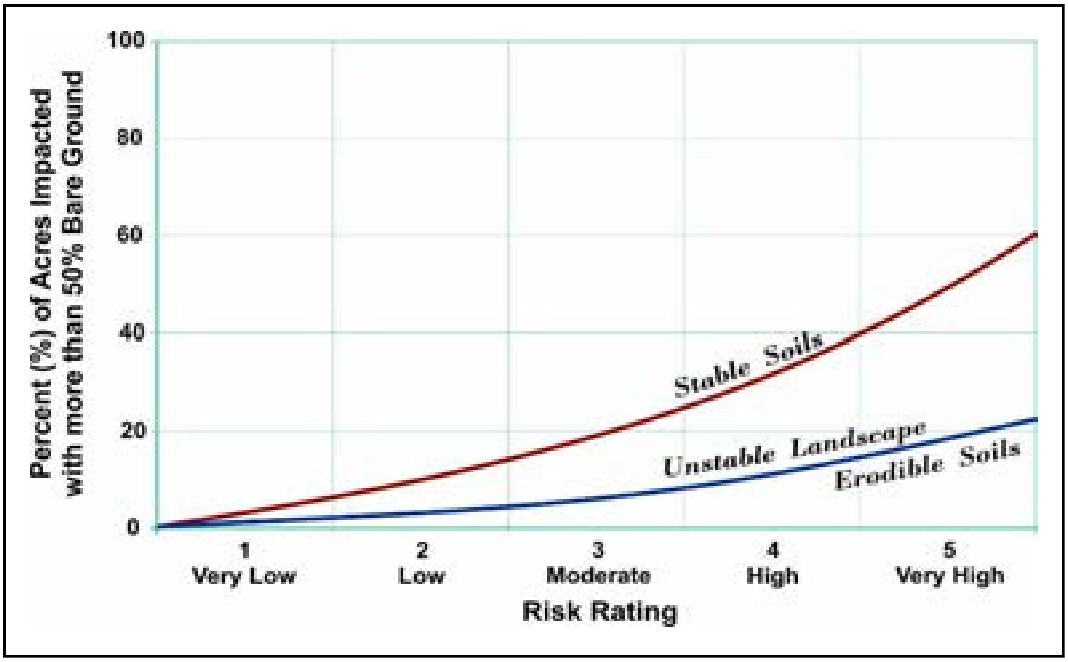


Figure 4-7. Surface erosion risk based on percent of acres impacted with more than 50% bare ground by soil type.

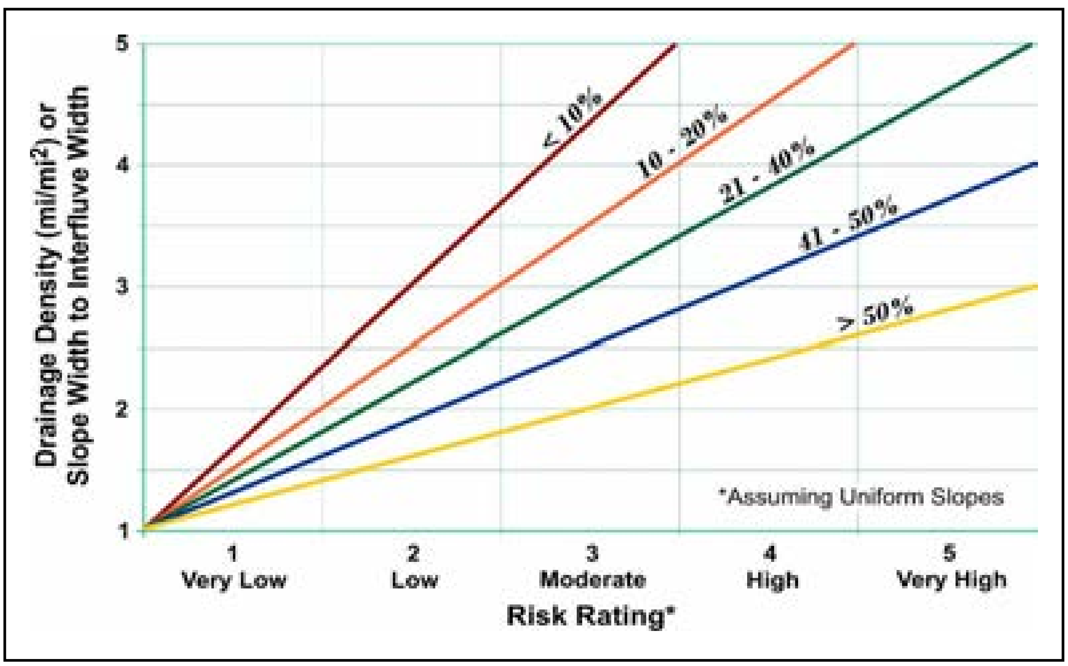


Figure 4-8. Surface erosion sediment delivery risk based on drainage density by slope gradient (%).

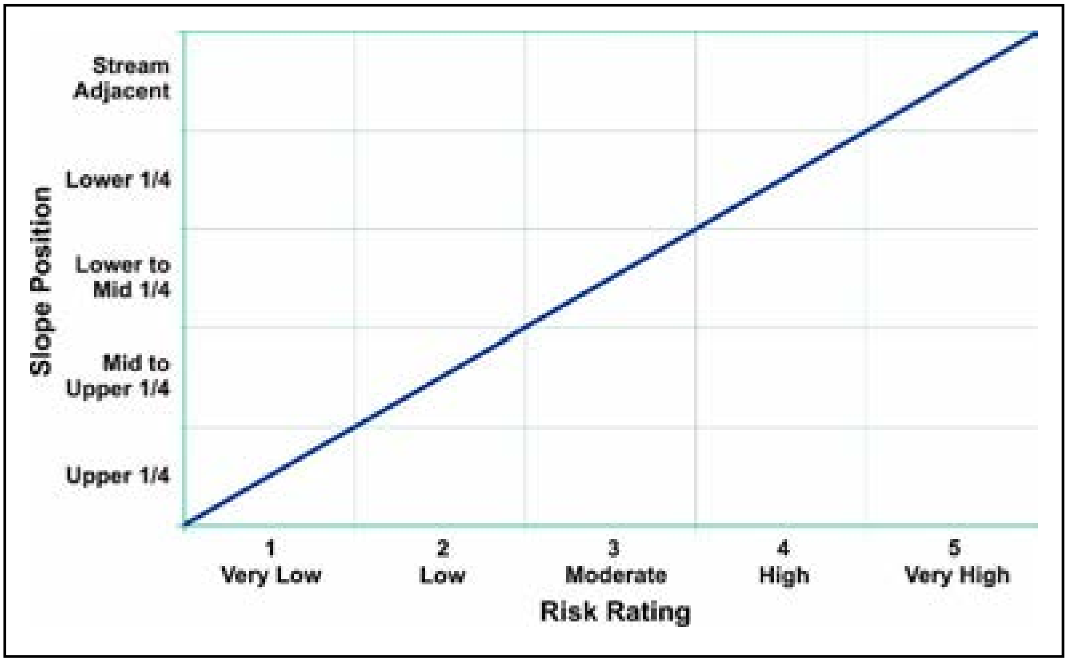


Figure 4-9. Surface erosion sediment delivery risk based on slope position.

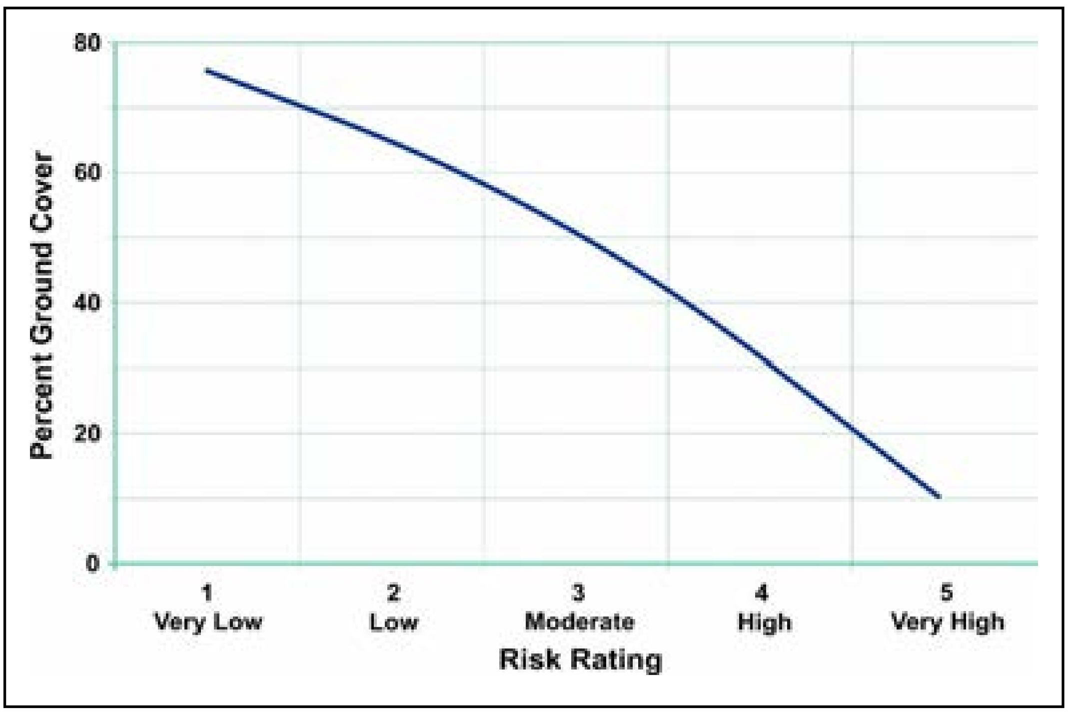


Figure 4-10. Surface erosion sediment delivery risk based on percent ground cover.

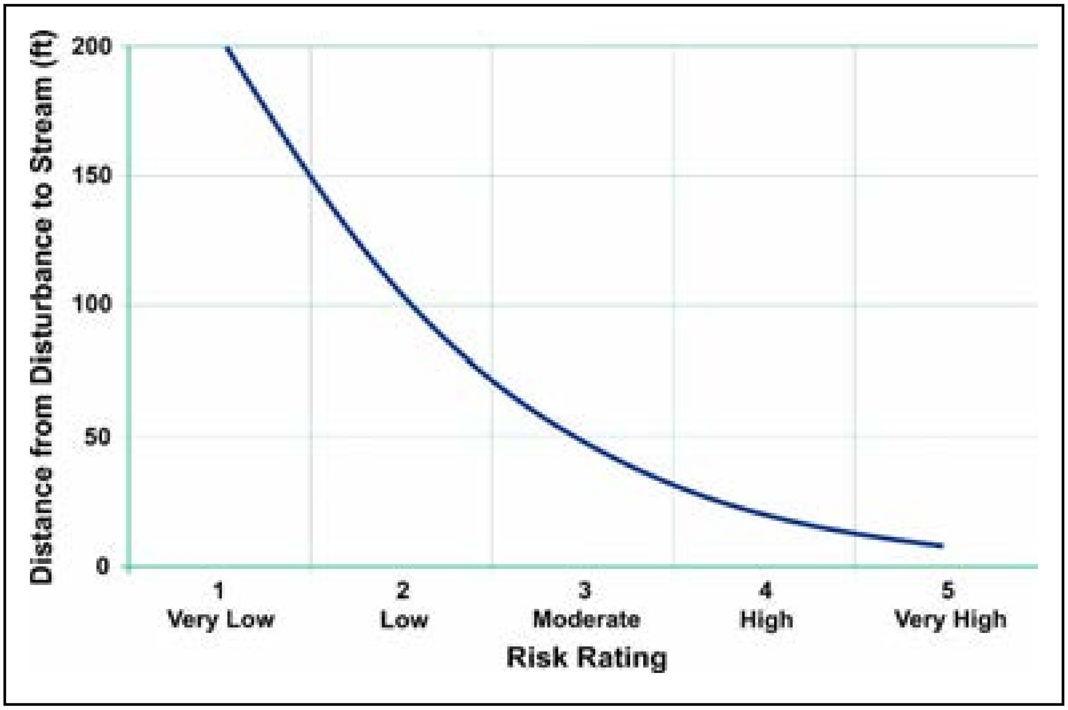


Figure 4-11. Surface erosion sediment delivery risk based on distance from disturbance to stream (ft).

