Upper Colorado Headwaters Phase 1 Watershed Assessment

Prioritization of watershed-based hazards to water supplies

Report Prepared for:

USDA Forest Service

Rocky Mountain Region

Bark Beetle Incident

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TABLE OF CONTENTS

Appendices

List of Tables

List of Figures

Upper Colorado Headwaters Phase 1 Watershed Assessment

Prioritization of watershed-based hazards to water supplies

INTRODUCTION

This Phase 1 Watershed Assessment is designed to be the first phase of a process to identify and prioritize sixth-level watersheds based upon their hazards of generating flooding, debris flows and increased sediment yields following wildfires that could have impacts on water supplies. It is intended to expand upon current wildfire hazard reduction efforts by including water supply watersheds as a community value. The watershed assessment follows the ranking procedure for each of the four integral components as prescribed by the Front Range Watershed Protection Data Refinement Work Group (2009).

This Phase 1 Watershed Assessment is one of 15 that are being completed for the Bark Beetle Incident team in the Rocky Mountain Region (Region 2) of the USDA Forest Service (Figure 1). The Bark Beetle Incident team covers the following three National Forests:

1. White River National Forest
2. Medicine Bow-Routt National Forests
3. Arapaho-Roosevelt National Forests

Phase 2 of the Watershed Assessment process would be to gather the key water supply stakeholders to communicate the suggested process, show them the results of Phase 1, listen to any suggested changes, make appropriate changes and build collaborative support for the assessment process. The stakeholder process is critical to local support for the results of the assessment, and the effectiveness of implementing recommendations that would come out of the assessment process.

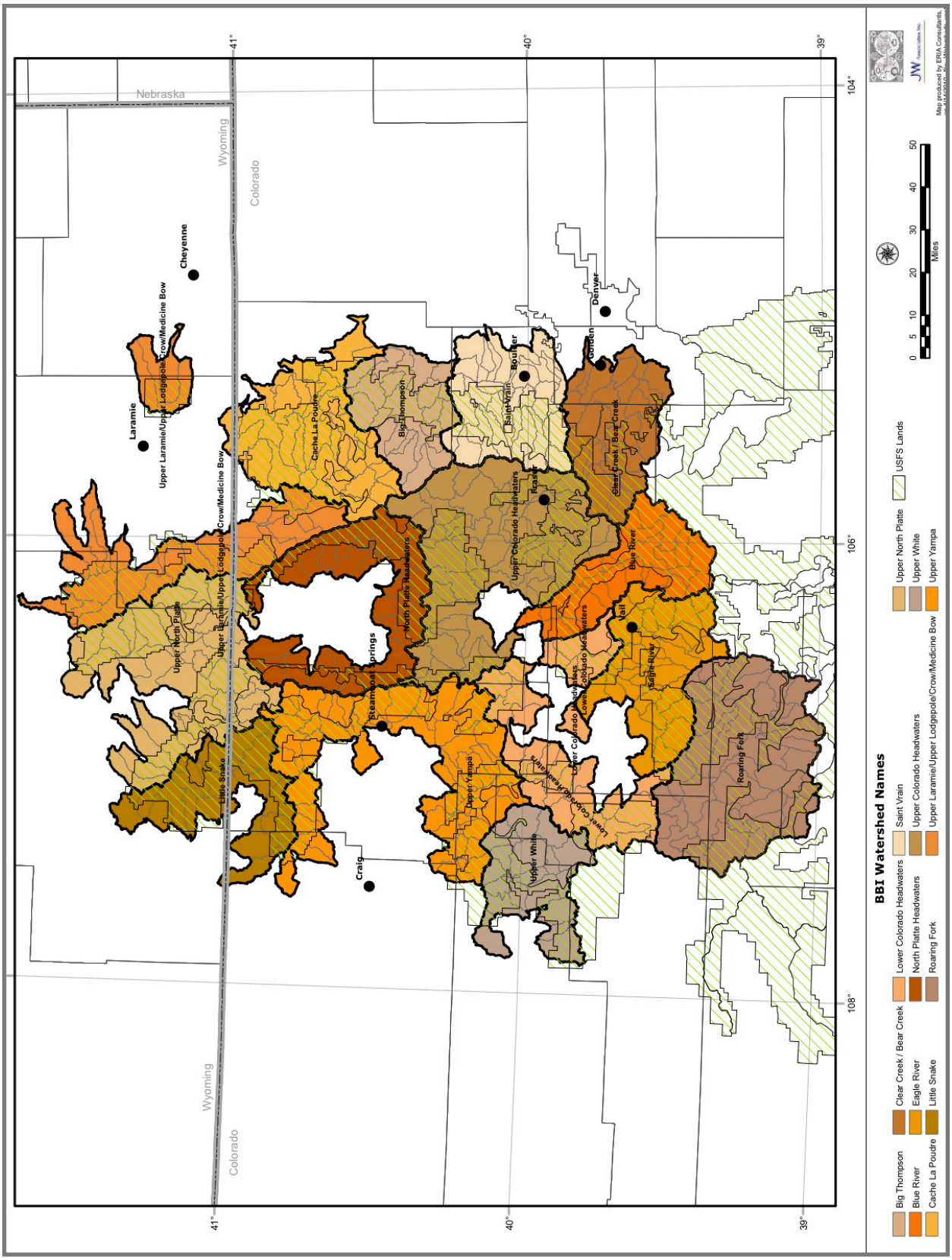


Figure 1. Bark Beetle Incident Phase 1 Watersheds

WATERSHED DESCRIPTION

The Upper Colorado Headwaters watershed is the upper portion of the Colorado Headwaters watershed. This is the headwaters of the Colorado River in Colorado. The watershed was divided for a previous watershed assessment on the Upper Colorado Headwaters because it was too large. This watershed assessment is designed to assess hazards from forest fires to water supply. Therefore, the subwatersheds that are mostly non-forested were eliminated from this watershed assessment.

The Upper Colorado Headwaters Watershed is approximately 1,084,520 acres in area and is part of one fourth-level[1] (eight-digit) watershed (HUC 14010001). For this watershed assessment, three sixth-level watersheds were eliminated based upon their wildfire hazard, ruggedness, and an examination of how well they fit into this assessment. The Upper Colorado Headwaters watershed used in this analysis is 1,015,917 acres, contains eight fifth-level watersheds and 47 sixth-level watersheds, which are the analysis units for this watershed assessment (Front Range Watershed Protection Data Refinement Work Group 2009). The Upper Colorado Headwaters watershed and its fifth-level and sixth-level watersheds are shown on Figure 2 and listed in Table 1.

[I] The watersheds that were used are part of the existing national network of delineated watersheds. Hydrologic Unit Codes (HUCs) are nested watersheds and are designated numerically by levels (Federal Geographic Data Committee 2004). Sixth-level HUCs or watersheds, use the 11th and 12th digits in the HUC code. Fifth-level HUCs use the ninth and 10th digits in the HUC code.

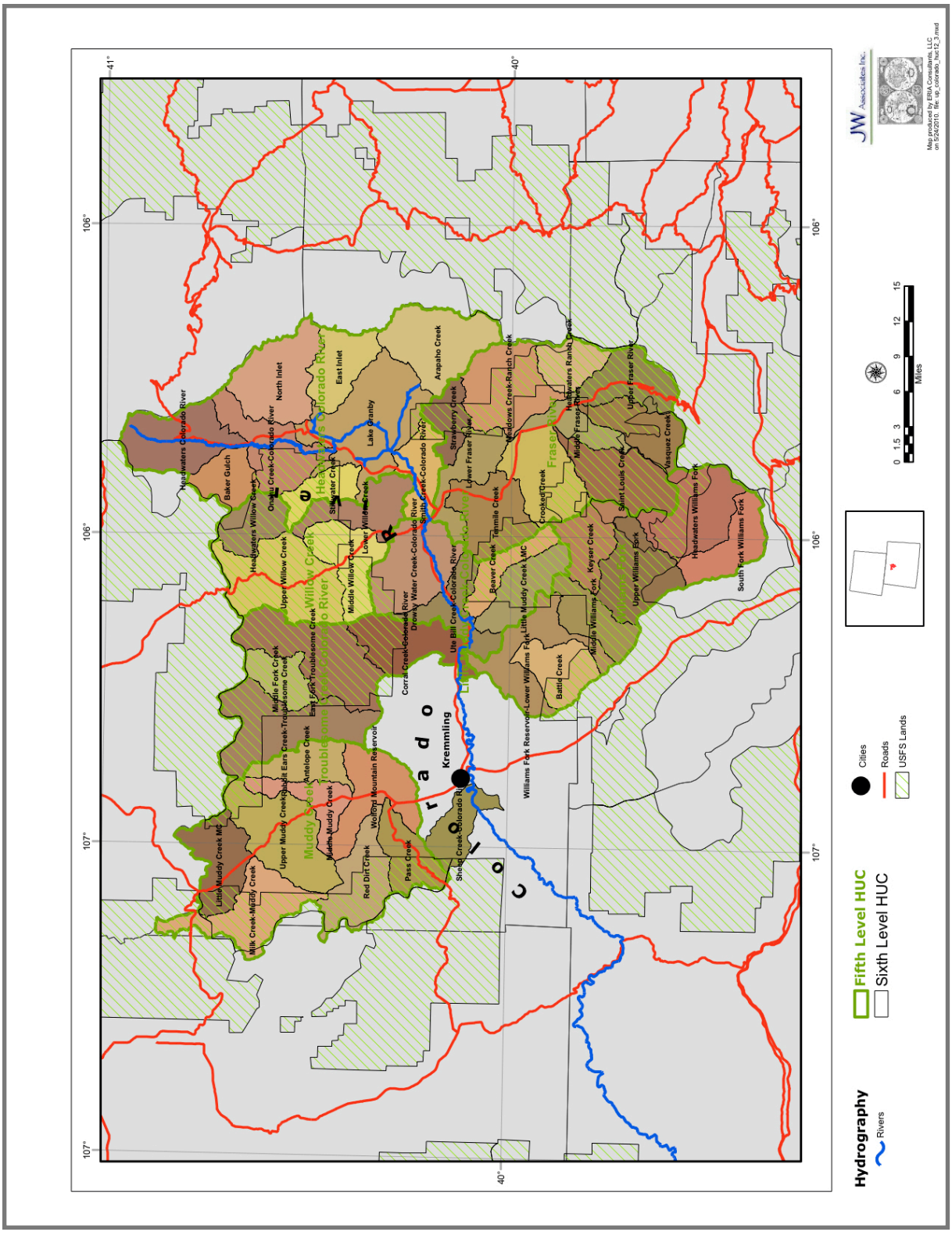


Figure 2. Upper Colorado Headwaters Watershed Analysis Area[2]

[2] The fifth-level watersheds are shown in Figure 2.

Table 1. Fifth-level & Sixth-level Watersheds in Upper Colorado Headwaters Watershed[3]

Fifth-level Watershed	Sixth-level Watershed	Watershed Area (acres)	Hydrologic Unit Code (HUC)	Map #
Willow Creek HUC 1401000101	Headwaters Willow Creek	14,274	140100010101	134
	Upper Willow Creek	37,834	140100010102	113
	Middle Willow Creek	20,435	140100010103	122
	Lower Willow Creek	18,044	140100010104	121
Fraser River HUC 1401000102	Vasquez Creek	17,871	140100010201	102
	Upper Fraser River	19,380	140100010202	142
	Saint Louis Creek	24,465	140100010203	107
	Headwaters Ranch Creek	12,763	140100010204	133
	Meadows Creek-Ranch Creek	29,878	140100010205	143
	Middle Fraser River	11,694	140100010206	141
	Crooked Creek	26,368	140100010207	100
	Strawberry Creek	10,807	140100010208	114
	Tenmile Creek	23,742	140100010209	120
	Lower Fraser River	16,505	140100010210	101
Headwaters Colorado River HUC 1401000102	Baker Gulch	13,150	140100010301	110
	Headwaters Colorado River	27,632	140100010302	111
	Onahu Creek-Colorado River	24,368	140100010303	109
	East Inlet	18,019	140100010304	139
	North Inlet	29,333	140100010305	106
	Stillwater Creek	11,228	140100010306	112
	Arapaho Creek	30,877	140100010307	136
	Lake Granby	44,897	140100010308	138
	Smith Creek-Colorado River	14,553	140100010309	115
Williams Fork HUC 1401000102	South Fork Williams Fork	17,754	140100010401	119
	Headwaters Williams Fork	28,310	140100010402	135
	Keyser Creek	17,458	140100010403	127
	Upper Williams Fork	25,795	140100010404	144
	Middle Williams Fork	16,379	140100010405	128
	Battle Creek	17,202	140100010406	145
	Williams Fork Reservoir-Lower Williams Fork	25,325	140100010407	108
Little Muddy Creek HUC 1401000102	Drowsy Water Creek-Colorado River	29,178	140100010501	125
	Beaver Creek	11,757	140100010502	124
	Little Muddy Creek LMC	18,403	140100010503	103
	Ute Bill Creek-Colorado River	16,620	140100010504	118
Troublesome Creek HUC 1401000102	Corral Creek-Colorado River	22,451	140100010601	104
	Middle Fork Creek	12,536	140100010602	116
	East Fork Troublesome Creek	35,917	140100010603	130
	Rabbit Ears Creek-Troublesome Creek	36,168	140100010604	117

[3] Map numbers are used in Figures 3, 6 and 9

[4] The fifth-level watershed Sheep Creek is identified as Sheephorn Creek in the USGS database. However Sheephorn Creek is located in another watershed and therefore was renamed Sheep Creek to avoid being misleading.

