VI. HYDROLOGY

1. Analysis Area and Information Sources

The portion of the project related to post-fire timber salvage occurs on lands burned during the 2001 Moose Fire, primarily in the lower portion of Big Creek. The road management proposal occurs throughout the Big Creek basin. The description of the affected environment will discuss attributes of the entire Big Creek basin, along with two small ephemeral basins that drain into the North Fork of the Flathead River directly north of Big Creek. The analysis area consists of these same three basins because the measurable effect to the water resource is limited to that area.

The analysis is structured to determine the existing condition of the watershed resource within the project area and determine whether proposed activities may affect wetlands and/or riparian areas, stream channels, water quantity, and water quality.

The primary information sources of information used in this document are data gathered by personnel from the Flathead National Forest or the Montana Department of Fish, Wildlife, and Parks. Previous reports used for background information include the Big Mountain Expansion EIS (1995), the Big Creek Geographic Unit Ecosystem Analysis at the Watershed Scale (1999), the Watershed Restoration Plan for Big Creek (2002a), the Moose Fire Burned Area Emergency Rehabilitation Report (2001a), Wildfires of 2001 – Post Fire Assessment (2001). Scientific literature that was developed locally, or literature pertinent to the topic based upon similar physical, chemical, biological or issue parameters, was used and cited.

Computer Models Used for Evaluation

There were two computer models used in this assessment of the soil and water effects to Big Creek. Both of these models used northwest data during their development. Although the models generate specific quantitative values for water yield and sediment, the results are estimates used as a tool to interpret how the natural system may respond. A model's output is meaningful when it is used to evaluate existing conditions in light of the area watershed and stream characteristics, field data, and best professional judgment. The modeling results are interpreted in combination with the physical channel stability measurements, to determine the risk of channel erosion to an individual stream channel.

The R1WATSED model was used to estimate the increased water yields and suspended sediment generated from proposed salvage timber harvest and road building activities in various analysis watersheds. R1WATSED uses the procedure discussed in "Forest Hydrology, Hydrologic Effects of Vegetation Manipulation, Part II" (U.S. Forest Service 1976). This procedure uses the "equivalent clearcut area" (ECA) concept to estimate water yield. Additionally, it uses elevation, aspect, and precipitation to estimate the water yield increase resulting from removing over-story vegetation cover from an acre of forestland. Water yield decreases from a harvested area as the vegetation recovers. The rate of decrease is based upon habitat type (U.S. Forest Service 1976). It should be noted that the model calculates the estimated water yield increase over a fully forested condition. This is a slight over-estimation for the watersheds in this area due to the shallow rocky soils in the headwater areas, the presence of wet meadows, marshes, and ponds with no forest cover. The WATSED model is most valuable in comparing the estimated water yield and sediment yield between alternatives.

The surface erosion potential for each landtype in Big Creek was estimated using the Water Erosion Prediction Project computer model (WEPP). The WEPP model calculates the runoff and erosion from a hill-slope. The output includes: inches of precipitation, the number and the amount of runoff from rainfall events, the number and the amount of runoff from snowmelt events, the upland erosion rate, the potential sediment yield, and the probability of erosion and/or sediment delivery occurring during the time period. The absolute soil erosion values that WEPP calculates for a given slope condition must be viewed with some caution because the model documentation states that a wide confidence interval surrounds the calculated values. The soil scientist using the model for this analysis found the calculated erosion rates to be very reasonable for these hill-slopes and treatment conditions. For complete documentation on the WEPP model refer to the Internet website http://forest.moscowfsl.wsu.edu/fswepp.

2. Affected Environment

General Watershed Characterization

Big Creek is a major tributary to the North Fork of the Flathead River, which occupies portions of northwest Montana and southeast British Columbia, Canada. Big Creek is a 52,524 acres (82 mile^2) watershed with elevation ranging from 3,300 feet to about 6,817 feet. Big Creek is a fourth order stream about 14 miles long. The gradient of Big Creek tributaries in the uppermost portions of the watershed is approximately 1,000 feet per mile (18% stream slope). The gradient of the main stem of Big Creek is 400 feet per mile for the uppermost four miles (7% stream slope), 200 feet per mile for the stretch in which Big Creek meanders on its valley floor (4% stream slope), and 70 feet per mile in the lowermost 8 miles near the Big Creek Campground (1% stream slope).

The average annual precipitation in the Big Creek drainage ranges from approximately 62 inches at the top of Big Mountain to 28 inches along the North Fork of the Flathead River. Approximately 60% of the precipitation falls as snow, which results in a snow pack of about 100 inches on top of Big Mountain. This precipitation results in an estimated average runoff of 36 inches per year at the highest elevations and approximately 9 inches at the mouth of Big Creek. Streamflow begins to increase in April as the snow pack melts with warming spring temperatures. The stream flows typically peak in late May or June as the snow pack melts. Not all snowmelt or rainfall of the study area becomes surface runoff, at least not immediately. Some may infiltrate the ground to become groundwater that percolates downward in the soil and bedrock and resurfaces in wet areas, small ponds, and perennial streams at various elevations below the point of infiltration. Slow release of groundwater provides the stream base flow starting in mid July to mid September. Big Creek is a key spawning stream for bull trout and west slope cutthroat trout because of the clean, cold water and the size and distribution of stream bottom gravel.

Table 3-58 reports the named streams that occur in the Big Creek basin, which river or stream they are tributary to, and the size of each individual named stream basin. Also, refer to Map 1-2 for a map of the streams in the Big Creek watershed.