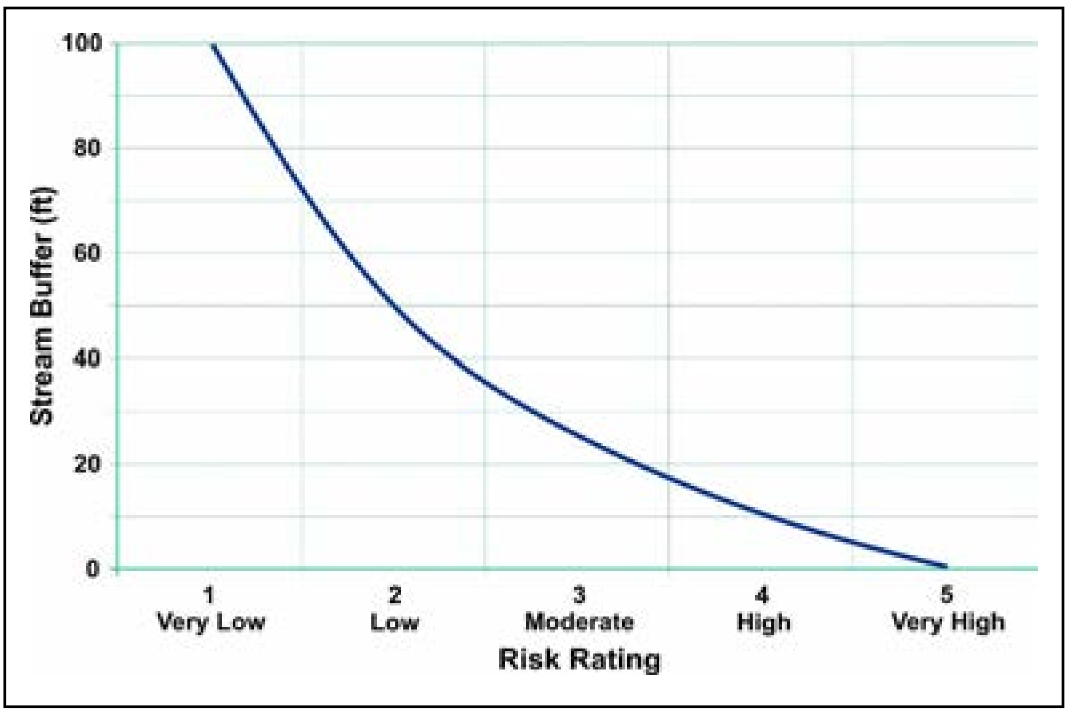


Figure 4-12. Surface erosion sediment delivery risk based on stream buffer (ft).

Figure 4-13. Overall sediment delivery risk based on the sum of individual sediment delivery risk ratings.

Worksheet 4-5a. Risk rating worksheet for surface erosion and sediment delivery potential for the sub-watersheds.

	Surface Erosion Potential							Sediment Delivery Potential: Continue only if Rating in Column (8) is *High* or *Very High*							
								Converted Ratios or Conditions for Numerical Risk Ratings of Sediment Delivery Potential							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Microsheds advanced from RLA in Trail Creek Watershed	Total Acres of Sub-watershed	Acres Impacted*	Percent of Acres Impacted [(3)/(2)X 100]	**Acres Impacted (3) with more than 50% Bare Ground	Percent of Acres Impacted with more than 50% Bare Ground [(5)/(3)X 100]	Landscape Type (Stable or Unstable)	**Overall Risk Rating:** Surface Erosion **(Fig. 4-7)**	**Risk Rating:** Drainage Density by Slope Gradient (%) **(Fig. 4-8)**	**Risk Rating:** Slope Position **(Fig. 4-9)**	**Risk Rating:** Percent Ground Cover **(Fig. 4-10)**	**Risk Rating:** Distance of Disturbance to Stream (ft) **(Fig. 4-11)**	**Risk Rating:** Stream Buffer (ft) **(Fig. 4-12)**	**Total Individual Risk Rating Points ∑[(9) through (13)]**	**Overall Risk Rating:** Sediment Delivery Potential; Use (14) Points **(Fig. 4-13)**	**% of Sub-watershed with *H* or *VH* Erosion Potential, and with *H* or *VH* Sediment Delivery Potential** (see map)
TC 1	**1202**	**1046**	**87.02**	**105**	**10**	**Unstable**	**H (4)**	**VH (5)**	**VH (5)**	**M (3)**	**H (4)**	**H (4)**	**21**	**H (4)**	**10**
TC 2	**854**	**829**	**97.08**	**83**	**10**	**Unstable**	**H (4)**	**VH (5)**	**VH (5)**	**M (3)**	**H (4)**	**H (4)**	**21**	**H (4)**	**10**
TC 3	**3024**	**2334**	**77.18**	**233**	**10**	**Unstable**	**H (4)**	**VH (5)**	**VH (5)**	**M (3)**	**H (4)**	**H (4)**	**21**	**H (4)**	**10**
TC 4	**2229**	**1635**	**73.34**	**164**	**10**	**Unstable**	**H (4)**	**VH (5)**	**VH (5)**	**M (3)**	**H (4)**	**H (4)**	**21**	**H (4)**	**10**
TC 7	**2153**	**2162**	**100.43**	**216**	**10**	**Unstable**	**H (4)**	**VH (5)**	**VH (5)**	**M (3)**	**H (4)**	**H (4)**	**21**	**H (4)**	**10**

***Do not include road acres**

****Column (5) utilized *Mod* and *High* burn severity to get bare ground percent**

From field observations, about 10% of the impacted acres have more then 50% bare ground

Worksheet 4-5b. Risk rating worksheet for surface erosion and sediment delivery potential for the main trunk streams.

	Surface Erosion Potential							Sediment Delivery Potential — Continue only if Rating in Column (8) is *High* or *Very High*							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
								Converted Ratios or Conditions for Numerical Risk Ratings of Sediment Delivery Potential							
Sub-watershed Location (I.D.)	Total Corridor Acres of Sub-watershed	Acres Impacted*	Percent of Acres Impacted [(3)/(2)X100]	Acres Impacted (3) with more than 50% Bare Ground	Percent of Acres Impacted with more than 50% Bare Ground [(5)/(3)X100]	Landscape Type (Stable or Unstable)	**Overall Risk Rating:** Surface Erosion **(Fig. 4-7)**	**Risk Rating:** Drainage Density by Slope Gradient (%) **(Fig. 4-8)**	**Risk Rating:** Slope Position **(Fig. 4-9)**	**Risk Rating:** Percent Ground Cover **(Fig. 4-10)**	**Risk Rating:** Distance of Disturbance to Stream (ft) **(Fig. 4-11)**	**Risk Rating:** Stream Buffer (ft) **(Fig. 4-12)**	**Total Individual Risk Rating Points ∑[(9) through (13)]**	**Overall Risk Rating:** Sediment Delivery Potential; Use (14) Points **(Fig. 4-13)**	**% of Sub-watershed with *H* or *VH* Erosion Potential, and with *H* or *VH* Sediment Delivery Potential** (see map)
Trail Creek	**223**	**22.3**	**10%**	**4.46**	**20%**	**unstable**	**VH (5)**	**H (4)**	**VH (5)**	**H (4)**	**H (4)**	**VH (5)**	**22**	**H (4)**	**10%**
West Creek	**484**	**48.4**	**10%**	**9.68**	**20%**	**unstable**	**VH (5)**	**H (4)**	**VH (5)**	**H (4)**	**H (4)**	**VH (5)**	**22**	**H (4)**	**10%**
Trout Creek	**843**	**84.3**	**10%**	**16.86**	**20%**	**unstable**	**VH (5)**	**H (4)**	**VH (5)**	**H (4)**	**H (4)**	**VH (5)**	**22**	**H (4)**	**10%**
Horse Creek	**85**	**8.5**	**10%**	**1.7**	**20%**	**unstable**	**VH (5)**	**H (4)**	**VH (5)**	**H (4)**	**H (4)**	**VH (5)**	**22**	**H (4)**	**10%**

***Do not include road acres.**

Streamflow Change Potential

The risk ratings for potential increases in streamflow are based on acreages impacted by wildfire, roads and stand treatments that prompted changes in evapo-transpiration, interception loss and snowpack deposition pattern changes. The mapping of fire intensity of the Hayman fire used only the acreages that had a *Moderate* to *High* burn intensity, as the *Low* intensity burn acreage was not utilized (**Table 1**). The potential increase in streamflow due to less consumptive use is adjusted by the "weak link" stream type (the stream type most susceptible for channel erosion based on increased flood flows). The criteria is based on the percent of the watershed impacted by stream type and are shown in **Figure 4-14** and **Figure 4-15**. **Figure 16** was used to adjust the *Moderate* risk rating for TC3 to *Very High* due to the high percentage and high intensity of wildfire in this area and potential flood peak increases. Because urban effects (**Figure 4-15**) and diversions creating a decrease in streamflow from "donor" streams (**Figure 4-17**) are not applicable to the Horse Creek Watershed, these criteria were *not used* in the risk rating assessment. However, due to the high percentage of watershed impacted and the sensitive stream types, all of the sub-drainages rated *High* to *Very High* and are recommended to advance to *PLA* (**Worksheet 4-6a**). The trunk streams, using the entire watershed above the mouth of each major drainage, also indicated *High* to *Very High* ratings to justify advancement to the *PLA* (**Worksheet 4-6b**). The magnitude of watershed impacted on Trail Creek is 42%, Horse Creek 26%, West Creek 37%, and Trout Creek 15%, all requiring advancement to the *PLA* (**Worksheet 4-6b**). Mitigation for these *High* to *Very High* sediment supply risk areas is related to stabilizing streambed and banks, grade control, development of floodplain function and converting unstable stream types to more stable and resilient stream types (i.e., F to C, G to B, etc.). In many cases, the G channel has incised in alluvial fans; thus the stable form would be the D steam type to induce naturally stored sediment on the fan rather than rout the sediment to the receiving channel. It will take many years for these watersheds to recover hydrologically, but continued effort to replant and help in revegetation efforts would be beneficial. Additional specific recommendations and design criteria will result from a more detailed *PLA* for these areas.

The roads and the increased sediment due to streamflow increases appear to be some of the most significant sources of sediment at this level of assessment and will be quantified in the *PLA* where a water yield model, sediment rating curves and sediment transport models will determine sediment transport capacity and supply from these processes. The aerial photo shown in **Figure 28** depicts a tributary to Trail Creek as well as the mainstem showing exposed soils susceptible to accelerated erosion due to the potential increase in flood peaks from the recent Hayman wildfire. The stream type is a G4 that has cut through and abandoned a previously active alluvial fan.

Table 1. Total acres divided by intensity of the burn: *Low*, *Moderate* or *High*.

Microsheds advanced from RLA in Trail Creek Watershed	Total Acres	*Low* Intensity Burn Acres	*Moderate* Intensity Burn Acres	*High* Intensity Burn Acres	Unburned Acres
TC 1	1202	603	151	254	194
TC 2	854	478	200	129	47
TC 3	3024	982	1236	91	715
TC 4	2229	633	1061	69	436
TC 7	2153	783	826	416	128

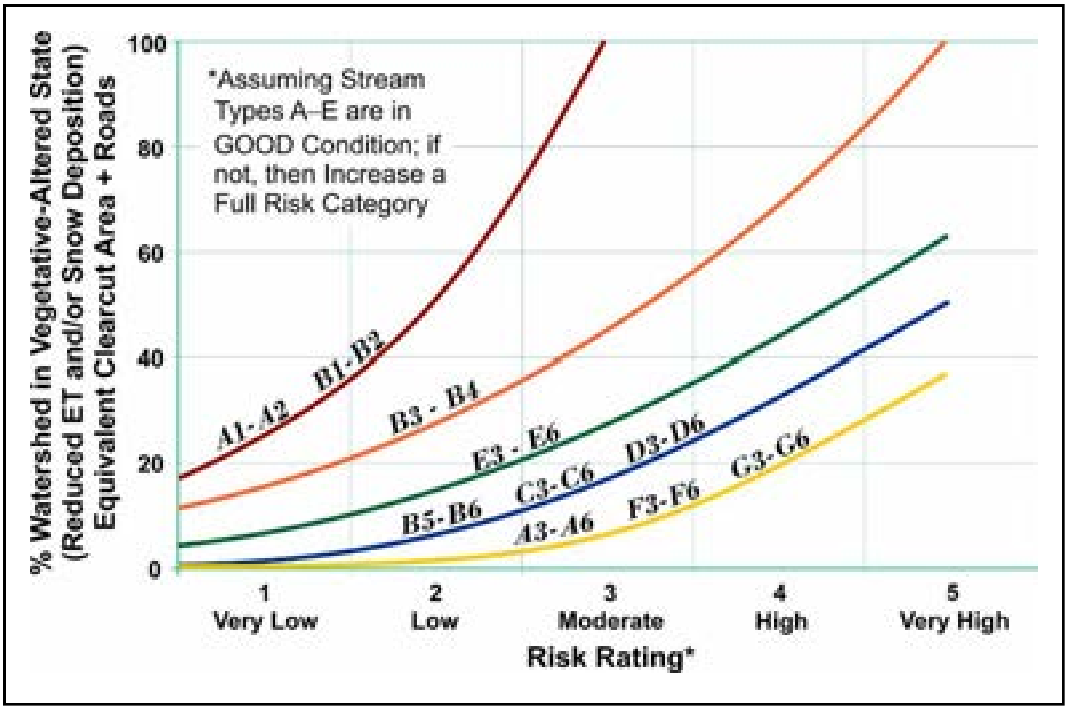


Figure 4-14. Rural watershed flow-related sediment increase risk based on percent of watershed in vegetation-altered state by stream type.