Table 1. Fifth-level & Sixth-level Watersheds in Upper Colorado Headwaters (continued)

Fifth-level Watershed	Sixth-level Watershed	Watershed Area (acres)	Hydrologic Unit Code (HUC)	Map #
Muddy Creek HUC 1401000102	Little Muddy Creek MC	21,219	140100010701	123
	Milk Creek-Muddy Creek	26,691	140100010702	132
	Upper Muddy Creek	33,430	140100010703	126
	Middle Muddy Creek	13,263	140100010704	105
	Antelope Creek	14,482	140100010705	140
	Red Dirt Creek	23,545	140100010706	129
	Pass Creek	15,974	140100010707	131
	Wolford Mountain Reservoir	24,098	140100010708	137
Sheep Creek[4] HUC 1401000109	Sheep Creek-Colorado River	13,845	140100010901	146
	Total Area	**1,015,917**		

WATERSHED ASSESSMENT

The potential of a watershed to deliver sediments following wildfire depends on forest and soil conditions, the physical configuration of the watersheds, and the sequence and magnitude of rain falling on the burned area. High-severity fires can cause changes in watershed conditions that are capable of dramatically altering runoff and erosion processes in watersheds. Water and sediment yields may increase as more of the forest floor is affected by fire.

This Phase 1 - Upper Colorado Headwaters Watershed Assessment provides the analysis for the first three components specified in Front Range Watershed Protection Data Refinement Work Group (2009) procedure. It provides the analysis for: wildfire hazard, flooding or debris flow hazard, and soil erodibility. This Phase 1 assessment combines those three components into a composite hazard ranking. This report discusses the technical approach for each component and the process used to assemble the watershed ranking.

The categories used in the prioritization are numbered one though five, with one being the lowest ranking and five being the highest. The numeric ranges for each category are as follows;

Category 1 - 0.5 to 1.49
Category 2 - 1.5 to 2.49
Category 3 - 2.5 to 3.49
Category 4 - 3.5 to 4.49
Category 5 - 4.5 to 5.49

The categories are used in this analysis for the purpose of comparing watersheds to each other within the Upper Colorado Headwaters watershed. Comparisons with other watershed assessments are not valid because this approach prioritizes watersheds by comparing them to the other sixth-level watersheds only in this watershed assessment area.

Component 1 - Wildfire Hazard

The forest conditions that are of concern for the assessments are the wildfire hazard based on existing forest conditions. The wildfire hazard (Flame Length) was determined using the Fire Behavior Assessment Tool (FBAT) (http://www.fire.org) which is an interface between ArcMap and FlamMap. The input spatial data were collected from LANDFIRE project (http://www.landfire.gov/).

After a mountain pine beetle outbreak there are substantial increases in the amount of fine dead fuels in the canopy. The majority of these fuels remain in the canopy for 2-3 years post outbreak (Knight 1987, Schmid and Amman 1992). Therefore, certain input spatial data sets were updated based on Mountain Pine Beetle (MPB) mortality conditions using USDA Forest Service, Rocky Mountain Region Aerial Detection Survey (ADS) Data from the years 2002-2007 (http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/). The assumptions used in the FBAT model are presented in Appendix A.

The flame length results were divided into five categories of wildfire hazard ranging from lowest (Category 0) to highest (Category 4). The flame length categories that were used are;

Flame Length Category 0 - 0 meters

Flame Length Category 1 - 1 to 10 meters

Flame Length Category 2 - 11 to 25 meters

Flame Length Category 3 - 26 to 40 meters

Flame Length Category 4 - >40 meters

Figure 3 shows the results of the wildfire hazard modeling. The results were categorized by sixth-level watershed into five categories that are used throughout the analysis (see Table B-1 in Appendix B) using the following formula.

Wildfire Hazard Ranking = (Percentage in Category 3 + Percentage in Category 4 * 2)

The categorized wildfire hazard by sixth-level watershed was mapped (Figure 4). The map shows that the highest hazards are in the following sixth-level watersheds: Headwaters Willow Creek, Headwaters Ranch Creek, Saint Louis Creek, Onahu Creek-Colorado River, Meadows Creek-Ranch Creek, Headwaters Colorado River, Strawberry Creek, Vasquez Creek, Middle Fraser River, and Baker Gulch. In addition, 15 watersheds were ranked as Category 4, which is the next highest category (see Table B-1 in Appendix B). Headwaters Willow Creek was skewing the categorization because of its high wildfire hazard score. The wildfire hazard score for Headwaters Willow Creek was manually given a score slightly higher than the next highest score (Table B-1 in Appendix B).

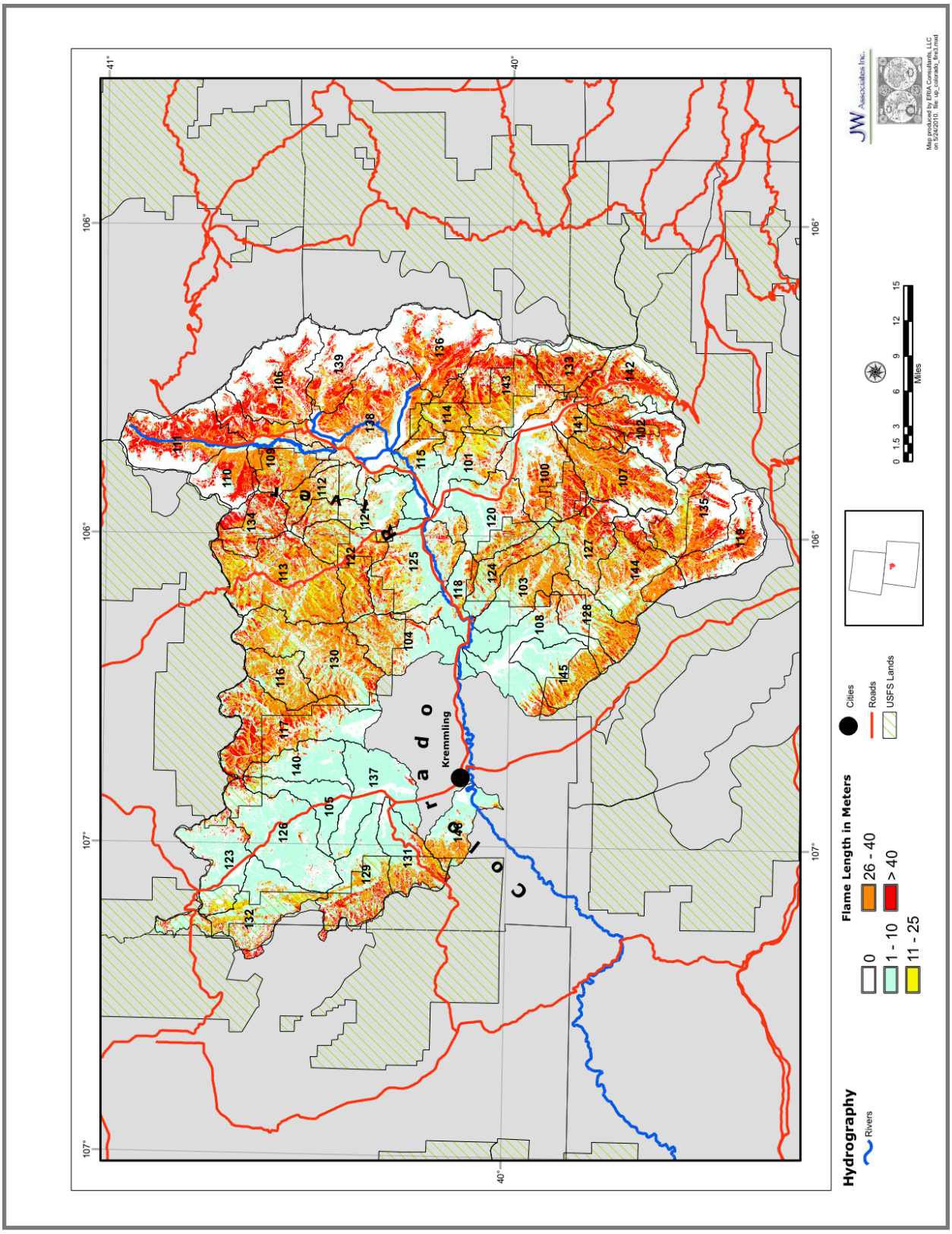


Figure 3. Upper Colorado Headwaters Watershed Wildfire Hazard Modeling Results

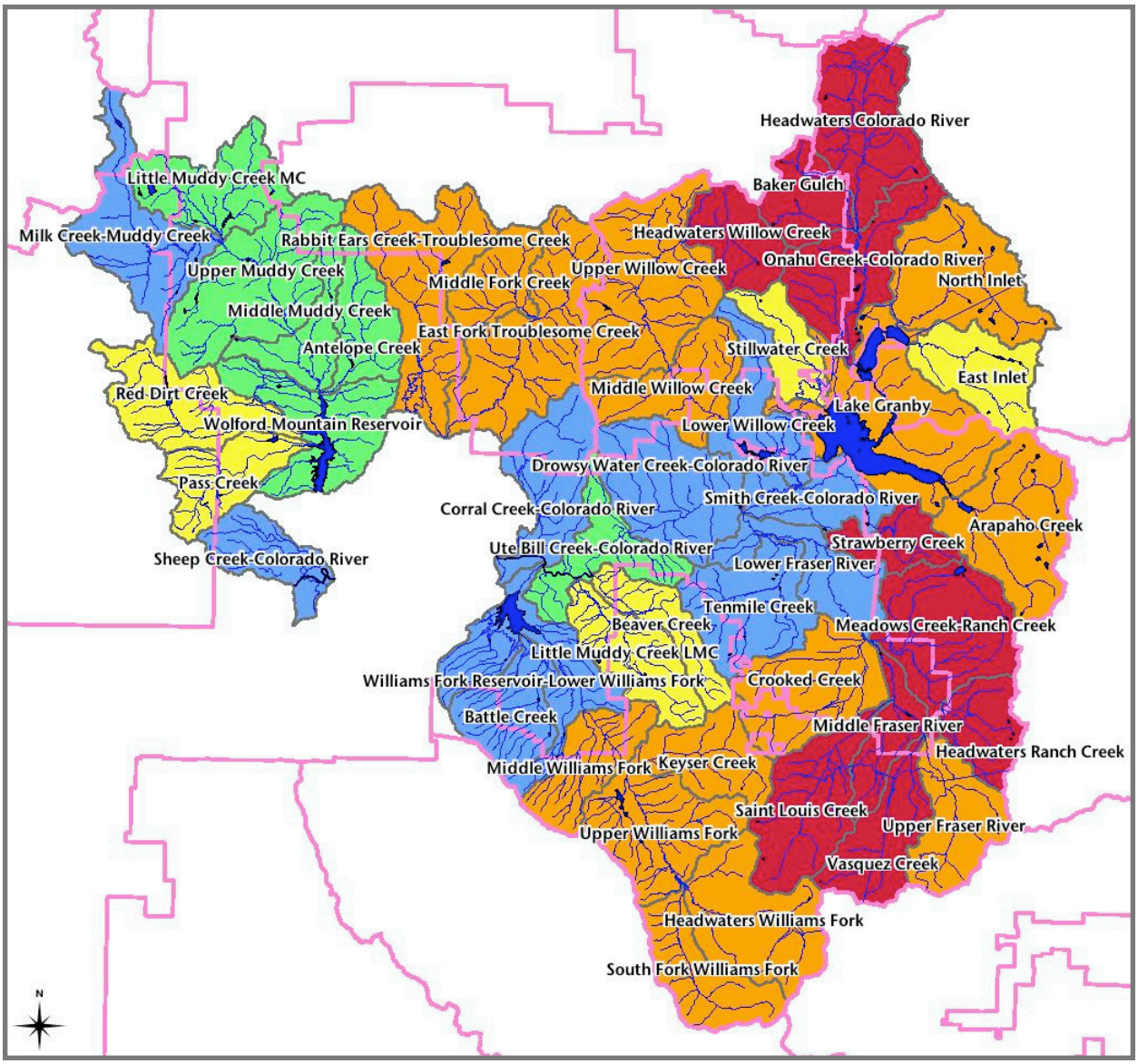


Figure 4. Upper Colorado Headwaters Watershed Wildfire Hazard Ranking

Component 2 - Flooding or Debris Flow Hazard

A combination of ruggedness and road density (miles of road per square mile of watershed area) was used to assess the flooding or debris flow hazard portion of the analysis. The two components, ruggedness and road density, are described below.

Ruggedness

Watershed steepness or ruggedness is an indicator of the relative sensitivity to debris flows following wildfires (Cannon and Reneau 2000). The more rugged the watershed, the higher its sensitivity to generating debris flows following wildfire (Melton 1957). The Melton ruggedness factor is basically a slope index.

Melton (1957) defines ruggedness, R, as;

$$R = H_b A_b^{-0.5}$$

Where A_b is basin area (square feet) and H_b is basin height (feet) measured from the point of highest elevation along the watershed divide to the outlet.

The ruggedness result in some watersheds was adjusted because they do not accurately reflect the slope in those watersheds. Those situations are most common in composite watersheds because they are disconnected from their headwaters. These watersheds can have a high hazard for debris flows because they contain a main stem of a creek or river with several steep first order streams as tributaries. In those situations, the ruggedness calculation was adjusted up by reducing the watershed area. These adjustments were completed on the following watersheds; Arapaho Creek, Headwaters Ranch Creek, North Inlet, Headwaters Williams Fork, Middle Williams Fork, Meadows Creek-Ranch Creek, Upper Williams Fork, Onahu Creek-Colorado River, Battle Creek, Williams Fork Reservoir-Lower Williams Fork, Drowsy Water Creek-Colorado River, Middle Willow Creek, Middle Fork Creek, Headwaters Colorado River, Rabbit Ears Creek-Troublesome Creek, Upper Willow Creek, Upper Muddy Creek, Little Muddy Creek LMC, Crooked Creek, Milk Creek-Muddy Creek, Tenmile Creek, Wolford Mountain Reservoir, and Lower Fraser River.

Figure 5 displays the categorized ruggedness for the Upper Colorado Headwaters Watershed. The tabular results are presented on Table B-2 in Appendix B. The map (Figure 5) shows that the most rugged sixth-level watersheds are East Inlet, Arapaho Creek, Headwaters Ranch Creek, North Inlet, Baker Gulch, Headwaters Williams Fork, Middle Fraser River, Middle Williams Fork, Upper Fraser River, Stillwater Creek, and Keyser Creek.

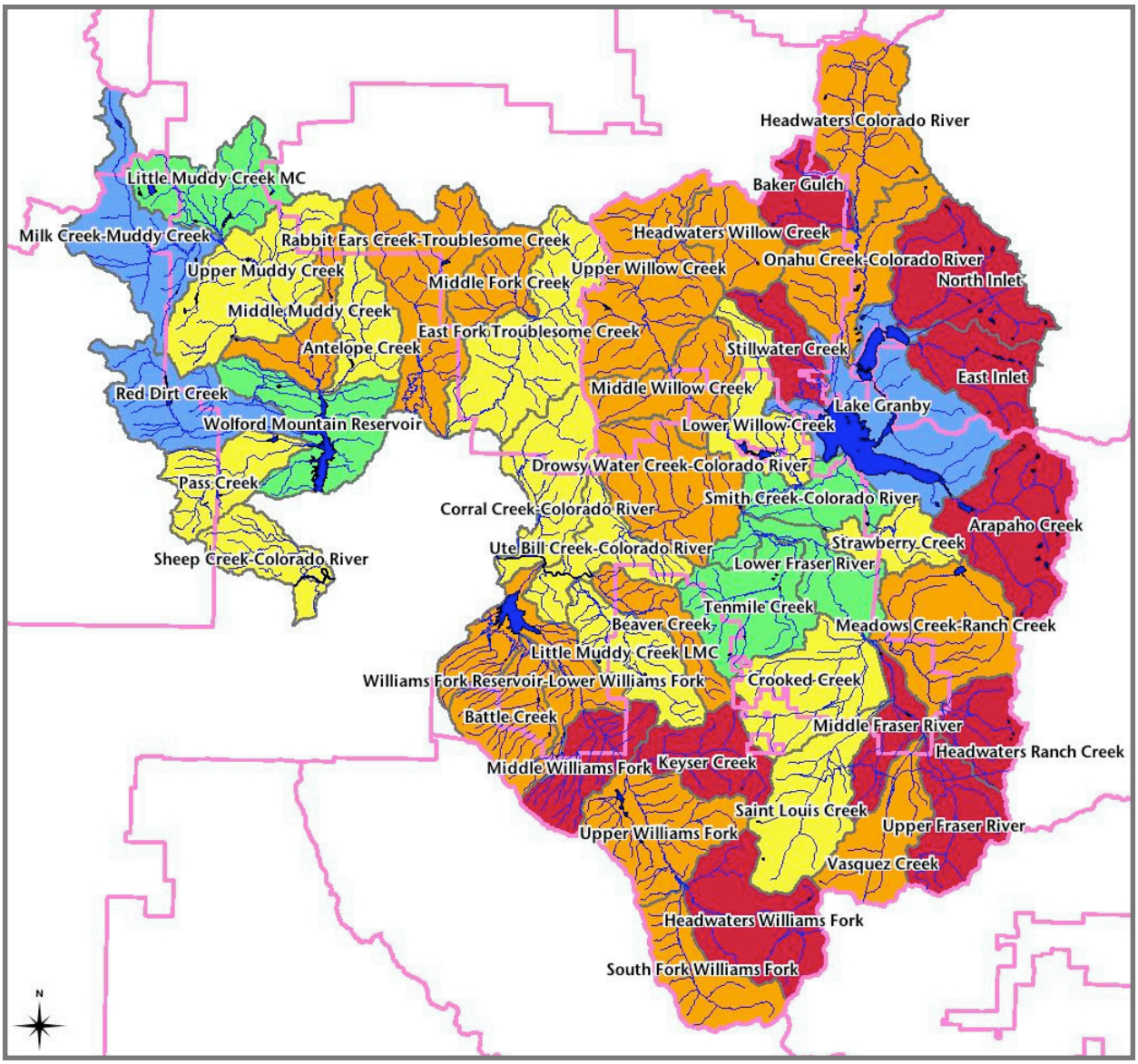


Figure 5. Upper Colorado Headwaters Watershed Ruggedness Ranking

Road Density

Roads can convert subsurface runoff to surface runoff and then route the surface runoff to stream channels, increasing peak flows (Megan and Kidd 1972, Ice 1985, and Swanson et al. 1987). Therefore, watersheds with higher road densities have a higher sensitivity to increases in peak flows following wildfires. Road density in miles of road per square mile of watershed area was used as an indicator of flooding hazard. The U.S. Forest Service roads data was used on National Forest System (NFS) lands because it is the most accurate roads data for those roads in the forest. On all other lands the U.S. Census Bureau's Tiger database was used because it is a consistent roads data layer (Figure 6).

Road densities were adjusted in some watersheds for two separate reasons. One reason for adjusting the road density was the situation where a watershed had a much higher road density than the next highest value, so that watershed was skewing the categorization. In that situation, the watershed was manually given a road density slightly higher than the next highest score.

The other situation where road density was adjusted is where some of the roads within a watershed were within towns, developed areas, or outside the forested areas of the watershed. The roads that are of interest in this analysis are those roads that would increase the risk of flooding or debris flows following wildfires in forested areas. The watersheds were all examined by looking at the roads data overlain on digital images and vegetation mapping. If it was found that there were significant lengths of road outside forested areas, the road density in those watersheds was adjusted down based on ocular estimates.

Road density in the Middle Fraser River, Crooked Creek, Tenmile Creek, Lower Fraser River, Ute Bill Creek-Colorado River, and Lake Granby was adjusted down. The adjustments are displayed on Table B-3 in Appendix B.

Figure 7 displays the categorized road density for the Upper Colorado Headwaters Watershed and tabular results are presented in Appendix B (Table B-3). Figure 7 shows that the highest rankings are in Middle Fraser River, Pass Creek, Upper Fraser River, Beaver Creek, and Corral Creek-Colorado River.