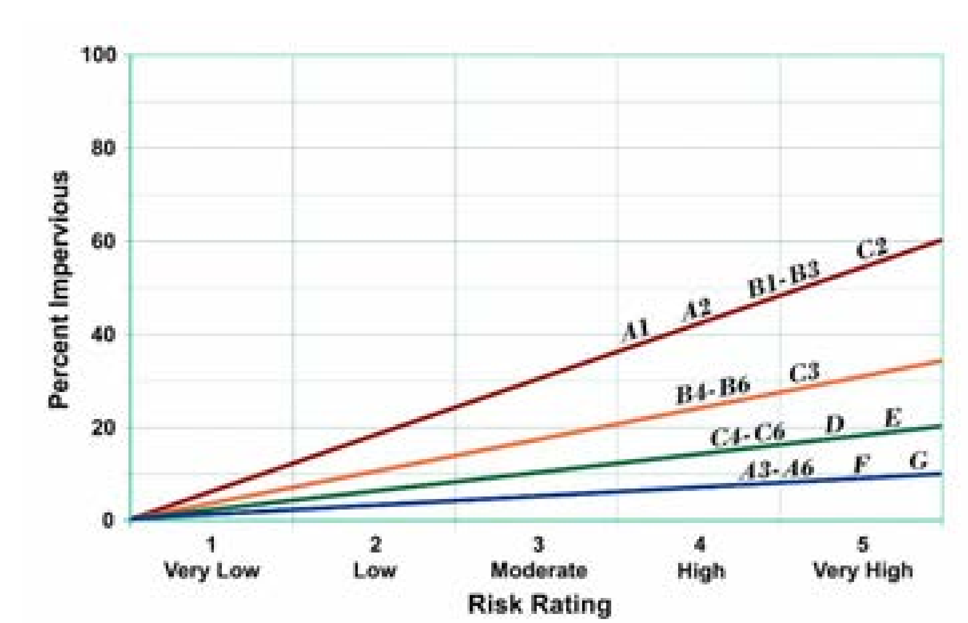
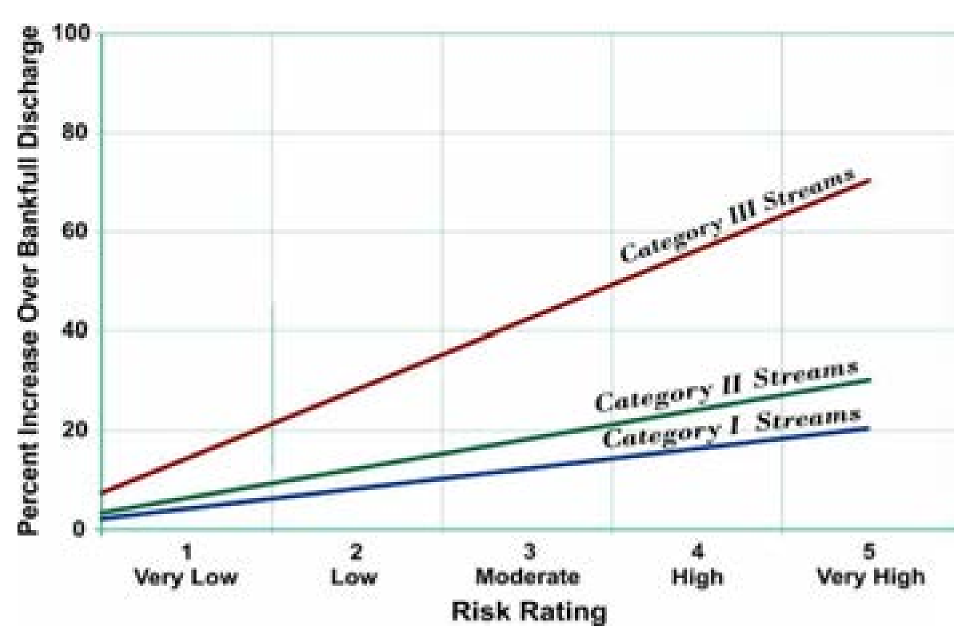


Figure 4-15. Urban development flow-related sediment increase risk based on percent impervious by stream type.



Stream Type Category	***Stream Types***
Category I (Entrenched)	*A3–A6, F3–F6, G3–G6*
Category II	*E3–E6, D3–D6, C3–C6, B5–B6*
Category III	*A1–A2, B1–B4, C1–C2, F1–F2, G1–G2*
**If Duration in Days are Doubled, then Category I and II Stream Types = HIGH – VERY HIGH Depending on Extent of Duration in Days*	

Figure 4-16. Relation of potential risk for channel adjustment/sediment supply due to increase in bankfull discharge from increased streamflow from imported water or reservoir releases by stream type category. Category I stream types are the most sensitive or subjective to rapid adverse change due to flow increases.

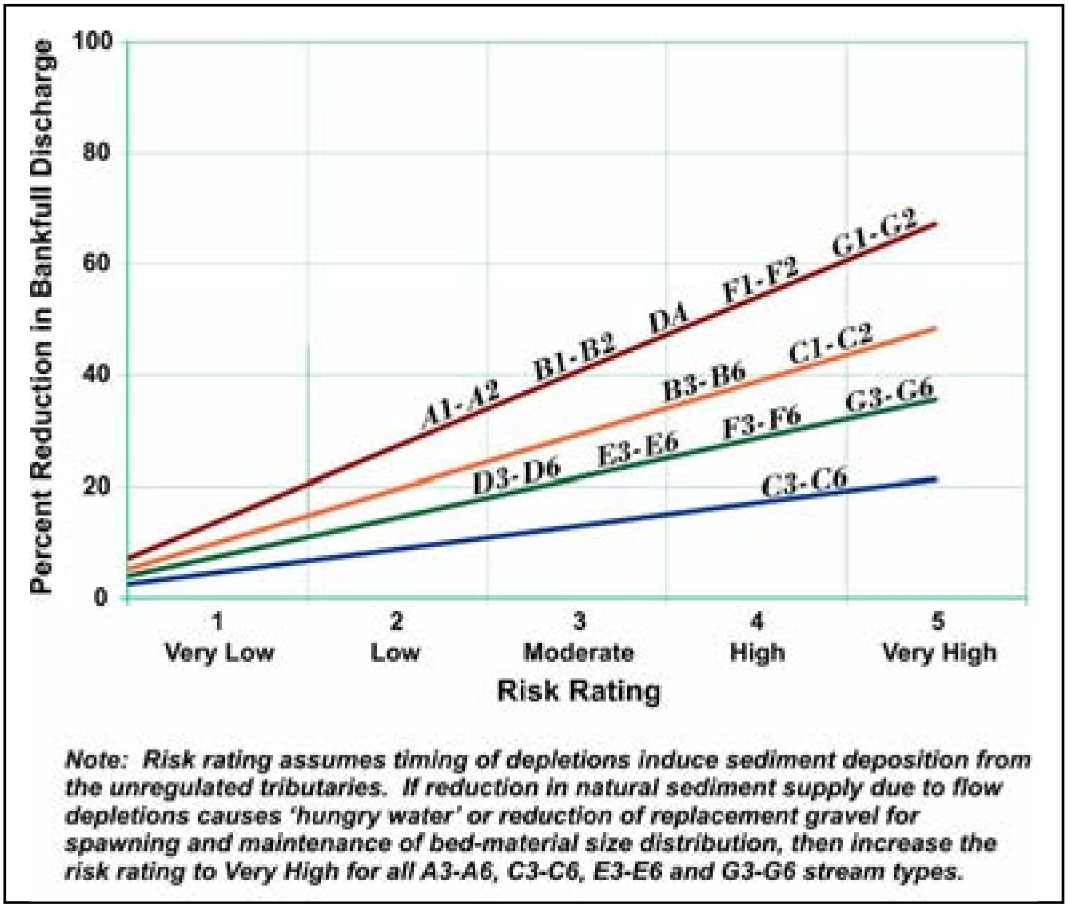


Figure 4-17. Relation of potential risk of adverse channel adjustment due to flow depletion/timing change by stream type.

Worksheet 4-6a. Risk rating worksheet for streamflow changes for the sub-watersheds.

					Rural Sub-watershed Risk				Urban Sub-watershed Risk				Adjustments		
(1)	(2)				(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Microsheds advanced from *RLA* in Trail Creek Watershed	Total Acres	Road acres	Mod/ High Fire Acres	Salvage Acres	Acres Cleared/ Harvested (Include Roads) **[Roads + Clearcut = Total]**	Percent Cleared/ Harvested of Total **[(3)/(2)X 100]**	Stream Type Most Susceptible to Change or "Weak Link"	**Risk Rating:** Rural Sub-watershed Risk **(Fig. 4-14)** (4) by Stream Type (5)	Total Impervious Acres	Percent Impervious **[(7)/(2)X100]**	Stream Type Most Susceptible to Change or "Weak Link"	**Risk Rating:** Urban Sub-watershed Risk (**Fig. 4-15**) (8) by Stream Type (9)	**Risk Rating:** Percent Increase over Bankfull Discharge **(Fig. 4-16)***	**Risk Rating:** Percent Reduction in Bankfull Discharge **(Fig. 4-17)***	**Overall Risk Rating:** Streamflow Changes (Insert Adjective and Numeric Rating)
TC 1	**1202**	**15.4**	**405**	**118**	**538**	**44.8**	**F/G**	**H (4)**	**No Urban Risk**						**H (4)**
TC 2	**854**	**2.6**	**329**	**0**	**332**	**38.8**	**F/G**	**H (4)**							**H (4)**
TC 3	**3024**	**23.6**	**1327**	**0**	**1351**	**44.7**	**F/G**	**M (3)***					**VH (5)***		**VH (5)***
TC 4	**2229**	**31.9**	**1130**	**892**	**2054**	**92.1**	**F/G**	**VH (5)**							**VH (5)**
TC 7	**2153**	**13.3**	**1240**	**718**	**1971**	**91.6**	**F/G**	**VH (5)**							**VH (5)**

Overall Risk Rating for TC3 is *Very High* based on increase in bankfull flow

Worksheet 4-6b. Risk rating worksheet for streamflow changes for the main trunk streams.

						Rural Sub-watershed Risk						Urban Sub-watershed Risk				Adjustments		
(1)		(2)				(3)			(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Sub-watershed Location/River Reach I.D.	Total Acres	Riparian area river corridor acreage	Corridor Road Acres	Logged areas and salvage	Fire	Acres Cleared/ Harvested (Include Roads) **[Roads + Clearcut = Total]**	Roads	Salvage Acres	Percent Cleared/ Harvested of Total	Stream Type Most Susceptible to Change or "Weak Link"	**Risk Rating:** Rural Sub-watershed Risk **(Fig. 4-14)** (4) by Stream Type (5)	Total Impervious Acres	Percent Impervious **[(7)/(2)X 100]**	Stream Type Most Susceptible to Change or "Weak Link"	**Risk Rating:** Urban Sub-watershed Risk (**Fig. 4-15**) (8) by Stream Type (9)	**Risk Rating:** Percent Increase over Bankfull Discharge **(Fig. 4-16)***	**Risk Rating:** Percent Reduction in Bankfull Discharge **(Fig. 4-17)***	**Overall Risk Rating:** Streamflow Changes (Insert Adjective and Numeric Rating)
Trail Creek	**10,611**	**223**	**25**	**1,728**	**4,378**	**6,219**	**113**	**1,728**	**42%**	**F4/G4**	**VH (5)**	**No Urban Risk**				**VH (5)**		**VH (5)**
West Creek	**33,612**	**484**	**34**	**1,920**	**11,011**	**991**	**358**	**1,920**	**37%**	**F4/G4**	**VH (5)**					**VH (5)**		**VH (5)**
Trout Creek	**85,117**	**843**	**9**	**432**	**5,318**	**6,809**	**656**	**432**	**15%**	**F4/G4**	**H (4)**					**VH (5)**		**VH (5)**
Horse Creek	**135,557**	**85**	**7**	**4,080**	**20,707**	**14,019**	**1,144**	**4,080**	**26%**	**F4/G4**	**VH (5)**					**VH (5)**		**VH (5)**

Figure 28. Tributary to Trail Creek showing exposed soil and active stream channel erosion processes accelerated due to increased flood peaks.

Streambank Erosion Risk

The risk rating for potential sediment supply from streambank erosion is based on dominant stream type, riparian vegetation composition, bank-height ratio (study bank height divided by bankfull depth at the toe of the bank), and the ratio of radius of curvature to bankfull width. The criteria for such ratings are shown in **Figure 4-18**, **Figure 4-19** and **Figure 4-20**. The final summary risk rating is shown in **Figure 4-21** and recorded in **Worksheets 4-7a** and **4-7b**. The *High* risk Trail Creek sub-drainages all rated *High* to *Very High* and require advancement to *PLA*. This indicates that streambank erosion is also a dominant process within these sub-drainages that must be addressed if accelerated sediment supply is to be significantly reduced. The mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek have *Moderate* to *Very High* risk ratings also requiring advancement to *PLA* (**Worksheet 4-6b**). Tons per year of streambank erosion by specific locations will be quantified in the *PLA* evaluation. The anticipated values of sediment from streambank erosion based on the increased flows, road encroachment and existing unstable stream types will be disproportionately high. Mitigation in the form of river restoration will undoubtedly provide significant reductions in accelerated sediment supply from the streambanks.

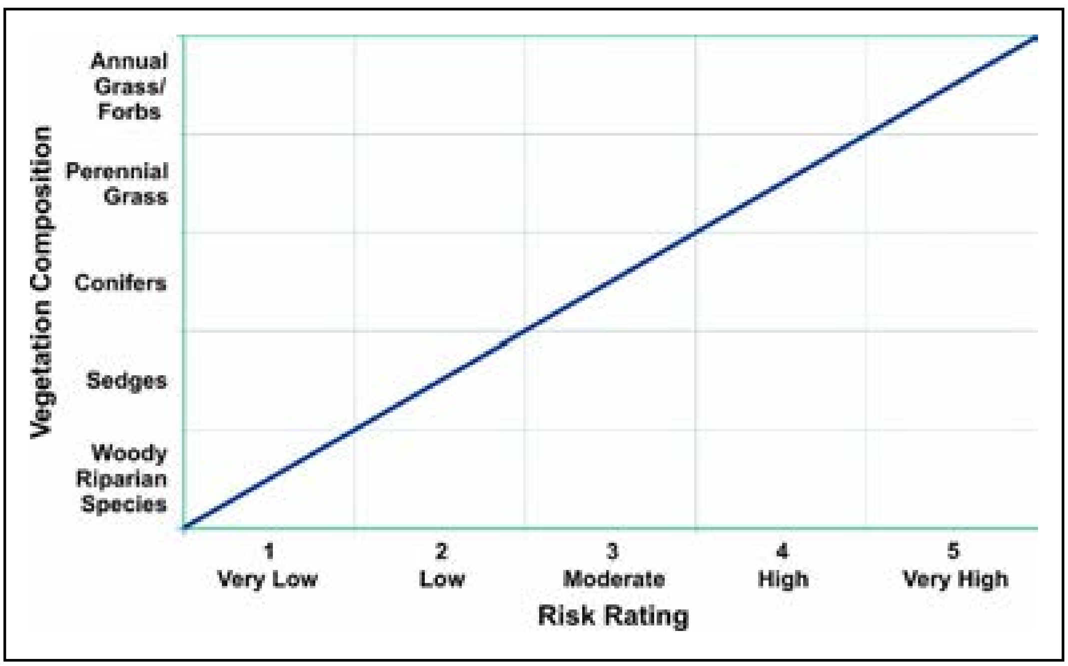


Figure 4-18. Streambank erosion risk based on vegetation composition.