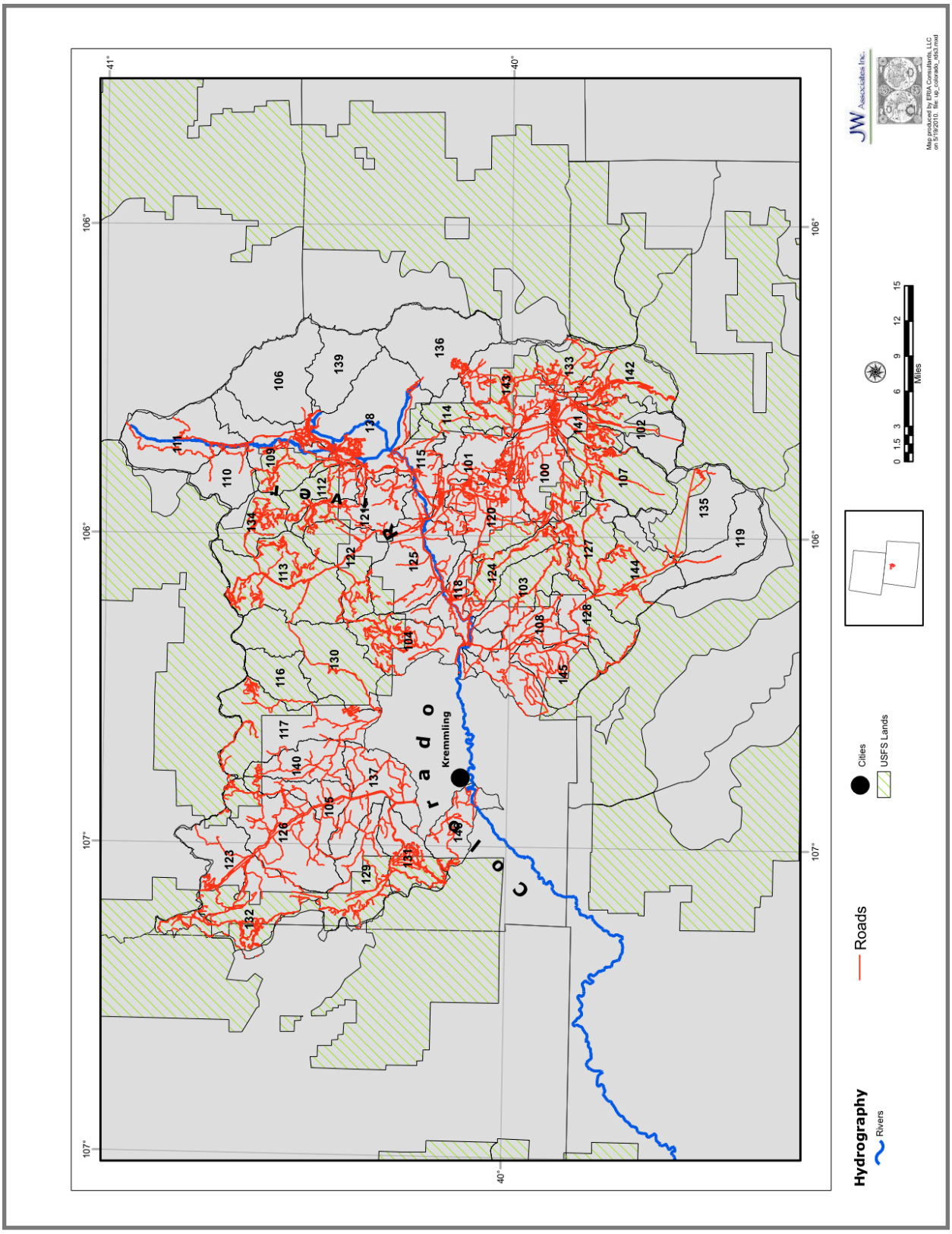


Figure 6. Upper Colorado Headwaters Watershed Roads Map

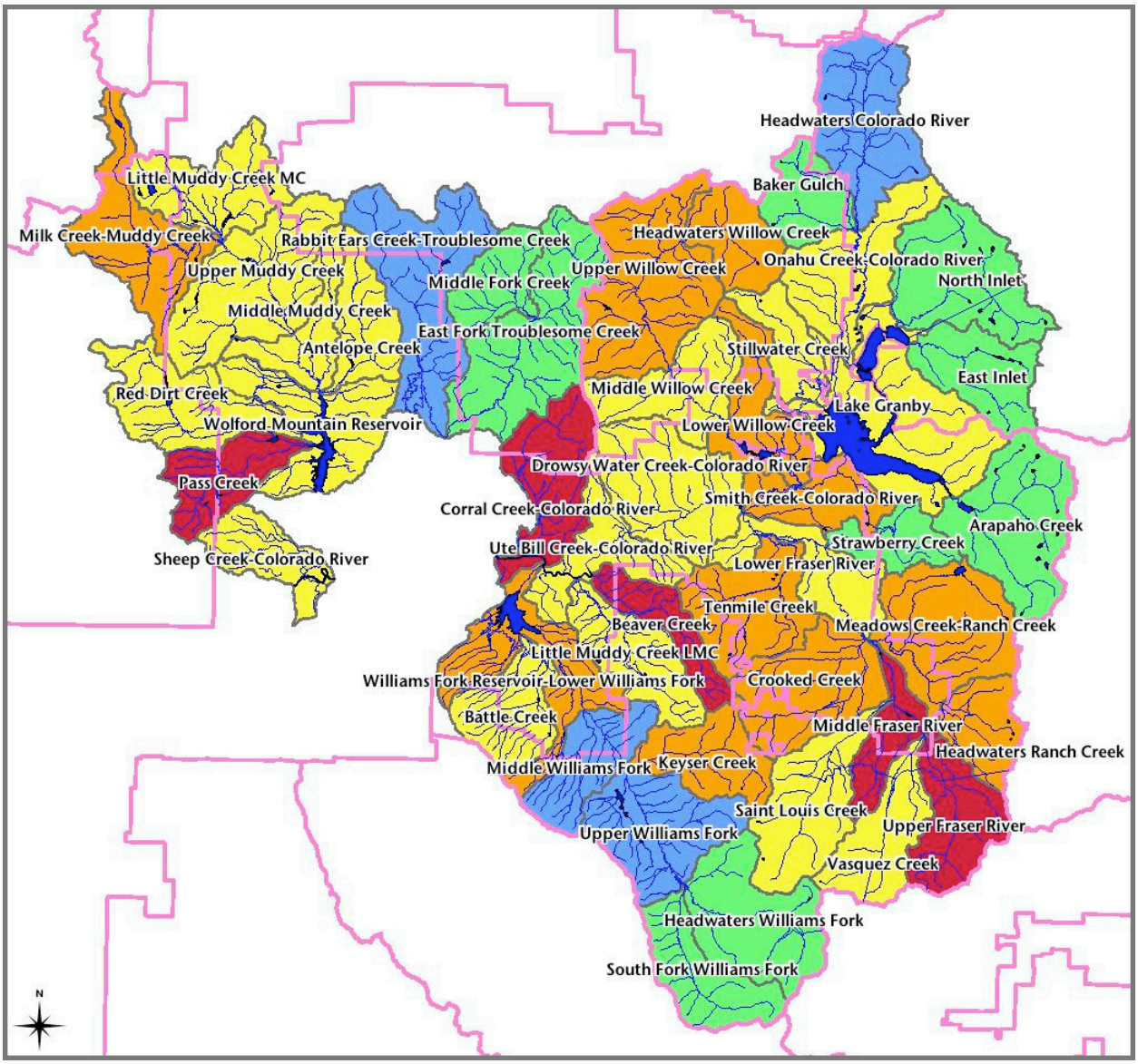
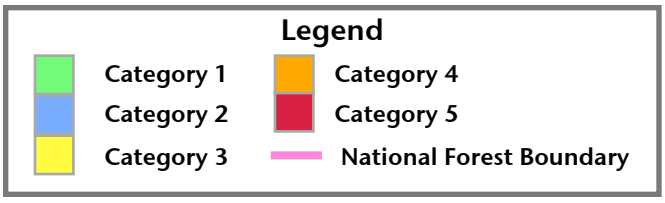


Figure 7. Upper Colorado Headwaters Watershed Road Density Ranking



Flooding or Debris Flow Hazard Ranking

The Flooding or Debris Flow Hazard is the combination of ruggedness and road density. The procedure from the Front Range Watershed Work Group (2009) assigned ruggedness a higher value than road density in this ranking. While ruggedness is the most important factor, an increase in road density will magnify the effects of ruggedness on the flooding/debris flow hazard. Accordingly, the analysis for flooding or debris flow hazard for the Upper Colorado Headwaters Watershed used the following formula. The results of this calculation were then re-categorized into five hazard rankings.

Flooding or Debris Flow Hazard Ranking = (Road Density Ranking + Ruggedness Ranking * 2)

Figure 8 shows that areas of the watershed with high road densities and high ruggedness rank high in this combined factor. The best way to look at this map is to look at a single watershed on the ruggedness and road density maps, noting the rankings on each. Then look at this map and see how they result in the final ranking for this component. The tabular results are presented in Table B-4 in Appendix B.

The highest ranked sixth-level watersheds are Middle Fraser River, Upper Fraser River, and Headwaters Ranch Creek.

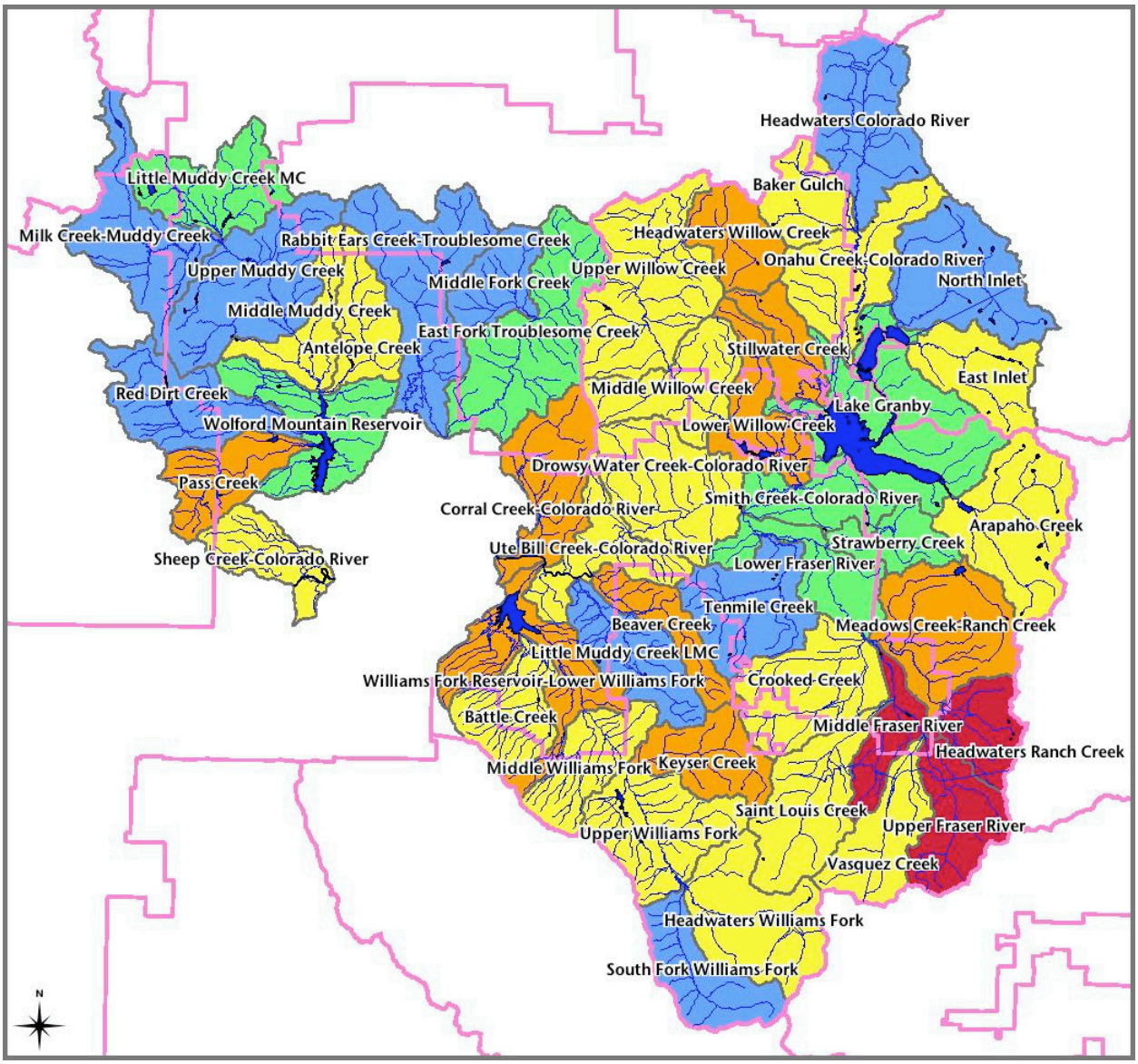
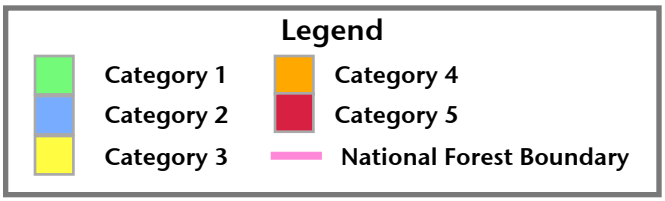


Figure 8. Upper Colorado Headwaters Watershed Flooding/Debris Flow Hazard Ranking



Component 3 - Soil Erodibility

High-severity fires can cause changes in watershed components that can dramatically change runoff and erosion processes in watersheds. Water and sediment yields may increase as more of the forest floor is consumed (Wells et al. 1979, Robichaud and Waldrop 1994, Soto et al. 1994, Neary et al. 2005, and Moody et al. 2008) and soil properties are altered by soil heating (Hungerford et al. 1991).

Two soils data sets were evaluated for use in this analysis. They were the U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) STATSGO and SSURGO soils data. STATSGO data are relatively coarse soils data, created at a scale of 1:250,000 and are available for the entire watershed assessment area. SSURGO soils data do not cover all the watershed assessment area, though efforts by the NRCS are currently under way to produce an updated soils data layer.

The data used in this analysis is the U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) SSURGO soils data combined with the U.S. Forest Service soils data. SSURGO data does not cover all the watershed but is available at a preferable scale (generally ranges from 1:12,000 to 1:63,360) than STATSGO data. The U.S. Forest Service soils data is comparable with the SSURGO data in scale and quality. Areas without SSURGO data were filled in with U.S. Forest Service soils data (Figure 9).

The soil erodibility analysis used a combination of two standard erodibility indicators: the inherent susceptibility of soil to erosion (K factor) and land slope derived from Unites States Geological Survey (USGS) 30-meter digital elevation models. The K factor data from the SSURGO spatial database was combined with a slope grid using NRCS (USDA NRCS 1997) slope-soil relationships (Table 2) to create a classification grid divided into slight, moderate, severe and very severe erosion hazard ratings.

Table 2. NRCS Criteria for Determining Potential Soil Erodibility

Percent Slope	K Factor <0.1	K Factor 0.1 to 0.19	K Factor 0.2 to 0.32	K Factor >0.32
0-14	Slight	Slight	Slight	Moderate
15-34	Slight	Slight	Moderate	Severe
35-50	Slight	Moderate	Severe	Very Severe
>50	Moderate	Severe	Very Severe	Very Severe

The potential soil erodibility hazard rankings are shown on Figure 10 and the tabular results are presented in Table B-5 in Appendix B. The map shows areas of high soil erodibility in the assessment area. The highest ranked sixth-level watersheds based on soil erodibility are East Inlet, South Fork Williams Fork, North Inlet, Headwaters Williams Fork, and Headwaters Colorado River. The soil erodibility value for Upper Fraser River was adjusted up due to the presence of large quantities of highway sand that increase the concern for soil erosion.

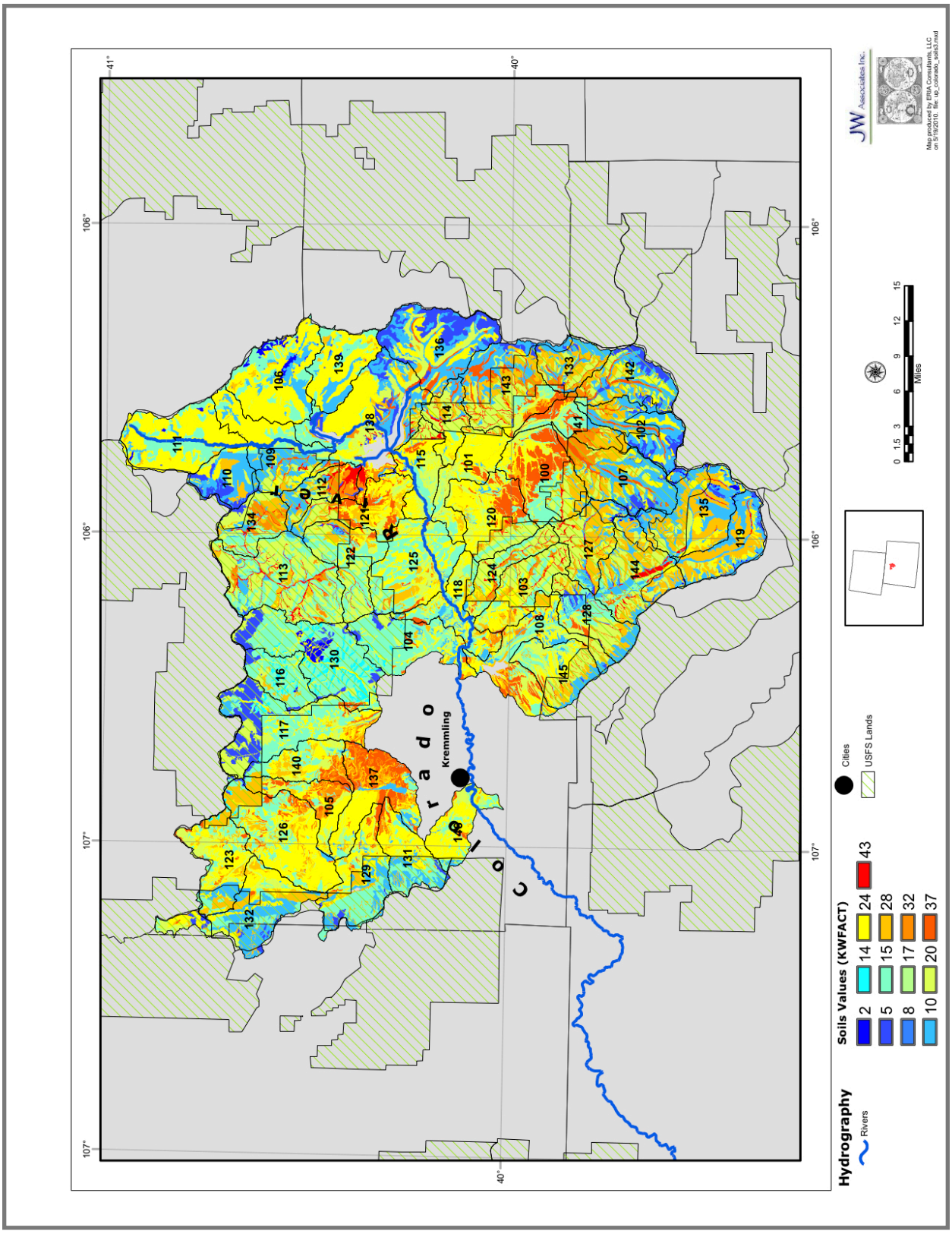


Figure 9. Upper Colorado Headwaters Watershed Soils K-Factor Map

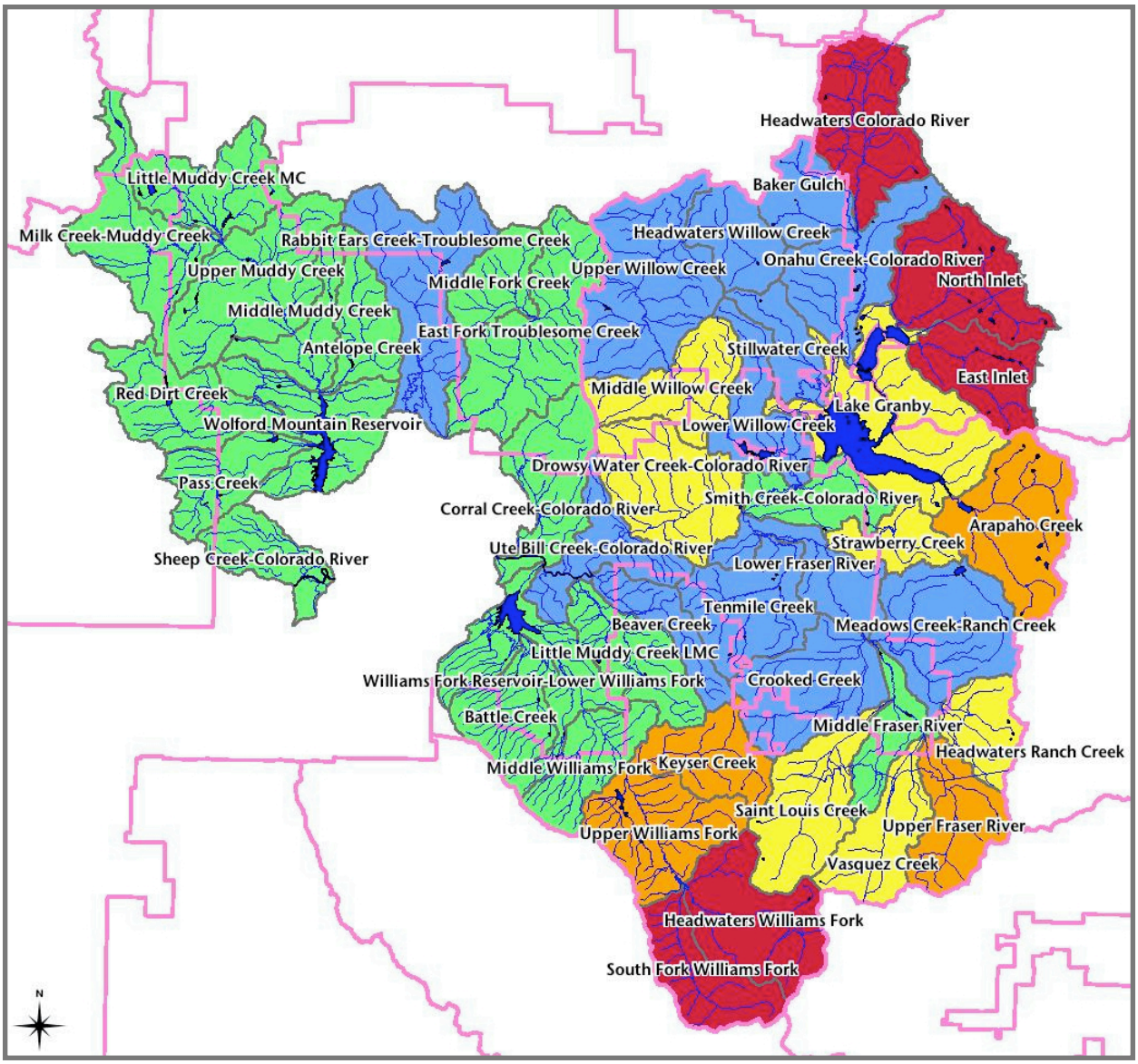


Figure 10. Upper Colorado Headwaters Watershed Potential Soil Erodibility Hazard Ranking

Legend

- Category 1
- Category 2
- Category 3
- Category 4
- Category 5
- National Forest Boundary

Composite Hazard Ranking

The Composite Hazard Ranking combines the first three components (Wildfire Hazard, Flooding/Debris Flow Hazard and Soil Erodibility) by numerically combining their rankings for each sixth-level watershed and then re-categorizing the results. The Composite Hazard Ranking map is useful in comparing relative watershed hazards based solely on environmental factors. Figure 11 shows the Composite Hazard Ranking for the Upper Colorado Headwaters Watershed. The tabular results that display the rankings for Wildfire Hazard, Flooding/Debris Flow Hazard and Soil Erodibility, as well as the composite rankings are presented in Table B-6 in Appendix B. The highest ranked sixth-level watersheds are Upper Fraser River, Keyser Creek, Headwaters Ranch Creek, Headwaters Colorado River, and Meadows Creek-Ranch Creek. There are 14 watersheds in Category 4.

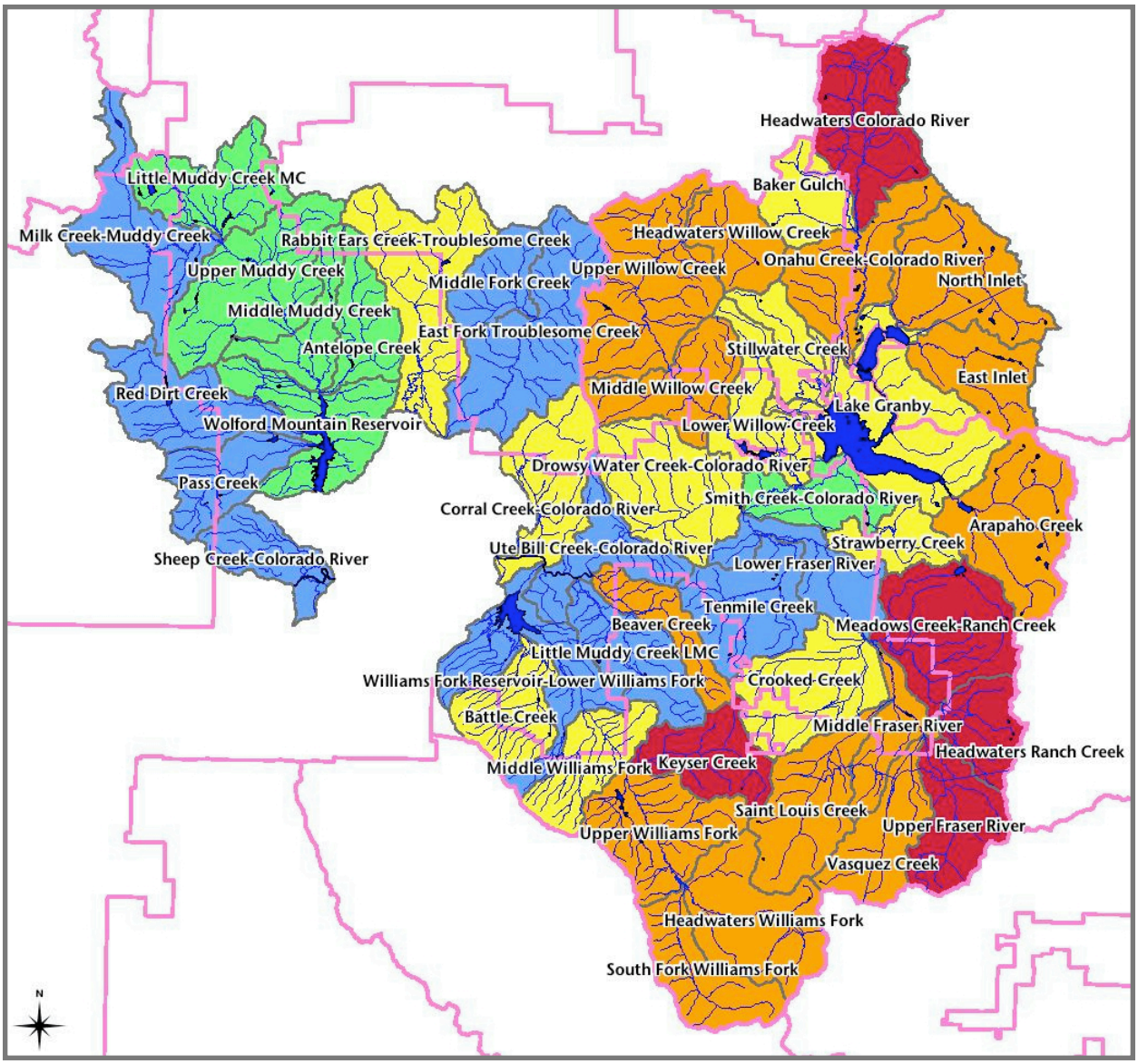


Figure 11. Upper Colorado Headwaters Watershed Composite Hazard Ranking

Component 4 - Water Supply Ranking

Surface water intakes, diversions, conveyance structures, storage reservoirs and streams are all susceptible to the effects of wildfires. The suggested approach from the procedure prescribed by the Front Range Watershed Protection Data Refinement Work Group (2009) is to first rank watersheds based upon the presence of water nodes.