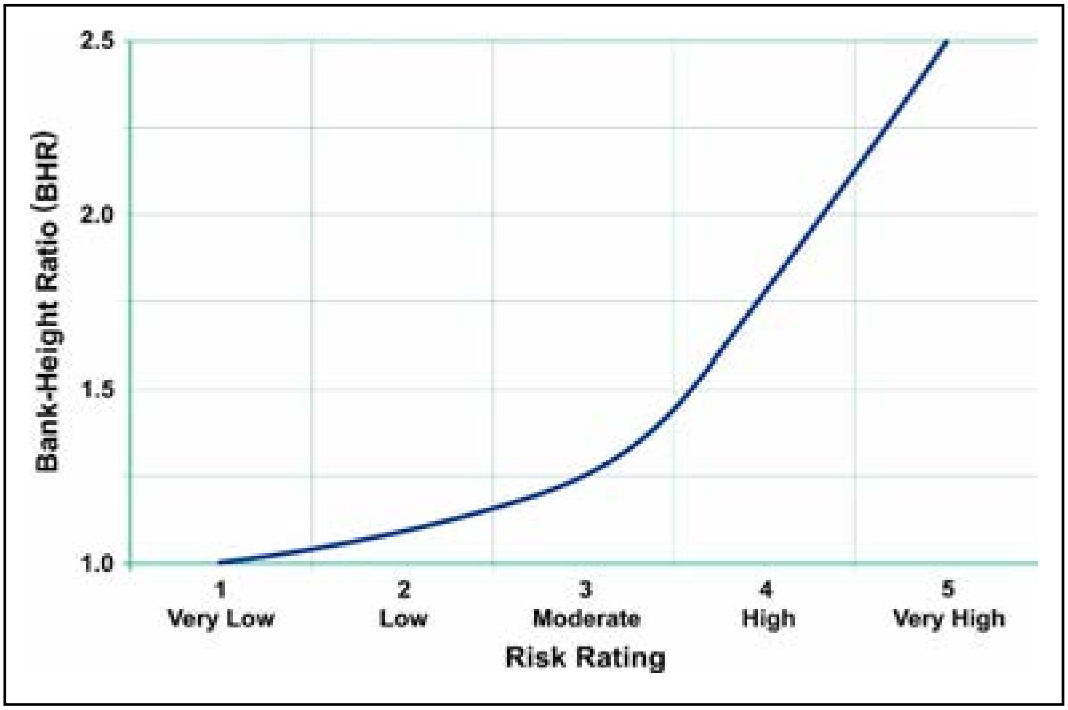


Figure 4-19. Streambank erosion risk based on Bank-Height Ratio (BHR).

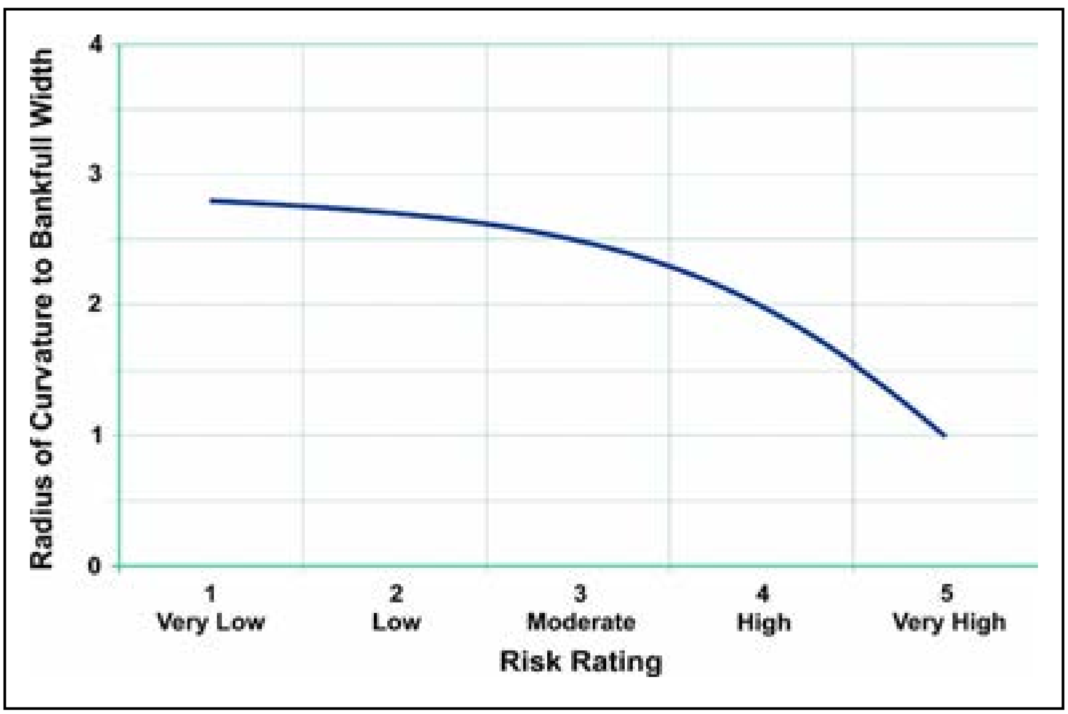


Figure 4-20. Streambank erosion risk based on radius of curvature divided by width.

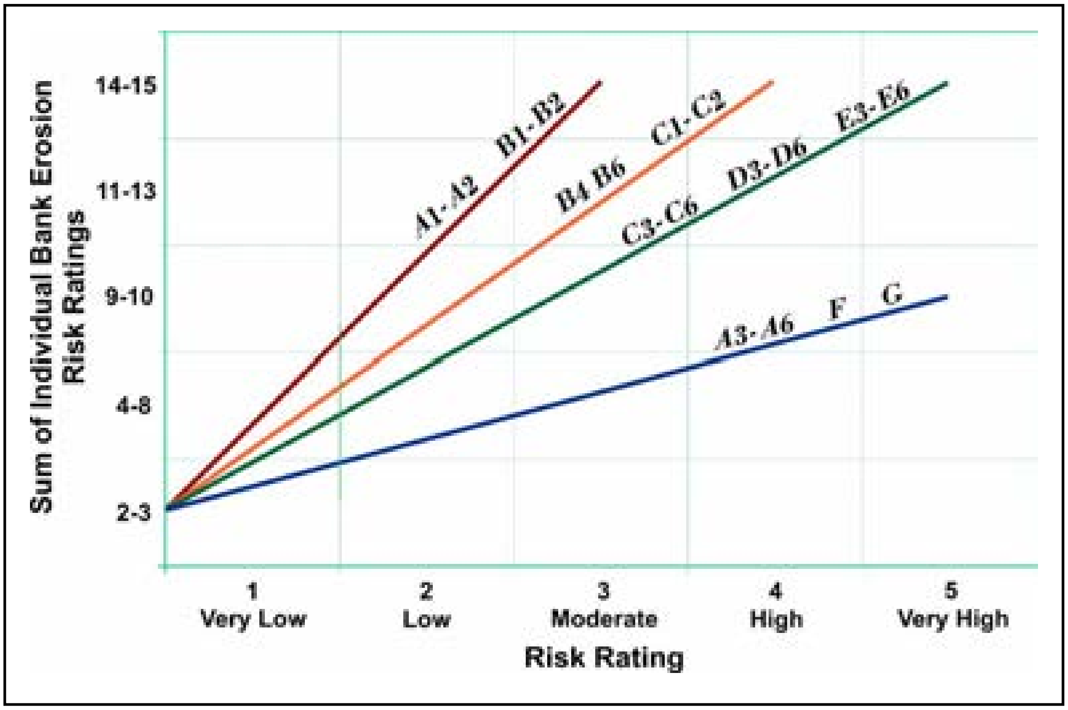


Figure 4-21. Overall streambank erosion risk based on the sum of individual risk ratings by stream type.

Worksheet 4-7a. Risk rating worksheet for streambank erosion for the sub-watersheds.

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sub-Microshed for rep weak link	**Representative Weak Link Stream Type**	Vegetation Composition	**Risk Rating:** Vegetation Composition **(Fig. 4-18)**	Bank-Height Ratio - Assumed from Stream Type	**Risk Rating:** Bank-Height Ratio **(Fig. 4-19)**	Radius of Curvature Divided by Bankfull Width	**Risk Rating:** Radius of Curvature Divided by Bankfull Width **(Fig. 4-20)**	**Total Individual Risk Rating Points by Reach ∑[(3)+(5)+(7)]**	**Overall Risk Rating by Stream Type (Fig. 4-21)**
TC 1 - A	**F**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**>2.3**	**VH (5)**	**2**	**H (4)**	**13**	**VH (5)**
TC1 - B	**F/B**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**>2.3**	**VH (5)**	**2**	**H (4)**	**13**	**VH (5)**
TC2 - A	**F**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**>2.3**	**VH (5)**	**2**	**H (4)**	**13**	**VH (5)**
TC2 - B	**F/B**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**>2.3**	**VH (5)**	**2**	**H (4)**	**13**	**VH (5)**
TC 3 - A	**D**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**1.6**	**VH (5)**	**1.3**	**H (4)**	**14**	**H (4)**
TC3 - B	**F**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**>2.3**	**VH (5)**	**2**	**H (4)**	**13**	**VH (5)**
TC4 - A	**D**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**1.6**	**VH (5)**	**1.3**	**H (4)**	**13**	**H (4)**
TC7 - A	**F**	Mixture of Veg, but High Risk Rating; Perennial Grass Dominated throughout burn area	**H (4)**	**>2.3**	**VH (5)**	**2**	**H (4)**	**13**	**VH (5)**
Judgement call on radius of curvature to bankfull width based upon typical measurements for these types of streams									
D - very low sinuosity - very wide bankfull width - 1.3 ratio									
F - moderate sinuosity - wide bankfull width - 2.0 ratio									

Worksheet 4-7b. Risk rating worksheet for streambank erosion for the main trunk streams.

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Location Code/ River Reach I.D.	**Stream Type**	Vegetation Composition	**Risk Rating:** Vegetation Composition **(Fig. 4-18)**	Bank-Height Ratio	**Risk Rating:** Bank-Height Ratio **(Fig. 4-19)**	Radius of Curvature Divided by Bankfull Width	**Risk Rating:** Radius of Curvature Divided by Bankfull Width **(Fig. 4-20)**	**Total Individual Risk Rating Points by Reach ∑[(3)+(5)+(7)]**	**Overall Risk Rating by Stream Type (Fig. 4-21)**
Trail Creek	**G**	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	F	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	C	**woody**	**L (1)**	**>2.3**	**VH (5)**	**2.5**	**M (3)**	**9**	**M (3)**
West Creek	**G**	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	F	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	C	**woody**	**L (1)**	**>2.3**	**VH (5)**	**2.5**	**M (3)**	**9**	**M (3)**
Trout Creek	**G**	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	F	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	C	**woody**	**L (1)**	**>2.3**	**VH (5)**	**2.5**	**M (3)**	**9**	**M (3)**
Horse Creek	**G**	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	F	**perennial, conifers**	**H (4)**	**>2.3**	**VH (5)**	**>2.5**	**L (2)**	**11**	**VH (5)**
	C	**woody**	**L (1)**	**>2.3**	**VH (5)**	**2.5**	**M (3)**	**9**	**M (3)**

In-channel Mining Risk Rating

No in-channel mining activities have occurred in the Horse Creek Watershed and therefore the in-channel mining risk ratings are *Very Low* as shown in **Worksheet 4-8**.

Worksheet 4-8. Risk rating worksheet for in-channel mining.

(1)	(2)	(3)	(4)	(5)
Microsheds advanced from *RLA* in Trail Creek Watershed	Total Acres of Reach	Total Acres Impacted by In-Channel Mining	Percent of Channel Length Impacted by In-Channel Mining **[(3)/(2)X100]**	**Overall Adjective and Numeric Risk Rating (Fig. 4-22)** (4) by Stream Type
TC 1	**No MINING Activities**			**VL (1)**
TC 2				**VL (1)**
TC 3				**VL (1)**
TC 4				**VL (1)**
TC 7				**VL (1)**

If no in-channel mining is occuring, Very Low (1) is automatically inserted in the RRISSC summary worksheet

Direct Channel Impacts

Direct channel impacts are rated based on riparian vegetation changes due to direct disturbances such as grazing, site conversion, logging, fires, etc.; the length of channel impacted from straightening, encroachment, floodplain elimination, poor drainage crossings, channel re-alignments, etc.; and channel blockages from large woody debris, all related to stream type. Evaluation of activities that affect the dimension, pattern and profile of rivers and their relative stability is the focus of this rating. Criteria used for the ratings are shown in **Figures 4-23, Figure 4-24** and **Figure 4-25** and summarized in **Worksheet 4-9a** and **4-9b**. The high risk sub-drainages of Trail Creek all rated *High* to *Very High* risk (**Worksheet 4-9a**). The major mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek all rated *Very High* due the road encroachment, poor stream crossings, large woody debris from the fire, ATV trails along the channels and riparian vegetation changes (**Worksheet 4-9b**).

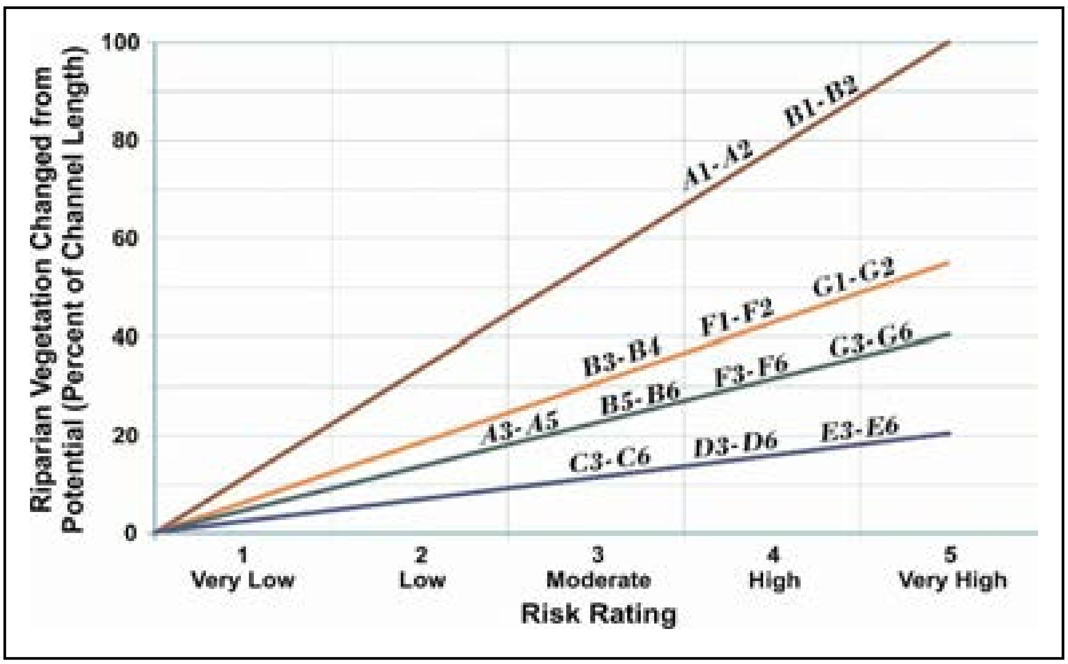


Figure 4-23. Risk rating for potential introduced sediment and channel instability by stream type based on percentage of channel length affected by vegetation change.

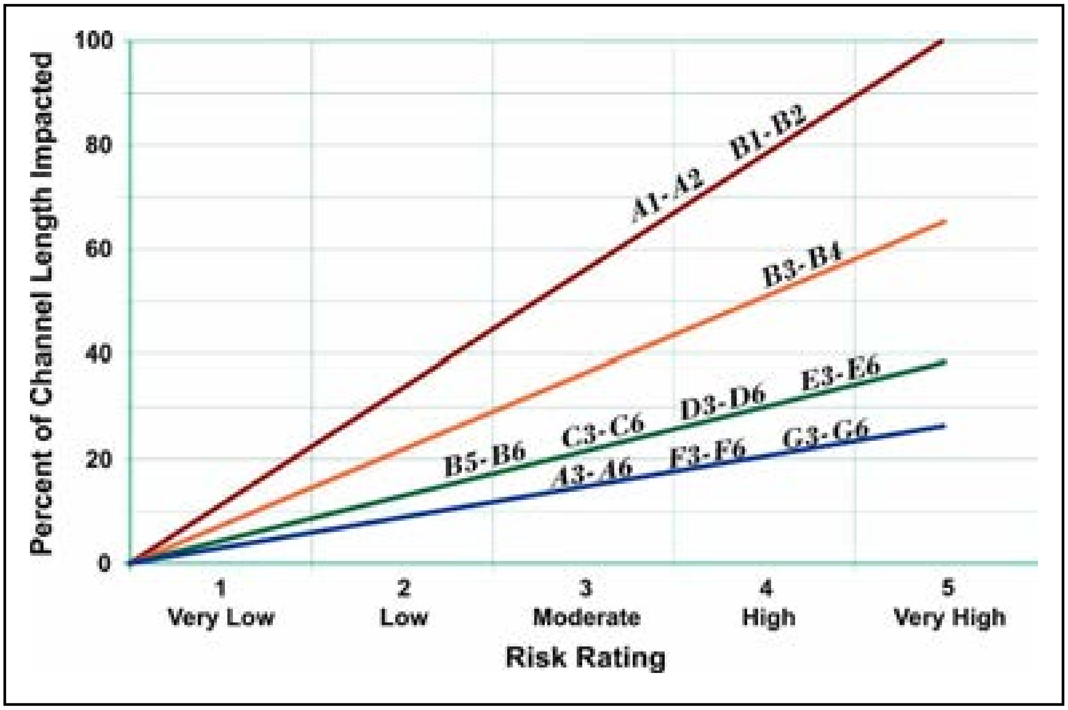


Figure 4-24. Risk rating relation of percent of channel length impacted by vegetation utilization and bank impacts according to stream type.

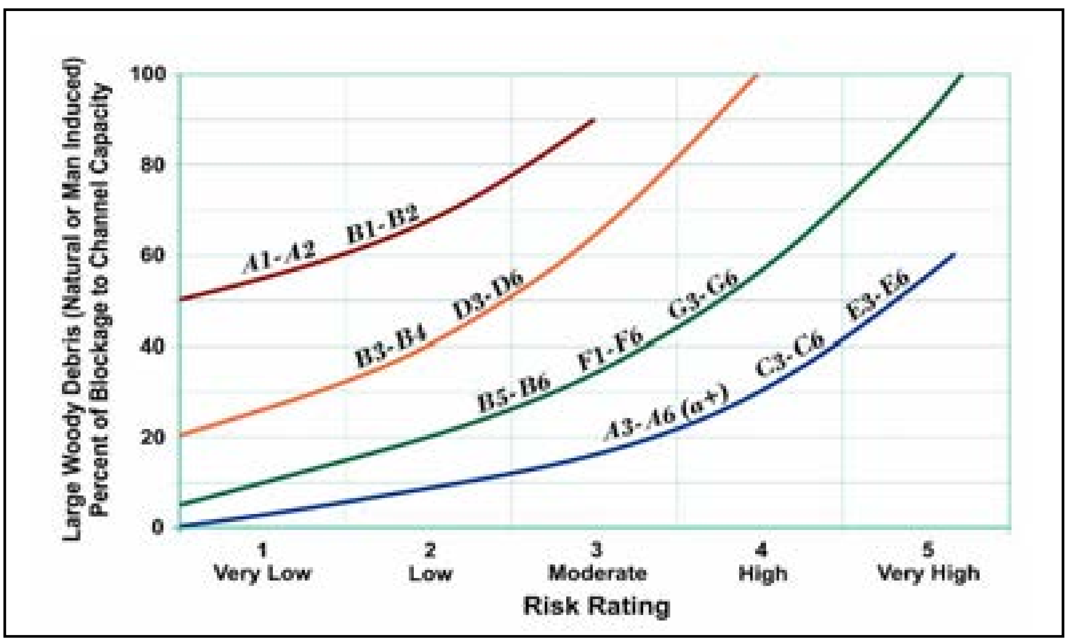


Figure 4-25. Risk rating in relation to channel blockage from large woody debris by stream type.

Worksheet 4-9a. Risk rating worksheet for direct channel impacts for the sub-watersheds.

(1)		(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
Sub-Microshed for rep weak link	**Represen-tative Weak Link Stream Type**	Total Channel Length (ft) (from L hydro clip)	Riparian Vegetation Change (ft)	Percent of Total Length Impacted **[(3)/(2)X100]**	**Risk Rating:** Percent of Riparian Vegetation Change **(Fig. 4-23)** (4) by Stream Type	Length Impacted by Direct Channel Disturbance (ft) (roads/trails - digitized layer)	Acres of salvage	Percent of Total Length Impacted **[(6)/(2)X100]**	**Risk Rating:** Percent of Channel Length Impacted **(Fig. 4-24)** (7) by Stream Type	Length Impacted by Large Woody Debris (ft)	Percent of Length of Debris Blockage **[(9)/(2)X100]**	**Risk Rating:** Debris Blockage **(Fig. 4-25)**	**Overall Risk Rating for Direct Channel Impacts** (Insert Highest Risk Rating from Columns 5, 8 and 11)
TC 1 - A	**F**	**5396**	**2698**	**50**	**H (4)**	**0**	**20**	**0**	**VL (1)**	**3570**	**66**	**H (4)**	**H (4)**
TC1 - B	**F/B**	**42476**	**21238**	**50**	**H (4)**	**35156**	**95**	**83**	**VH (5)**	**11750**	**28**	**M (3)**	**VH (5)**
TC2 - A	**F**	**9794**	**4897**	**50**	**H (4)**	**1962**	**0**	**20**	**H (4)**	**5360**	**55**	**H (4)**	**H (4)**
TC2 - B	**F/B**	**36676**	**18338**	**50**	**H (4)**	**6536**	**0**	**18**	**M (3)**	**10455**	**29**	**M (3)**	**H (4)**
TC 3 - A	**D**	**14735**	**7367.5**	**50**	**VH (5)**	**4479**	**0**	**30**	**H (4)**	**4540**	**31**	**VL (1)**	**VH (5)**
TC3 - B	**F**	**21912**	**10956**	**50**	**H (4)**	**1199**	**0**	**5**	**L (2)**	**6615**	**30**	**M (3)**	**H (4)**
TC4 - A	**D**	**10445**	**5222.5**	**50**	**VH (5)**	**757**	**2**	**7**	**VL (1)**	**3675**	**35**	**L (2)**	**VH (5)**
TC7 - A	**F**	**23615**	**11807.5**	**50**	**H (4)**	**6525**	**189**	**28**	**VH (5)**	**7300**	**31**	**M (3)**	**VH (5)**

Veg change, (non riparian) in ephemeral is about 30% putting the risk at (4) - *High*

Debris, utilized ground truthing in F channels to realize that downed wood/debris affects all of these, and not so much in the steeper side drainages

Worksheet 4-9b. Risk rating worksheet for direct channel impacts for the main trunk streams.

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Location Code/ River Reach I.D.	**Stream Type**	Total Channel Length (ft)	Riparian Vegetation Change (ft) from potential	Percent of Total Length Impacted **[(3)/(2)X100]**	**Risk Rating:** Percent of Riparian Vegetation Change **(Fig. 4-23)** (4) by Stream Type	Length Impacted by Direct Channel Disturbance (ft)	Percent of Total Length Impacted **[(6)/(2)X100]**	**Risk Rating:** Percent of Channel Length Impacted **(Fig. 4-24)** (7) by Stream Type	Length Impacted by Large Woody Debris (ft) Beaver Dams Fire Debris	Percent of Length of Debris Blockage **[(9)/(2)X100]**	**Risk Rating:** Debris Blockage **(Fig. 4-25)**	**Overall Risk Rating for Direct Channel Impacts** (Insert Highest Risk Rating from Columns 5, 8 and 11)
Trail Creek	**G, F & C**	**59,517**	**41,662**	**70%**	**VH(5)**	**29,578**	**50%**	**VH(5)**	**8,928**	**15%**	**L (2)**	**VH (5)**
West Creek	**G, F & C**	**121,489**	**85,042**	**70%**	**VH(5)**	**60,745**	**50%**	**VH(5)**	**18,223**	**15%**	**L (2)**	**VH (5)**
Trout Creek	**G, F & C**	**146,176**	**102,323**	**70%**	**VH(5)**	**73,088**	**50%**	**VH(5)**	**21,926**	**15%**	**L (2)**	**VH (5)**
Horse Creek	**G, F & C**	**21,438**	**15,007**	**70%**	**VH(5)**	**10,719**	**50%**	**VH(5)**	**3,216**	**15%**	**L (2)**	**VH (5)**

Channel Enlargement Risk Potential

Channel enlargement risk is based on a cumulative summary of the previous ratings of streamflow change, streambank erosion and direct channel impacts. The criteria used to assign total points by stream type are shown in **Figure 4-26**. The risk rating summary for the high risk sub-drainages of Trail Creek watershed are summarized in **Worksheet 4-10a**. The risk ratings were all *Very High* for channel enlargement. This indicates that the *PLA* is required to address these processes in detail at these locations. Stream restoration must also address these processes in addition to mitigation of excess sediment supply and channel instability. The mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek also rated from *High* (C stream types) to *Very High* for the G and F stream types (**Worksheet 4-10b**), and are recommended to also advance to *PLA*.