Surface drinking water supply collection points from the Source Water Assessment and Protection (SWAP) Program (see http://www.cdphe.state.co.us/wq/sw/swaphom.html for basic information on the SWAP Program) were used to identify which sixth-level watersheds contain critical components of the public water supply infrastructure in Colorado. For this assessment, water nodes were defined as coordinate points corresponding to surface water intakes, upstream diversion points and classified drinking water reservoirs.

Water supply locations may not be identified in the state's database for some drinking water supply reservoirs that do not have associated direct surface water intakes. Also, some water supply reservoirs may not be identified in the SWAP database. The Water Supply map was modified to include these features by including all named reservoirs.

Figure 12 shows the sixth-level watersheds that have water supply locations in blue and those without water supply locations in green.

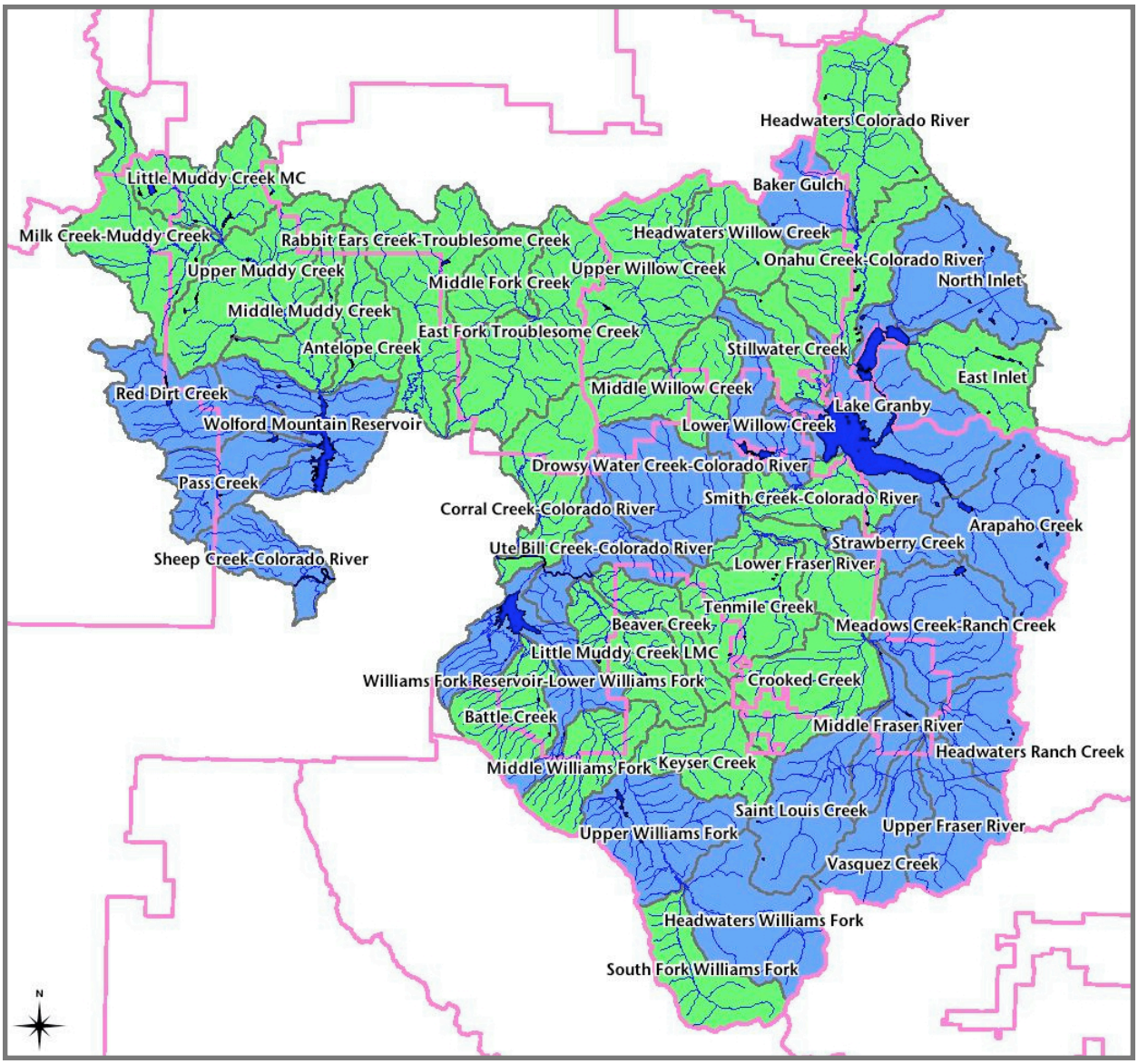


Figure 12. Upper Colorado Headwaters Watershed Water Supply Map

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APPENDIX A

UPPER COLORADO HEADWATERS WILDFIRE HAZARD MODELING METHODOLOGY

The forest conditions that are of concern for the assessments are the wildfire hazard based on existing forest conditions. The wildfire hazard (Flame Length) was determined using the Fire Behavior Assessment Tool (FBAT) (http://www.fire.org) which is an interface between ArcMap and FlamMap. The input spatial data were collected from LANDFIRE project (http://www.landfire.gov/).

After a mountain pine beetle outbreak there are substantial increases in the amount of fine dead fuels in the canopy. The majority of these fuels remain in the canopy for 2-3 years post outbreak (Knight 1987, Schmid and Amman 1992). Therefore, certain input spatial data sets were updated reflecting Mountain Pine Beetle (MPB) mortality conditions using USDA Forest Service, Rocky Mountain Region Aerial Detection Survey (ADS) Data from the years 2002 - 2007 (http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/). The following modeling settings and spatial data modification were used:

Modeling Setting

1. Scott and Burgan (2005) Fire Behavior Model (Fuel Moisture is shown in Table A-1)
2. Uphill wind direction
3. Scott & Reinhardt (2001) crown fire calculation
4. Foliar Moisture at 100%

Spatial Data Modifications

1. Canopy Cover was assigned a value of 10% when coincident with MPB mortality from ADS for years 2002-2007.
2. Canopy Base Height (CBH) was reduced by 25% for MPB mortality derived from ADS for the years 2002-2006.
3. CBH was reassigned a value of 0 for MPB mortality from ADS for the year 2007.
4. Canopy Bulk Density (CBD) was reduced by 50% for MPB mortality derived from ADS for the years 2002-2006

Table A-1. Fuel Moisture (percent) used in FBAT Model Runs

Scott and Burgan (2005) fuel model	1-Hour Fuel	10-Hour Fuel	100-Hour Fuel	Live Herbaceous	Live Woody
1	4	5	8	200	95
2	4	5	8	150	95
3	4	5	8	85	95
4	4	5	8	85	95
5	4	5	8	85	150
6	4	5	8	85	95
7	4	5	8	85	95
8	4	5	8	85	95
9	4	5	8	85	95
10	4	5	8	85	95
11	4	5	8	85	95
12	4	5	8	85	95
13	4	5	8	85	95
14	3	4	8	85	95
15	3	4	8	85	95
16	3	4	8	85	95
17	3	4	8	85	95
18	3	4	8	85	95
19	3	4	8	85	95
20	3	4	8	85	95
21	3	4	8	85	95
22	3	4	8	85	95
23	3	4	8	85	95
24	3	4	8	85	95
25	3	4	8	85	95
26	3	4	8	85	95
27	3	4	8	85	95
28	3	4	8	85	95
29	3	4	8	85	95
30	3	4	8	85	95
31	3	4	8	85	95
32	3	4	8	85	95
33	3	4	8	85	95
34	3	4	8	85	95
35	3	4	8	85	95
36	3	4	8	85	95
37	3	4	8	85	95
38	3	4	8	85	95
39	3	4	8	85	95
40	3	4	8	85	95
41	3	4	8	85	95
42	3	4	8	85	95
43	3	4	8	85	95
44	3	4	8	85	95
45	3	4	8	85	95
46	3	4	8	85	95
47	3	4	8	85	95
48	3	4	8	85	95
49	3	4	8	85	95
50	3	4	8	85	95

Weather Data

The weather data used comes from the Colorado Wildfire Risk Assessment Statewide (CRA) dataset prepared by Sandborn under contract to the Colorado State Forest Service. For the Colorado Fire Risk Assessment nine weather influence zones (WIZ) were developed for analysis purposes. A WIZ is an area where for analysis purposes the weather on any given day is uniform. Within each WIZ, daily weather data was gathered for the years 1980-2006. Where not available, the weather data was gathered from the earliest year through 2006. Several weather stations were analyzed within each WIZ. From this analysis, one representative weather station was selected for each WIZ. From this data set, percentile weather was developed for each WIZ using the Fire Family Plus software package.

For this watershed assessment the percentile weather for WIZ CO 02 (Dowd 1986-2006) was used for all watersheds on the west side of the continental divide and WIZ CO 03 (Coral Creek 1980-2006) was used for all watersheds on the east side of the continental divide. The 20-foot wind speeds for the "High" case was used in the modeling runs (Table A-2).

In addition the wind direction was assumed to be uphill (parallel with slope) in all instances. This setting encourages crown fire initiation and establishes a common baseline for the evaluation of areas within the landscape based upon the fuels hazard represented by vegetation conditions.

Table A-2. Wind Speed (Miles per Hour) used in FBAT Model Runs

Watershed Name	Wind Speed (mph)	Probable Momentary Gust Speed (mph)
North Platte	15	29
Upper North Platte	15	29
Crow/Medicine Bow/Upper Laramie/Upper Lodgepole	12	25
Clear/Bear Creek	12	25
Big Thompson	12	25
Cache la Poudre	12	25
Blue River	15	29
Eagle River	15	29
Upper Yampa	15	29
Little Snake	15	29
Upper White	15	29
Lower Colorado	15	29
Upper Colorado	15	29
Saint Vrain	12	25
Roaring Fork	15	29

Categorization of Results

The FBAT model results were divided into five categories of flame length. These values range from lowest (Category 0) to highest (Category 4) based upon flame length. The flame length categories that were used are:

Flame Length Category 0 - 0 meters

Flame Length Category 1 - 1 to 10 meters

Flame Length Category 2 - 11 to 25 meters

Flame Length Category 3 - 26 to 40 meters

Flame Length Category 4 - >40 meters

APPENDIX B

DETAILED UPPER COLORADO HEADWATERS WATERSHED ASSESSMENT RESULTS

Table B-1. Upper Colorado Headwaters Watershed Wildfire Hazard Ranking[1]

Sixth-level Watershed Name	Watershed Area (acres)	Wildfire Hazard Calculation	Wildfire Rank
Headwaters Willow Creek	14,274	85.0%	*5.5*
Headwaters Ranch Creek	12,763	84.7%	*5.5*
Saint Louis Creek	24,465	80.1%	*5.2*
Onahu Creek-Colorado River	24,368	74.2%	*4.8*
Meadows Creek-Ranch Creek	29,752	73.3%	*4.8*
Headwaters Colorado River	27,632	71.8%	*4.7*
Strawberry Creek	10,807	71.0%	*4.7*
Vasquez Creek	17,871	70.1%	*4.6*
Middle Fraser River	11,694	69.6%	*4.6*
Baker Gulch	13,150	69.1%	*4.5*
Rabbit Ears Creek-Troublesome Creek	36,120	68.0%	*4.5*
Keyser Creek	17,458	67.5%	*4.4*
Middle Willow Creek	20,435	67.4%	*4.4*
Upper Willow Creek	37,834	65.1%	*4.3*
Upper Fraser River	19,380	64.9%	*4.3*
Upper Williams Fork	25,731	64.6%	*4.3*
Headwaters Williams Fork	28,310	59.6%	*4.0*
Lake Granby	36,066	58.8%	*3.9*
Crooked Creek	26,368	58.2%	*3.9*
Middle Williams Fork	16,379	56.2%	*3.8*
South Fork Williams Fork	17,754	56.0%	*3.8*
East Fork Troublesome Creek	35,917	55.9%	*3.7*
Middle Fork Creek	12,536	55.6%	*3.7*
North Inlet	29,302	54.9%	*3.7*
Arapaho Creek	30,740	51.9%	*3.5*
East Inlet	17,986	47.1%	*3.2*
Stillwater Creek	11,228	46.4%	*3.2*
Beaver Creek	11,757	44.9%	*3.1*
Red Dirt Creek	23,350	43.8%	*3.0*
Little Muddy Creek LMC	18,354	37.9%	*2.7*
Pass Creek	15,917	37.0%	*2.6*
Battle Creek	17,202	32.6%	*2.3*
Corral Creek-Colorado River	22,451	32.3%	*2.3*
Milk Creek-Muddy Creek	26,648	29.4%	*2.1*
Drowsy Water Creek-Colorado River	29,178	28.7%	*2.1*
Tenmile Creek	23,742	27.8%	*2.0*
Lower Willow Creek	17,754	26.1%	*1.9*
Sheep Creek-Colorado River	13,845	25.6%	*1.9*
Lower Fraser River	16,505	23.9%	*1.8*
Williams Fork Reservoir-Lower Williams Fork	23,977	21.7%	*1.7*
Smith Creek-Colorado River	14,553	20.5%	*1.6*
Ute Bill Creek-Colorado River	16,620	17.5%	*1.4*
Little Muddy Creek MC	21,075	11.4%	*1.1*
Antelope Creek	14,482	9.5%	*0.9*
Upper Muddy Creek	33,430	7.0%	*0.8*
Middle Muddy Creek	13,263	4.9%	*0.7*
Wolford Mountain Reservoir	22,548	2.1%	*0.5*

[1] Headwaters Willow Creek was skewing the categorization because of its high wildfire hazard score of 93.7. It was manually given a score slightly higher than the next highest score.

Table B-2. Upper Colorado Headwaters Watershed Ruggedness Ranking[2, 3]

Sixth-level Watershed Name	Maximum Elevation	Minimum Elevation	Difference Elevation	Ruggedness	Ruggedness Rank
East Inlet	13,306	8,374	4,932	0.1760	*5.5*
Arapaho Creek	13,504	8,291	5,213	0.1741	*5.4*
Headwaters Ranch Creek	12,290	8,706	3,584	0.1700	*5.2*
North Inlet	13,286	8,374	4,912	0.1683	*5.1*
Baker Gulch	12,651	8,766	3,885	0.1623	*4.8*
Headwaters Williams Fork	13,500	8,912	4,588	0.1600	*4.7*
Middle Fraser River	11,917	8,317	3,600	0.1595	*4.7*
Middle Williams Fork	11,602	8,143	3,459	0.1586	*4.7*
Upper Fraser River	13,333	8,740	4,594	0.1581	*4.6*
Stillwater Creek	11,769	8,288	3,482	0.1574	*4.6*
Keyser Creek	12,756	8,439	4,316	0.1565	*4.6*
Meadows Creek-Ranch Creek	12,871	8,317	4,554	0.1546	*4.5*
Upper Williams Fork	12,650	8,439	4,212	0.1539	*4.4*
Onahu Creek-Colorado River	12,848	8,372	4,476	0.1536	*4.4*
Battle Creek	11,199	7,808	3,391	0.1517	*4.3*
South Fork Williams Fork	13,121	8,912	4,210	0.1514	*4.3*
Williams Fork Reservoir-Lower Williams Fork	11,566	7,484	4,082	0.1505	*4.3*
Vasquez Creek	12,929	8,735	4,194	0.1503	*4.3*
Drowsy Water Creek-Colorado River	11,398	7,685	3,713	0.1473	*4.1*
Middle Willow Creek	11,495	8,194	3,300	0.1463	*4.1*
Middle Fork Creek	11,443	8,391	3,052	0.1460	*4.1*
Headwaters Colorado River	12,901	8,766	4,135	0.1460	*4.1*
Beaver Creek	10,733	7,554	3,179	0.1405	*3.8*
Middle Muddy Creek	10,845	7,498	3,347	0.1392	*3.8*
Rabbit Ears Creek-Troublesome Creek	11,816	7,656	4,160	0.1387	*3.7*
Headwaters Willow Creek	12,313	8,892	3,420	0.1372	*3.7*
Upper Willow Creek	12,297	8,430	3,866	0.1347	*3.5*
Antelope Creek	10,848	7,499	3,348	0.1333	*3.5*

[2] Ruggedness is based on Melton (1957)

[3] These watersheds were manually adjusted because they do not accurately reflect the ruggedness in those watersheds. The original values were; Arapaho Creek (0.1422), Headwaters Ranch Creek (0.1520), North Inlet (0.1374), Headwaters Williams Fork (0.1306), Middle Williams Fork (0.1295), Meadows Creek-Ranch Creek (0.1262), Upper Williams Fork (0.1256), Onahu Creek-Colorado River (0.1374), Battle Creek (0.1239), Williams Fork Reservoir-Lower Williams Fork (0.1229), Drowsy Water Creek-Colorado River (0.1041), Middle Willow Creek (0.1106), Middle Fork Creek (0.1306), Headwaters Colorado River (0.1192), Rabbit Ears Creek-Troublesome Creek (0.1048), Upper Willow Creek (0.0952), Upper Muddy Creek (0.0871), Little Muddy Creek LMC (0.0974), Crooked Creek (0.1031), Milk Creek-Muddy Creek (0.0807), Tenmile Creek (0.0821), Wolford Mountain Reservoir (0.0618), and Lower Fraser River (0.0763).

Table B-2. Upper Colorado Headwaters Watershed Ruggedness Ranking (continued)

Sixth-level Watershed Name	Maximum Elevation	Minimum Elevation	Difference Elevation	Ruggedness	Ruggedness Rank
Saint Louis Creek	12,810	8,526	4,284	0.1312	*3.4*
Lower Willow Creek	11,620	7,942	3,677	0.1312	*3.4*
Sheep Creek-Colorado River	10,493	7,301	3,192	0.1300	*3.3*
Ute Bill Creek-Colorado River	10,961	7,482	3,479	0.1293	*3.3*
Corral Creek-Colorado River	11,398	7,426	3,971	0.1270	*3.2*
Upper Muddy Creek	10,934	7,608	3,326	0.1232	*3.0*
Little Muddy Creek LMC	10,290	7,534	2,756	0.1192	*2.8*
Strawberry Creek	10,614	8,046	2,568	0.1184	*2.8*
East Fork Troublesome Creek	12,288	7,654	4,634	0.1171	*2.7*
Pass Creek	10,532	7,486	3,046	0.1155	*2.6*
Crooked Creek	11,775	8,280	3,495	0.1153	*2.6*
Red Dirt Creek	10,800	7,485	3,315	0.1035	*2.1*
Milk Creek-Muddy Creek	10,651	7,899	2,752	0.0989	*1.8*
Lake Granby	12,383	8,280	4,103	0.0928	*1.5*
Tenmile Creek	10,550	7,908	2,642	0.0918	*1.5*
Wolford Mountain Reservoir	9,374	7,372	2,002	0.0874	*1.3*
Lower Fraser River	9,887	7,841	2,046	0.0853	*1.2*
Smith Creek-Colorado River	9,743	7,842	1,901	0.0755	*0.7*
Little Muddy Creek MC	10,054	7,899	2,155	0.0709	*0.5*

Table B-3. Upper Colorado Headwaters Watershed Road Density Ranking[4]

Sixth-level Watershed Name	Roads (miles)	Roads Adjusted (miles)	Watershed Area (sq. mi.)	Road density (miles per sq. mi.)	Road Density Rank
Middle Fraser River	95.2	63.8	18.27	3.49	*5.5*
Pass Creek	79.8	79.8	24.87	3.21	*5.1*
Upper Fraser River	96.7	96.7	30.28	3.19	*5.1*
Beaver Creek	53.8	53.8	18.37	2.93	*4.7*
Corral Creek-Colorado River	102.4	102.4	35.08	2.92	*4.7*
Meadows Creek-Ranch Creek	117.5	117.5	46.49	2.53	*4.1*
Milk Creek-Muddy Creek	104.0	104.0	41.64	2.50	*4.1*
Lower Willow Creek	68.2	68.2	27.74	2.46	*4.0*
Crooked Creek	144.3	96.7	41.20	2.35	*3.9*
Keyser Creek	63.6	63.6	27.28	2.33	*3.8*
Smith Creek-Colorado River	52.4	52.4	22.74	2.31	*3.8*
Headwaters Willow Creek	50.3	50.3	22.30	2.25	*3.7*
Headwaters Ranch Creek	44.9	44.9	19.94	2.25	*3.7*
Williams Fork Reservoir-Lower Williams Fork	82.7	82.7	37.46	2.21	*3.7*
Tenmile Creek	120.7	80.9	37.10	2.18	*3.6*
Upper Willow Creek	126.1	126.1	59.12	2.13	*3.6*
Lower Fraser River	76.5	51.3	25.79	1.99	*3.3*
Stillwater Creek	34.0	34.0	17.54	1.94	*3.3*
Ute Bill Creek-Colorado River	73.8	49.5	25.97	1.90	*3.2*
Drowsy Water Creek-Colorado River	82.3	82.3	45.59	1.81	*3.1*
Battle Creek	47.4	47.4	26.88	1.76	*3.0*
Lake Granby	146.1	97.9	56.35	1.74	*3.0*
Middle Muddy Creek	36.0	36.0	20.72	1.74	*3.0*
Middle Willow Creek	54.4	54.4	31.93	1.70	*2.9*
Vasquez Creek	46.9	46.9	27.92	1.68	*2.9*
Upper Muddy Creek	87.2	87.2	52.23	1.67	*2.9*
Wolford Mountain Reservoir	58.5	58.5	35.23	1.66	*2.9*

[4] The road density was adjusted based upon the procedure discussed in the report (p. 12). The original road density values were; Middle Fraser River (5.21), Crooked Creek (3.50), Tenmile Creek (3.25), Lower Fraser River (2.97), Ute Bill Creek-Colorado River (2.84), and Lake Granby (2.59).