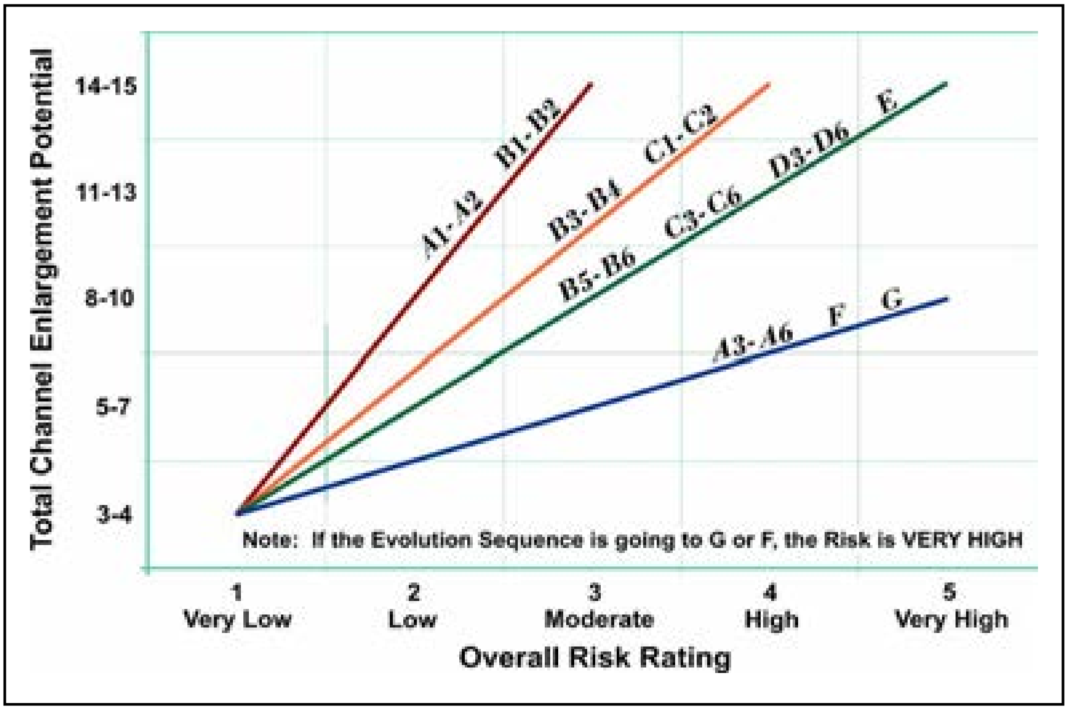


Figure 4-26. Increased sediment and channel instability risk based on channel enlargement potential by stream type.

Worksheet 4-10a. Risk rating worksheet for channel enlargement for the sub-watersheds.

(1)		(2)	(3)	(4)	(5)	(6)	(7)
Sub-Microshed for rep weak link	**Represen-tative Weak Link Stream Type**	**Overall Risk Rating:** Streamflow Changes **(Step 10 in Worksheet 4-2; Worksheet 4-6)**	**Overall Risk Rating:** Streambank Erosion **(Step 13 in Worksheet 4-2; Worksheet 4-7)**	**Overall Risk Rating:** Direct Channel Impacts **(Step 15 in Worksheet 4-2; Worksheet 4-9)**	**Total Numeric Score ∑[(2)+(3)+(4)]**	**Overall Risk Rating for Channel Enlargement (Fig. 4-26)** (5) by Stream Type	**Adjustment Due to In-Channel Mining***
TC 1 - A	F	H (4)	VH (5)	H (4)	13	VH (5)	N/A
TC1 - B	F/B	H (4)	VH (5)	VH (5)	14	VH (5)	N/A
TC2 - A	F	H (4)	VH (5)	H (4)	13	VH (5)	N/A
TC2 - B	F/B	H (4)	VH (5)	H (4)	13	VH (5)	N/A
TC 3 - A	D	VH (5)	H (4)	VH (5)	14	VH (5)	N/A
TC3 - B	F	VH (5)	VH (5)	H (4)	14	VH (5)	N/A
TC4 - A	D	VH (5)	H (4)	VH (5)	14	VH (5)	N/A
TC7 - A	F	VH (5)	VH (5)	VH (5)	15	VH (5)	N/A

Any in-channel mining automatically raises reach to *High* risk for enlargement and advances reach to *PLA.

Worksheet 4-10b. Risk rating worksheet for channel enlargement for the main trunk streams.

(1)		(2)	(3)	(4)	(5)	(6)	(7)
Location Code/ River Reach I.D.		**Overall Risk Rating:** Streamflow Changes **(Step 10 in Worksheet 4-2; Worksheet 4-6)**	**Overall Risk Rating:** Streambank Erosion **(Step 13 in Worksheet 4-2; Worksheet 4-7)**	**Overall Risk Rating:** Direct Channel Impacts **(Step 15 in Worksheet 4-2; Worksheet 4-9)**	**Total Numeric Score ∑[(2)+(3)+(4)]**	**Overall Risk Rating for Channel Enlargement (Fig. 4-26)** (5) by Stream Type	**Adjustment Due to In-Channel Mining***
Trail Creek	**G**	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	F	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	C	**VH (5)**	**M (3)**	**VH (5)**	**13**	**H (4)**	
West Creek	**G**	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	F	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	C	**VH (5)**	**M (3)**	**VH (5)**	**13**	**H (4)**	
Trout Creek	**G**	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	F	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	C	**VH (5)**	**M (3)**	**VH (5)**	**13**	**H (4)**	
Horse Creek	**G**	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	F	**VH (5)**	**VH (5)**	**VH (5)**	**15**	**VH (5)**	
	C	**VH (5)**	**M (3)**	**VH (5)**	**13**	**H (4)**	

Any in-channel mining automatically raises reach to *High* risk for enlargement and advances reach to *PLA.

Aggradation/Excess Sediment Deposition Risk

The risk ratings for aggradation/excess sediment deposition are based on departure from a stable width/depth ratio, evident depositional patterns and stream succession shifts from the stable form. The criteria used for the ratings are depicted in **Figure 4-27** and **Figure 4-28** in addition to criteria listed in **Worksheet 4-10**. The risk rating summaries for the Trail Creek sub-watersheds are shown in **Worksheet 4-10a** and overall rated *Very High* requiring advancement to *PLA*. The mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek also rated *High* for the G stream types and *Very High* for the F and C stream types (higher width/depth ratios). These reaches must also advance to *PLA*.

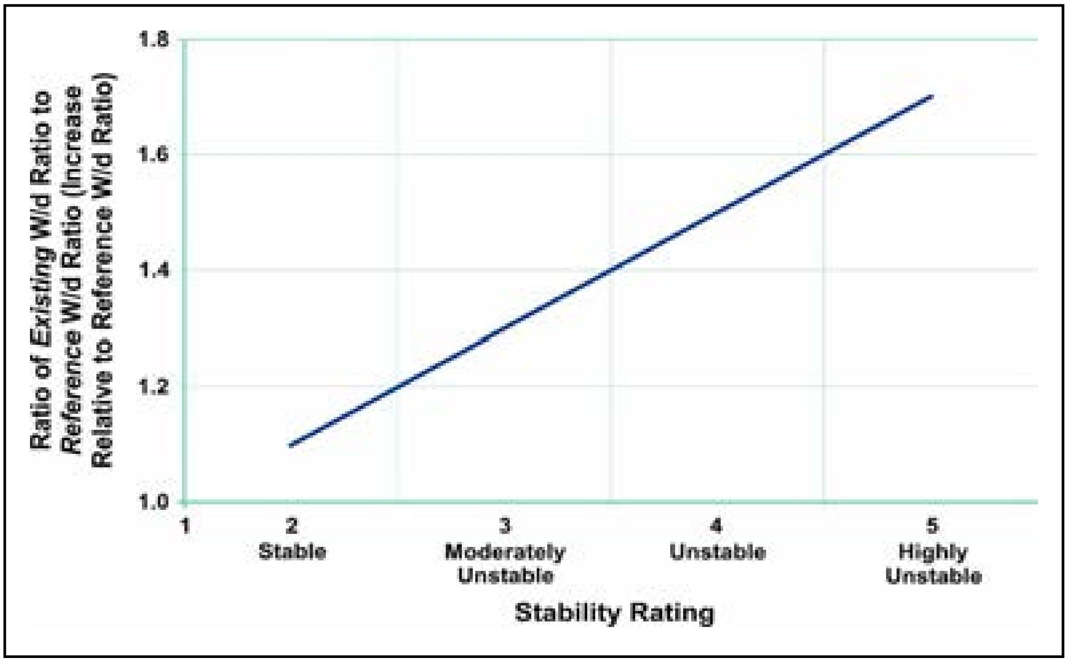


Figure 4-27. Relation of risk rating for over-wide channels based on departure ratio from reference condition.

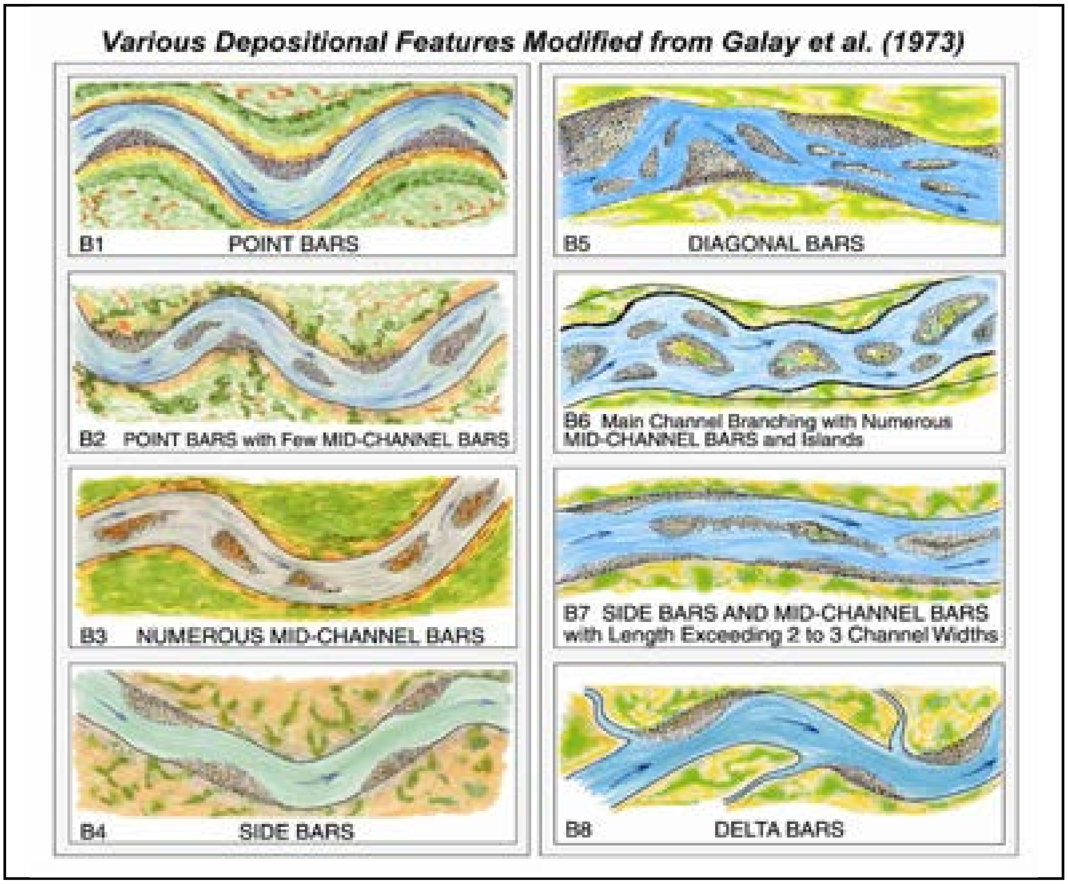


Figure 4-28. Depositional feature related to potential excess sediment/aggradation potential (Rosgen, 1996).

Worksheet 4-11a. Summary of risk ratings for potential aggradation or excess sediment deposition for the sub-watersheds.

		Hillslope Risk Ratings (Sediment Supply)						Channel Process Response to Excess Sediment							
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Sub-Watershed for rep weak link	**Represen-tative Weak Link Stream Type**	**Risk Rating:** Mass Erosion **(Step 6 in Worksheet 4-2; Worksheet 4-3)**	**Risk Rating:** Roads **(Step 7 in Worksheet 4-2; Worksheet 4-4)**	**Risk Rating:** Surface Erosion Risk/ Delivered Sediment Risk **(Step 8 in Worksheet 4-2; Worksheet 4-5)**	**Point Subtotal ∑[(2)+(3)+(4)]**	**Hillslope Summary Overall Rating**; Use Points from Column (5) (Insert Numeric and Adjective Ratings) **VL(1) = 3 L(2) = 4–7 M(3) = 8–10 H(4) = 11–14 VH(5) = >14**	Represent-ative location & associated rating points from column (6)*	**Risk Rating:** Width/Depth Ratio Departure **(Fig. 4-27)** **VL(1) = HS L(2) = S M(3) = MU H(4) = U VH(5) = HU**	**Risk Rating:** Channel Enlargement **(Step 16 in Worksheet 4-2; Worksheet 4-10)**	**Risk Rating:** Streambank Erosion **(Step 13 in Worksheet 4-2; Worksheet 4-7)**	**Point Subtotal ∑[(7)+(8)+(9)+(10)]**	**Risk Rating:** Use Points from Column (11) (Insert Adjective Risk Rating) **VL(1) < 5 L(2) = 5–8 M(3) = 9–12 H(4) = 13–16 VH(5) >16**	**Adjustments: Aggradation/Excess Sediment Indicators**** **a.** Obvious excess deposition **b.** Filling of pools **c.** Deposition of sand or larger material on floodplain **d.** Bi-modal **e.** Depositional patterns B3, B5-B7 **(Fig. 4-28)** (note categories tha	**Adjust-ment:** Reduction in Flow Due to Regulation **	**Final Aggradation/ Excess Sediment Deposition Risk Rating** (Insert Adjective Risk Rating)
TC 1		**M (3)**	**H (4)**	**H (4)**	**11**	**H (4)**									
TC 2		**M (3)**	**L (2)**	**H (4)**	**9**	**M (3)**									
TC 3		**M (3)**	**M (3)**	**H (4)**	**10**	**M (3)**									
TC 4		**M (3)**	**M (3)**	**H (4)**	**10**	**M (3)**									
TC 7		**M (3)**	**M (3)**	**H (4)**	**10**	**M (3)**									
TC 1 - A	**F**						**H (4)**	**H (4)**	**VH (5)**	**VH (5)**	**18**	**VH (5)**	**a, b, c, e**		**VH (5)**
TC1 - B	**F/B**						**H (4)**	**H (4)**	**VH (5)**	**VH (5)**	**18**	**VH (5)**	**a, b, c, e**		**VH (5)**
TC2 - A	**F**						**M (3)**	**H (4)**	**VH (5)**	**VH (5)**	**18**	**VH (5)**	**a, b, c, e**		**VH (5)**
TC2 - B	**F/B**						**M (3)**	**H (4)**	**VH (5)**	**VH (5)**	**18**	**VH (5)**	**a, b, c, e**		**VH (5)**
TC 3 - A	**D**						**M (3)**	**VH (5)**	**H (4)**	**H (4)**	**16**	**H (4)**	**a, b, c, e**		**VH (5)**
TC3 - B	**F**						**M (3)**	**H (4)**	**VH (5)**	**VH (5)**	**17**	**VH (5)**	**a, b, c, e**		**VH (5)**
TC4 - A	**D**						**M (3)**	**L (2)**	**VH (5)**	**H (4)**	**15**	**H (4)**	**a, b, c, e**		**VH (5)**
TC7 - A	**F**						**M (3)**	**H (4)**	**VH (5)**	**VH (5)**	**0**	**H (4)**	**a, b, c, e**		**VH (5)**

TC3A - B type reference for D type stream resulting in highly unstable from **Figure 4-27**

The D type channel is at the alluvial fan for the representative weakest link for TC4A - beacause it is prone to erosion, however, the D channel type is stable giving a W/D ratio change of 1

The F type channel has a reference channel of B - resulting in a 1.5 increase in W/D, resulting in an *Unstable* stability rating

Due to adjustments in column (13) - aggradation indicators - adjust one full level up

Worksheet 4-11b. Summary of risk ratings for potential aggradation or excess sediment deposition for the main trunk streams.

		Hillslope Risk Ratings (Sediment Supply)						Channel Process Response to Excess Sediment							
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Location Code/ River Reach I.D.		**Risk Rating:** Mass Erosion **(Step 6 in Worksheet 4-2; Worksheet 4-3)**	**Risk Rating:** Roads **(Step 7 in Worksheet 4-2; Worksheet 4-4)**	**Risk Rating:** Surface Erosion Risk/ Delivered Sediment Risk **(Step 8 in Worksheet 4-2; Worksheet 4-5)**	**Point Subtotal** **∑[(2)+(3)+(4)]**	**Hillslope Summary Overall Rating**; Use Points from Column (5) (Insert Numeric and Adjective Ratings) **VL(1) = 3 L(2) = 4–7 M(3) = 8–10 H(4) = 11–14 VH(5) = >14**	Represent-ative location & associated rating points from column (6)*	**Risk Rating:** Width/Depth Ratio Departure **(Fig. 4-27)** **VL(1) = HS L(2) = S M(3) = MU H(4) = U VH(5) = HU**	**Risk Rating:** Channel Enlargement **(Step 16 in Worksheet 4-2; Worksheet 4-10)**	**Risk Rating:** Streambank Erosion **(Step 13 in Worksheet 4-2; Worksheet 4-7)**	**Point Subtotal** **∑[(7)+(8)+(9)+(10)]**	**Risk Rating:** Use Points from Column (11) (Insert Adjective Risk Rating) **VL(1) < 5 L(2) = 5–8 M(3) = 9–12 H(4) = 13–16 VH(5) >16**	**Adjustments: Aggradation/Excess Sediment Indicators**** **a.** Obvious excess deposition **b.** Filling of pools **c.** Deposition of sand or larger material on floodplain **d.** Bi-modal **e.** Depositional patterns B3, B5-B7 **(Fig. 4-28)** (note categories tha	**Adjust-ment:** Reduction in Flow Due to Regulation**	**Final Aggradation/ Excess Sediment Deposition Risk Rating** (Insert Adjective Risk Rating)
Trail Creek	**G**	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**L (1)**	**VH (5)**	**VH (5)**	**15**	**H (4)**			**H (4)**
	F	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**19**	**VH (5)**	**a, b, d, e**		**VH (5)**
	C	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**H (4)**	**H (4)**	**M (3)**	**15**	**H (4)**	**a, b, d, e**		**VH (5)**
West Creek	**G**	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**L (1)**	**VH (5)**	**VH (5)**	**15**	**H (4)**			**H (4)**
	F	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**19**	**VH (5)**	**a, b, d, e**		**VH (5)**
	C	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**H (4)**	**H (4)**	**M (3)**	**15**	**H (4)**	**a, b, d, e**		**VH (5)**
Trout Creek	**G**	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**L (1)**	**VH (5)**	**VH (5)**	**15**	**H (4)**			**H (4)**
	F	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**19**	**VH (5)**	**a, b, d, e**		**VH (5)**
	C	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**H (4)**	**H (4)**	**M (3)**	**15**	**H (4)**	**a, b, d, e**		**VH (5)**
Horse Creek	**G**	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**L (1)**	**VH (5)**	**VH (5)**	**15**	**H (4)**			**H (4)**
	F	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**19**	**VH (5)**	**a, b, d, e**		**VH (5)**
	C	**VH (5)**	**VH (5)**	**H (4)**	**14**	**H (4)**	**H (4)**	**H (4)**	**H (4)**	**M (3)**	**15**	**H (4)**	**a, b, d, e**		**VH (5)**

Channel Evolution Potential

All sub-drainages rated *High* or *Very High* using **Table 4-5** due to the channel successional stage and stream type evolution. Many of the potential stable stream types of B4 were converted to G4 adding great amounts of sediment from both the streambed and streambanks. The increase in energy with the low width/depth ratios and the entrenched, high banks promote great erosion rates from channel enlargement and downcutting. Additional evolutionary changes are D4 to G4 in alluvial fans and other locations, C4 to G4, and G4 to F4 stream types. These evolutionary changes reflect major and widespread instability due to accelerated streambank erosion, downcutting and channel enlargement. Increased peak floods due to the Hayman fire aggravate such stream types and provide an exponential rate of sediment supply. The *High* to *Very High* risk ratings in this category indicate that the majority of the stream types are not operating at their natural stable potential type and will continue to provide excess sediment and channel impairment as a result. These *High* and *Very High* risk ratings are entered directly into the overall *RRISSC* summary worksheets. Such ratings will help advance these reaches to the *PLA* due to their inherent instability and associated adverse consequences. Potential mitigation following these assessments is to determine what constitutes the stable form and what scenario is the most appropriate in recommending stream restoration and conversion to a stable form.

Table 4-5. Risk ratings for various stream channel successional state scenarios.

Channel Successional States of Stream Type Evolution	Risk Rating
E to C	Moderate (3)
C to D	Very High (5)
B, C, E or D to G	Very High (5)
G to F	High (4)
G to B	Very Low (1)
F to B	Very Low (1)
F to C	Low (2)
F to D	Moderate (3)
All others (e.g., C to E)	Low (2)

Potential Degradation/Channel Scour Risk

The potential degradation risk ratings are also a cumulative summary of ratings based on potential streamflow increase (**Worksheet 4-6**), channel succession shifts (**Table 4-5**), road crossings (**Worksheet 4-13**), and direct channel impacts (**Worksheet 4-9**). The risk ratings of all Trail Creek sub-watersheds are *Very High* requiring advancement to *PLA* (**Worksheet 4-10a**). The risk summary for the mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek all rated as *Very High* primarily due to the presence of G stream types, the extent of direct disturbance from road encroachment, and the increase in streamflow from the Hayman wildfire (**Worksheet 4-10b**). These locations must also advance to *PLA*.

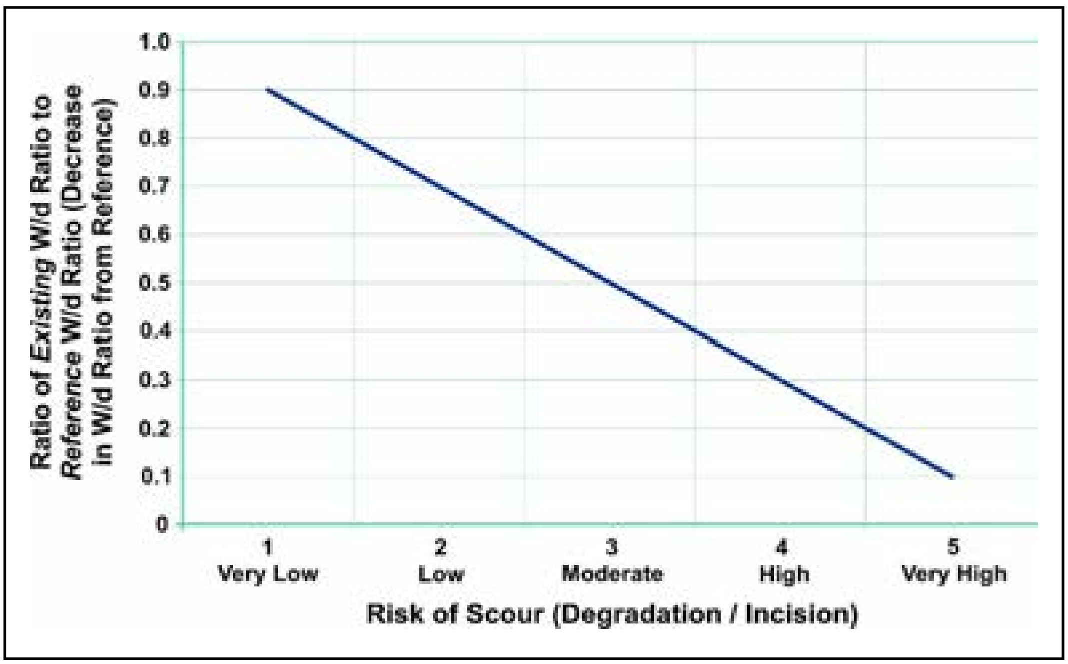


Figure 4-29. Conversion of a decrease in the existing width/depth ratio compared to reference width/depth ratio for potential degradation (incision due to excess energy). This relation is used only if the lowest bank height is greater than the maximum bankfull depth (Bank-Height Ratio (BHR) > 1.0).

Worksheet 4-12a. Risk rating worksheet for degradation for the sub-watersheds.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Location Code/ River Reach I.D.	**Risk Rating:** Streamflow Changes **(Step 10 in Worksheet 4-2; Worksheet 4-6)**	**Risk Rating:** In-Channel Mining Associated with Base-Level Shifts **(Step 14 in Worksheet 4-2; Worksheet 4-8)**	**Risk Rating:** Channel Evolution **(Step 18 in Worksheet 4-2; Table 4-5)**	**Risk Rating:** Road Drainage Designs, "Shot Gun" Culverts (Base-Level Shifts) (**Worksheet 4-13**)	**Risk Rating:** Direct Channel Impacts **(Step 15 in Worksheet 4-2; Worksheet 4-9)**	**Overall Risk Rating for Degradation** (Insert Highest Adjective Rating from Columns 2–6)
TC 1 - A	**H (4)**	**VL (1)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**
TC1 - B	**H (4)**	**VL (1)**	**VH (5)**	**M (3)**	**VH (5)**	**VH (5)**
TC2 - A	**H (4)**	**VL (1)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**
TC2 - B	**H (4)**	**VL (1)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**
TC 3 - A	**VH (5)**	**VL (1)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**
TC3 - B	**VH (5)**	**VL (1)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**
TC4 - A	**VH (5)**	**VL (1)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**
TC7 - A	**VH (5)**	**VL (1)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**

Worksheet 4-12b. Risk rating worksheet for degradation for the main trunk streams.