Table B-3. Upper Colorado Headwaters Watershed Road Density Ranking (continued)

Sixth-level Watershed Name	Roads (miles)	Roads Adjusted (miles)	Watershed Area (sq. mi.)	Road density (miles per sq. mi.)	Road Density Rank
Saint Louis Creek	63.4	63.4	38.23	1.66	*2.9*
Sheep Creek-Colorado River	35.6	35.6	21.63	1.65	*2.9*
Red Dirt Creek	60.1	60.1	36.48	1.65	*2.9*
Onahu Creek-Colorado River	61.7	61.7	38.08	1.62	*2.8*
Antelope Creek	34.7	34.7	22.63	1.53	*2.7*
Little Muddy Creek MC	48.8	48.8	32.93	1.48	*2.6*
Little Muddy Creek LMC	40.2	40.2	28.68	1.40	*2.5*
Upper Williams Fork	55.7	55.7	40.20	1.38	*2.5*
Rabbit Ears Creek-Troublesome Creek	65.1	65.1	56.44	1.15	*2.2*
Middle Williams Fork	29.3	29.3	25.59	1.14	*2.1*
Headwaters Colorado River	37.8	37.8	43.18	0.88	*1.8*
Headwaters Williams Fork	22.8	22.8	44.23	0.51	*1.2*
Baker Gulch	9.4	9.4	20.55	0.46	*1.2*
Strawberry Creek	7.1	7.1	16.89	0.42	*1.1*
East Fork Troublesome Creek	22.0	22.0	56.12	0.39	*1.1*
Arapaho Creek	16.3	16.3	48.03	0.34	*1.0*
South Fork Williams Fork	7.8	7.8	27.74	0.28	*0.9*
Middle Fork Creek	3.1	3.1	19.59	0.16	*0.7*
North Inlet	3.1	3.1	45.78	0.07	*0.6*
East Inlet	0.0	0.0	28.10	0.00	*0.5*

Table B-4. Upper Colorado Headwaters Flooding/Debris Flow Hazard Ranking[5]

Sixth-level Watershed Name	Ruggedness Ranking	Road Density Ranking	Combined Numeric Rank	Combined Ranking
Middle Fraser River	4.7	5.5	10.21	5.5
Upper Fraser River	4.6	5.1	9.72	5.2
Headwaters Ranch Creek	5.2	3.7	8.94	4.6
Meadows Creek-Ranch Creek	4.5	4.1	8.60	4.4
Beaver Creek	3.8	4.7	8.50	4.3
Keyser Creek	4.6	3.8	8.41	4.2
Williams Fork Reservoir-Lower Williams Fork	4.3	3.7	7.95	3.9
Stillwater Creek	4.6	3.3	7.89	3.9
Corral Creek-Colorado River	3.2	4.7	7.85	3.8
Pass Creek	2.6	5.1	7.71	3.7
Lower Willow Creek	3.4	4.0	7.39	3.5
Headwaters Willow Creek	3.7	3.7	7.38	3.5
Battle Creek	4.3	3.0	7.37	3.5
Onahu Creek-Colorado River	4.4	2.8	7.25	3.4
Drowsy Water Creek-Colorado River	4.1	3.1	7.22	3.4
Vasquez Creek	4.3	2.9	7.18	3.4
Upper Willow Creek	3.5	3.6	7.09	3.3
Middle Willow Creek	4.1	2.9	7.03	3.3
Upper Williams Fork	4.4	2.5	6.93	3.2
Middle Williams Fork	4.7	2.1	6.81	3.1
Middle Muddy Creek	3.8	3.0	6.74	3.0
Ute Bill Creek-Colorado River	3.3	3.2	6.50	2.9
Crooked Creek	2.6	3.9	6.47	2.9
Arapaho Creek	5.4	1.0	6.39	2.8
Saint Louis Creek	3.4	2.9	6.24	2.7
Sheep Creek-Colorado River	3.3	2.9	6.17	2.6
Antelope Creek	3.5	2.7	6.16	2.6
Baker Gulch	4.8	1.2	6.00	2.5
East Inlet	5.5	0.5	6.00	2.5
Headwaters Williams Fork	4.7	1.2	5.97	2.5
Milk Creek-Muddy Creek	1.8	4.1	5.91	2.5
Upper Muddy Creek	3.0	2.9	5.88	2.4
Rabbit Ears Creek-Troublesome Creek	3.7	2.2	5.87	2.4
Headwaters Colorado River	4.1	1.8	5.82	2.4
North Inlet	5.1	0.6	5.73	2.3
Little Muddy Creek LMC	2.8	2.5	5.30	2.0
South Fork Williams Fork	4.3	0.9	5.23	2.0
Tenmile Creek	1.5	3.6	5.12	1.9
Red Dirt Creek	2.1	2.9	4.91	1.8
Middle Fork Creek	4.1	0.7	4.80	1.7
Lower Fraser River	1.2	3.3	4.53	1.5
Lake Granby	1.5	3.0	4.53	1.5
Smith Creek-Colorado River	0.7	3.8	4.52	1.5
Wolford Mountain Reservoir	1.3	2.9	4.16	1.2
Strawberry Creek	2.8	1.1	3.86	1.0
East Fork Troublesome Creek	2.7	1.1	3.76	1.0
Little Muddy Creek MC	0.5	2.6	3.12	0.5

[5] Combined Ranking is Ruggedness Ranking times 2 plus the Road Density Ranking

Table B-5. Upper Colorado Headwaters Watershed Soil Erodibility Ranking[6, 7]

Sixth-level Watershed Name	Severe (%)	Very Severe (%)	Soil Erodibility Value	Soil Erodibility Rank
East Inlet	25.1%	21.9%	0.689	*5.5*
South Fork Williams Fork	29.8%	17.3%	0.644	*5.2*
North Inlet	25.3%	18.6%	0.626	*5.0*
Headwaters Williams Fork	29.1%	16.2%	0.614	*4.9*
Headwaters Colorado River	23.9%	16.4%	0.567	*4.6*
Upper Fraser River	20.5%	9.7%	0.529	*4.3*
Keyser Creek	25.9%	12.7%	0.513	*4.2*
Arapaho Creek	18.7%	15.8%	0.503	*4.1*
Upper Williams Fork	22.9%	10.1%	0.431	*3.5*
Strawberry Creek	24.7%	7.2%	0.391	*3.2*
Saint Louis Creek	19.6%	8.5%	0.366	*3.0*
Vasquez Creek	19.0%	8.3%	0.355	*3.0*
Middle Willow Creek	21.6%	6.1%	0.338	*2.8*
Lake Granby	17.2%	7.9%	0.329	*2.8*
Drowsy Water Creek-Colorado River	17.8%	6.2%	0.302	*2.6*
Headwaters Ranch Creek	19.9%	5.1%	0.302	*2.6*
Meadows Creek-Ranch Creek	18.1%	5.5%	0.290	*2.5*
Beaver Creek	17.6%	5.7%	0.290	*2.5*
Lower Fraser River	16.9%	5.8%	0.284	*2.4*
Lower Willow Creek	17.5%	3.8%	0.252	*2.2*
Headwaters Willow Creek	16.4%	4.4%	0.252	*2.2*
Rabbit Ears Creek-Troublesome Creek	16.5%	4.3%	0.250	*2.2*
Baker Gulch	12.8%	5.8%	0.244	*2.1*
Upper Willow Creek	15.1%	4.1%	0.233	*2.0*
Ute Bill Creek-Colorado River	11.2%	4.7%	0.205	*1.8*
Stillwater Creek	14.7%	2.8%	0.203	*1.8*
Crooked Creek	14.7%	2.7%	0.200	*1.8*
Tenmile Creek	13.0%	2.9%	0.189	*1.7*
Onahu Creek-Colorado River	10.4%	4.0%	0.185	*1.7*
Wolford Mountain Reservoir	11.4%	1.9%	0.152	*1.4*
Williams Fork Reservoir-Lower Williams Fork	10.5%	2.3%	0.151	*1.4*
Middle Williams Fork	10.5%	1.9%	0.142	*1.3*
Middle Fraser River	10.9%	1.6%	0.141	*1.3*
Battle Creek	10.5%	1.7%	0.139	*1.3*
Upper Muddy Creek	8.7%	2.5%	0.136	*1.3*
Little Muddy Creek LMC	9.1%	2.1%	0.133	*1.3*
East Fork Troublesome Creek	9.4%	1.7%	0.127	*1.2*
Corral Creek-Colorado River	7.6%	2.0%	0.116	*1.1*
Antelope Creek	8.6%	1.4%	0.114	*1.1*
Middle Fork Creek	8.5%	1.4%	0.113	*1.1*
Little Muddy Creek MC	6.6%	1.3%	0.092	*1.0*
Smith Creek-Colorado River	6.3%	1.4%	0.091	*1.0*
Middle Muddy Creek	6.3%	0.9%	0.081	*0.9*
Sheep Creek-Colorado River	5.2%	1.2%	0.075	*0.8*
Red Dirt Creek	4.1%	0.6%	0.052	*0.7*
Pass Creek	3.0%	0.7%	0.044	*0.6*
Milk Creek-Muddy Creek	2.5%	0.3%	0.031	*0.5*

[6] Soil Erodibility Value is percentage of Severe plus 2 times the percentage of Very Severe.

[7] The soil erodibility value for Upper Fraser River was adjusted up from 0.399 due to the presence of large quantities of highway sand that increase the concern for soil erosion.

Table B-6. Upper Colorado Headwaters Watershed Composite Hazard Ranking[8]

Sixth-level Watershed Name	Wildfire Hazard Rank	Flooding/ Debris Flow Rank	Soil Erodibility Rank	Composite Hazard Rank
Upper Fraser River	4.3	5.2	4.3	5.5
Keyser Creek	4.4	4.2	4.2	5.1
Headwaters Ranch Creek	5.5	4.6	2.6	5.0
Headwaters Colorado River	4.7	2.4	4.6	4.6
Meadows Creek-Ranch Creek	4.8	4.4	2.5	4.6
Headwaters Williams Fork	4.0	2.5	4.9	4.5
Middle Fraser River	4.6	5.5	1.3	4.5
East Inlet	3.2	2.5	5.5	4.4
Headwaters Willow Creek	5.5	3.5	2.2	4.4
North Inlet	3.7	2.3	5.0	4.3
Upper Williams Fork	4.3	3.2	3.5	4.3
Saint Louis Creek	5.2	2.7	3.0	4.3
Vasquez Creek	4.6	3.4	3.0	4.3
South Fork Williams Fork	3.8	2.0	5.2	4.2
Middle Willow Creek	4.4	3.3	2.8	4.1
Arapaho Creek	3.5	2.8	4.1	4.0
Onahu Creek-Colorado River	4.8	3.4	1.7	3.8
Beaver Creek	3.1	4.3	2.5	3.8
Upper Willow Creek	4.3	3.3	2.0	3.7
Baker Gulch	4.5	2.5	2.1	3.5
Rabbit Ears Creek-Troublesome Creek	4.5	2.4	2.2	3.4
Strawberry Creek	4.7	1.0	3.2	3.4
Stillwater Creek	3.2	3.9	1.8	3.3
Crooked Creek	3.9	2.9	1.8	3.2
Middle Williams Fork	3.8	3.1	1.3	3.0
Lake Granby	3.9	1.5	2.8	3.0
Drowsy Water Creek-Colorado River	2.1	3.4	2.6	3.0
Lower Willow Creek	1.9	3.5	2.2	2.8

[8] The Composite Hazard Rank is the average of the Wildfire Hazard Rank, Flooding/Debris Flow Rank, and Soil Erodibility Rank that is re-categorized into 5 categories using the procedure described in Front Range Watershed Protection Data Refinement Work Group (2009).

Table B-6. Upper Colorado Watershed Composite Hazard Ranking (continued)

Sixth-level Watershed Name	Wildfire Hazard Rank	Flooding/ Debris Flow Rank	Soil Erodibility Rank	Composite Hazard Rank
Corral Creek-Colorado River	2.3	3.8	1.1	2.6
Battle Creek	2.3	3.5	1.3	2.6
Williams Fork Reservoir-Lower Williams Fork	1.7	3.9	1.4	2.5
Pass Creek	2.6	3.7	0.6	2.5
Middle Fork Creek	3.7	1.7	1.1	2.3
Ute Bill Creek-Colorado River	1.4	2.9	1.8	2.1
Little Muddy Creek LMC	2.7	2.0	1.3	2.0
East Fork Troublesome Creek	3.7	1.0	1.2	2.0
Lower Fraser River	1.8	1.5	2.4	1.9
Tenmile Creek	2.0	1.9	1.7	1.9
Red Dirt Creek	3.0	1.8	0.7	1.8
Sheep Creek-Colorado River	1.9	2.6	0.8	1.8
Milk Creek-Muddy Creek	2.1	2.5	0.5	1.7
Antelope Creek	0.9	2.6	1.1	1.5
Middle Muddy Creek	0.7	3.0	0.9	1.4
Upper Muddy Creek	0.8	2.4	1.3	1.4
Smith Creek-Colorado River	1.6	1.5	1.0	1.2
Wolford Mountain Reservoir	0.5	1.2	1.4	0.8
Little Muddy Creek MC	1.1	0.5	1.0	0.5