(1)		(2)	(3)	(4)	(5)	(6)	(7)
Location Code/ River Reach I.D.		**Risk Rating:** Streamflow Changes **(Step 10 in Worksheet 4-2; Worksheet 4-6)**	**Risk Rating:** In-Channel Mining Associated with Base-Level Shifts **(Step 14 in Worksheet 4-2; Worksheet 4-8)**	**Risk Rating:** Channel Evolution **(Step 18 in Worksheet 4-2; Table 4-5)**	**Risk Rating:** Road Drainage Designs, "Shot Gun" Culverts (Base-Level Shifts) (**Worksheet 4-13, column 3 stream crossing structure**)	**Risk Rating:** Direct Channel Impacts **(Step 15 in Worksheet 4-2; Worksheet 4-9)**	**Overall Risk Rating for Degradation** (Insert Highest Adjective Rating from Columns 2–6)
Trail Creek	**G**	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	F	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	C	**VH (5)**	**VL (1)**	**VH (5)**	**M (3)**	**VH (5)**	**VH (5)**
West Creek	**G**	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	F	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	C	**VH (5)**	**VL (1)**	**VH (5)**	**M (3)**	**VH (5)**	**VH (5)**
Trout Creek	**G**	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	F	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	C	**VH (5)**	**VL (1)**	**VH (5)**	**M (3)**	**VH (5)**	**VH (5)**
Horse Creek	**G**	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	F	**VH (5)**	**VL (1)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**
	C	**VH (5)**	**VL (1)**	**VH (5)**	**M (3)**	**VH (5)**	**VH (5)**

Worksheet 4-13a. Risk rating worksheet for potential contraction scour/degradation/channel incision due to culverts or bridges for the sub-watersheds.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Location Code/ River Reach I.D.	**Percent Reduction of Sinuosity** (Insert Numeric Rating) (1) = No change (2) = Sinuosity reduced up to 50% (3) = Sinuosity reduced 50–80% (4) = Sinuosity reduced more than 80%	**Stream Crossing Structure** (Insert Numeric Rating) (1) = Bridge (2) = Arch culvert (3) = Culvert (4) = Over-steepened culvert	**Subtotal Σ[(2)+(3)]**	**Increase in Energy Slope** (Use (4) Points & Insert Numeric Rating) VL (1) = 2 L (2) = 3 M (3) = 4 H (4) = 5–6 VH (5) = 7–8	**Ratio of a Decrease in W/d Ratio to Existing Reference W/d Ratio (Figure 4-29)** (Insert Numeric Rating) VL (1) > 8.0 L (2) = 0.61–0.80 M (3) = 0.41–0.60 H (4) = 0.21–0.40 VH (5) ≤ 0.20	**Backwater Potential above Structure** (Insert Numeric Rating) VL (1) = None L (2) = Slight only for floods > 50 yr recurrence interval M (3) = Some for floods 11–50 yr recurrence interval H (4) = Evident for floods 2–10 yr recurrence interval VH (5) = Backwater at bankfull discharge	**Presence of Floodplain Drains (Through Fills)** (Insert Numeric Rating) VL (1) = All floods greater than bankfull drain through fill L (2) = Accomodates 90% of floods M (3) = Accomodates 50–89% of floods H (4) = Evident for floods 2–10 yr recurrence interval VH (5) = Backwater at bankfull discharge	**Subtotal Σ[(5)+(6)+(7)+(8)]**	**Overall Risk Rating: Culverts or Bridges** VL (1) = 4 L (2) = 5–8 M (3) = 9–12 H (4) = 13–16 VH (5) = 17–20
TC 1 - A*									**VL (1)***
TC1 - B	**(1)**	**(3)**	**4**	**M (3)**	**VL (1)**	**L (2)**	**H (4)**	**10**	**M (3)**
TC2 - A*									**VL (1)***
TC2 - B*									**VL (1)***
TC 3 - A*									**VL (1)***
TC3 - B*									**VL (1)***
TC4 - A*									**VL (1)***
TC7 - A*									**VL (1)***

* No bridges or culverts on these stream types; therefore, risk rating is automatically *Very Low*

Worksheet 4-13b. Risk rating worksheet for potential contraction scour/degradation/channel incision due to culverts or bridges for the main trunk streams.

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Location Code/ River Reach I.D.		**Percent Reduction of Sinuosity** (Insert Numeric Rating) (1) = No change (2) = Sinuosity reduced up to 50% (3) = Sinuosity reduced 50–80% (4) = Sinuosity reduced more than 80%	**Stream Crossing Structure** (Insert Numeric Rating) (1) = Bridge (2) = Arch culvert (3) = Culvert (4) = Over-steepened culvert	**Subtotal Σ[(2)+(3)]**	**Increase in Energy Slope** (Use (4) Points & Insert Numeric Rating) VL (1) = 2 L (2) = 3 M (3) = 4 H (4) = 5–6 VH (5) = 7–8	**Ratio of a Decrease in W/d Ratio to Existing Reference W/d Ratio (Figure 4-29)** (Insert Numeric Rating) VL (1) > 8.0 L (2) = 0.61–0.80 M (3) = 0.41–0.60 H (4) = 0.21–0.40 VH (5) ≤ 0.20	**Backwater Potential above Structure** (Insert Numeric Rating) VL (1) = None L (2) = Slight only for floods > 50 yr recurrence interval M (3) = Some for floods 11–50 yr recurrence interval H (4) = Evident for floods 2–10 yr recurrence interval VH (5) = Backwater at bankfull discharge	**Presence of Floodplain Drains (Through Fills)** (Insert Numeric Rating) VL (1) = All floods greater than bankfull drain through fill L (2) = Accomodates 90% of floods M (3) = Accomodates 50–89% of floods H (4) = Evident for floods 2–10 yr recurrence interval VH (5) = Backwater at bankfull discharge	**Subtotal Σ[(5)+(6)+(7)+(8)]**	**Overall Risk Rating: Culverts or Bridges** VL (1) = 4 L (2) = 5–8 M (3) = 9–12 H (4) = 13–16 VH (5) = 17–20
Trail Creek	**G**	**No potential contraction scour/degradation due to culverts or bridges; automatic *Very Low* rating**								**VL (1)**
	F	**No potential contraction scour/degradation due to culverts or bridges; automatic Very Low rating**								**VL (1)**
	C	**(1)**	**(3)**	**4**	**(3)**	**(1)**	**(4)**	**(4)**	**12**	**M (3)**
West Creek	**G**	**No potential contraction scour/degradation due to culverts or bridges; automatic *Very Low* rating**								**VL (1)**
	F	**No potential contraction scour/degradation due to culverts or bridges; automatic Very Low rating**								**VL (1)**
	C	**(1)**	**(3)**	**4**	**(3)**	**(1)**	**(4)**	**(4)**	**12**	**M (3)**
Trout Creek	**G**	**No potential contraction scour/degradation due to culverts or bridges; automatic *Very Low* rating**								**VL (1)**
	F	**No potential contraction scour/degradation due to culverts or bridges; automatic Very Low rating**								**VL (1)**
	C	**(1)**	**(3)**	**4**	**(3)**	**(1)**	**(4)**	**(4)**	**12**	**M (3)**
Horse Creek	**G**	**No potential contraction scour/degradation due to culverts or bridges; automatic *Very Low* rating**								**VL (1)**
	F	**No potential contraction scour/degradation due to culverts or bridges; automatic Very Low rating**								**VL (1)**
	C	**(1)**	**(3)**	**4**	**(3)**	**(1)**	**(4)**	**(4)**	**12**	**M (3)**

Overall RRISSC Assessment Summary

The summary of the subsequent risk ratings for the sub-drainages of the Trail Creek Watershed are presented in **Worksheet 4-2a**. This summary provides an overall review of the *RRISSC* assessment results and recommended advancement to *PLA*. The summary also includes a listing of the processes responsible for the *PLA* advancement recommendations related to the specific steps representing those processes (**Worksheet 4-2a**). The recommendation of the *RLA* appeared to be consistent to advance to the *PLA* with additional assessments. The tighter breakdown of sub-drainages allowed for additional data to be collected and additional sub-watersheds to be initially excluded from additional study. The mainstem reaches of Trail Creek, Horse Creek, West Creek and Trout Creek all indicated a cumulative risk rating of *Very High* and must advance to *PLA* (**Worksheet 4-2b**).

The preliminary conclusions of the *RRISSC* assessment present watershed managers the realization of the critical contribution of stream channel processes and hydrology changes from the high sediment supply and channel impairment in the Horse Creek Watershed. The stream channel processes of accelerated streambed and streambank erosion as well as channel enlargement are contributing disproportionate high rates to the sediment sources and adding to channel impairment. The roads are also a major sediment contributor due to their poor drainage and design, lack of maintenance, poor vegetal recovery, erodible soils and close proximity to the drainage network. The *PLA* will quantify all sediment sources so that proposed mitigation can show proportional contributions by various land uses and processes. Such data will assist in directing restoration designs and prioritization of its implementation.

Worksheet 4-2a. *RRISSC* summary worksheet for the Trail Creek sub-watersheds.

			Geographic Location				Stream Type Location								
Sub-Microshed for rep weak link	**Total Acres**	**Representative Weak Link Stream Type**	**Step 6:** Mass Erosion **(Worksheet 4-3)**	**Step 7:** Roads **(Worksheet 4-4)**	**Step 8:** Surface Erosion **(Worksheet 4-5)**	**Step 10:** Streamflow Change **(Worksheet 4-6)**	**Step 13:** Streambank Erosion **(Worksheet 4-7)**	**Step 14:** In-Channel Mining **(Worksheet 4-8)**	**Step 15:** Direct Channel Impacts **(Worksheet 4-9) - 50% surface for surface erosion around ephemeral draws**	**Step 16:** Channel Enlargement **(Worksheet 4-10)**	**Step 17:** Aggradation/ Excess Sediment **(Worksheet 4-11)**	**Step 18:** Channel Evolution/ Succession States **(Table 4-5)**	**Step 19:** Degradation **(Worksheet 4-12)**	**Processes Identified by Step for Advancement to *PLA (# corresponds to column - process)***	**Check Location Selected for Advancement to *PLA***
TC 1	**1202**		**M (3)**	**H (4)**	**H (4)**	**H (4)**								7, 8, 10	✓
TC 2	**854**		**M (3)**	**L (2)**	**H (4)**	**H (4)**								8, 10	✓
TC 3	**3024**		**M (3)**	**M (3)**	**H (4)**	**VH (5)**								8, 10	✓
TC 4	**2229**		**M (3)**	**M (3)**	**H (4)**	**VH (5)**								8, 10	✓
TC 7	**2153**		**M (3)**	**M (3)**	**H (4)**	**VH (5)**								8, 10	✓
Microsheds broken down further by representative weak link stream type for hydrologic and channel process risk assessments															
TC 1 - A	**61**	**F**				**VH (5)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓
TC1 - B	**975**	**F/B**				**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓
TC2 - A	**204**	**F**				**VH (5)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓
TC2 - B	**760**	**F/B**				**VH (5)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓
TC 3 - A	**124**	**D**				**H (4)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓
TC3 - B	**245**	**F**				**VH (5)**	**VH (5)**	**VL (1)**	**H (4)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓
TC4 - A	**94**	**D**				**H (4)**	**H (4)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓
TC7 - A	**309**	**F**				**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	**VH (5)**	10, 13, 15, 16, 17, 18, 19	✓

Worksheet 4-2b. *RRISSC* summary worksheet for the mainstem trunk streams.

Location Code/ River Reach I.D.	Total Corridor Acres	Stream Type	Geographic Location				Stream Type Location							Stream Type Location	
			Step 6: Mass Erosion **(Worksheet 4-3)**	**Step 7:** Roads **(Worksheet 4-4)**	**Step 8:** Surface Erosion **(Worksheet 4-5)**	**Step 10:** Streamflow Change **(Worksheet 4-6)**	**Step 13:** Streambank Erosion **(Worksheet 4-7)**	**Step 14:** In-Channel Mining **(Worksheet 4-8)**	**Step 15:** Direct Channel Impacts **(Worksheet 4-9)**	**Step 16:** Channel Enlarge-ment **(Worksheet 4-10)**	**Step 17:** Aggradation/ Excess Sediment **(Worksheet 4-11)**	**Step 18:** Channel Evolution/ Succession States **(Worksheet 4-12)**	**Step 19:** Degradation **(Worksheet 4-12)**	**Processes Identified by Step for Advance-ment to *PLA***	**Check Location Selected for Advance-ment to *PLA***
Trail Creek Main Trunk	**223**	**G**	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**H (4)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		F	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		C	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**M (3)**	**VL (1)**	**VH (5)**	**H (4)**	**VH (5)**	**5 (VH)**	**VH (5)**	**6, 7, 8, 10, 15, 16, 17, 18, 19**	✓
West Creek Main Trunk	**484**	**G**	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**H (4)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		F	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		C	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**M (3)**	**VL (1)**	**VH (5)**	**H (4)**	**VH (5)**	**5 (VH)**	**VH (5)**	**6, 7, 8, 10, 15, 16, 17, 18, 19**	✓
Trout Creek Main Trunk	**843**	**G**	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**H (4)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		F	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		C	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**M (3)**	**VL (1)**	**VH (5)**	**H (4)**	**VH (5)**	**5 (VH)**	**VH (5)**	**6, 7, 8, 10, 15, 16, 17, 18, 19**	✓
Horse Creek Main Trunk	**85**	**G**	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**H (4)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		F	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**VH (5)**	**VL (1)**	**VH (5)**	**VH (5)**	**VH (5)**	**4 (H)**	**VH (5)**	**6, 7, 8, 10, 13, 15, 16, 17, 18, 19**	✓
		C	**VH (5)**	**VH (5)**	**H (4)**	**VH (5)**	**M (3)**	**VL (1)**	**VH (5)**	**H (4)**	**VH (5)**	**5 (VH)**	**VH (5)**	**6, 7, 8, 10, 15, 16, 17, 18, 19**	✓

References Cited

Rosgen, D.L. (1994). A Classification of Natural Rivers. *Catena, 22*, 169–199.

Rosgen, D.L. (1996). *Applied River Morphology*. Pagosa Springs, CO: Wildland Hydrology.

Rosgen, D.L. (2001). A Stream Channel Stability Assessment Methodology. In *Proceedings of the Seventh Federal Interagency Sediment Conference: Vol. 1.* (pp. II-18–II-26). Reno, NV: Subcommittee on Sedimentation.

Rosgen, D.L. (2006). *Watershed Assessment of River Stability and Sediment Supply (WARSSS)*. Wildland Hydrology: Fort Collins, Colorado.