Table 3-58: The characterization of the Big Creek watershed and its named tributaries.

Watershed	Tributary To	Basin Size - Acres (sq. miles)
Big Creek	North Fork of Flathead River	52,524 (82 sq.miles)
Nicola Creek	Big Creek	3,208 (5.0)
Lakolaho Creek	Big Creek	1,347 (2.1)
Skookoleel Creek	Big Creek	5,538 (8.7)
Hallowat Creek (entire basin)	Big Creek	18,032 (28.1)
Elelehum Creek	Big Creek	3,238 (5.1)
Lookout Creek	Big Creek	2,220 (3.5)
Langford Creek	Big Creek	2,683 (4.2)
Vogt Creek	Big Creek	851 (1.3)
Kinnimiki Creek	Skookoleel Creek	709 (1.1)
Kletomus Creek	Hallowat Creek	3,555 (5.6)
Werner Creek	Hallowat Creek	2,534 (4.0)

As previously described, peak streamflow usually occurs in late May or early June from spring snowmelt. Flood flows rarely overtop the channel banks of Big Creek and erode adjacent land areas. High flows that erode the upper banks of the channel occur every three to five years. The last high flow was in the spring of 1997 from the snowmelt of an unusually deep snow pack. Figure 3-5 shows a comparison of the water flow in cubic feet/second for the 1992 water-year at the water-quality monitoring site in lower Big Creek and on the main stem of North Fork of the Flathead River, at Glacier Rim.

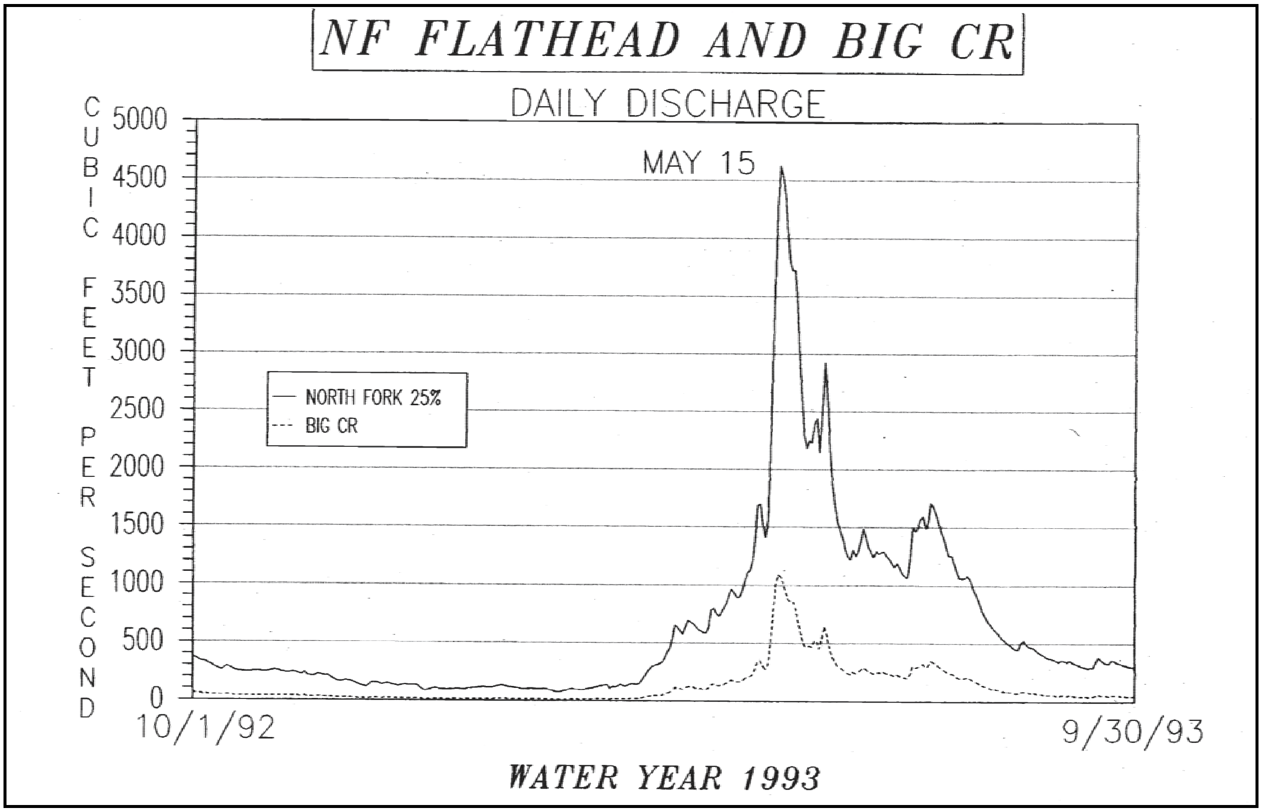

Figure 3-5: Comparison of the water flow at Glacier Rim for the North Fork of the Flathead River in comparison to Big Creek at Lookout Bridge for the 1993 water year.

A water quality-monitoring site (FL7012) was located at the Lookout Bridge, about two miles upstream from the mouth of Big Creek. Starting in 1986, Big Creek was one of the watersheds where suspended sediments and bedload sediments were measured to validate sediment yield assumptions made in the Forest Plan and the WATSED model. Table 3-59 displays the results of that monitoring data for seven years.

Table 3-59: Annual Sediment Yield for Big Creek at Lookout Bridge.

Monitoring Year	1986	1987	1988	1989	1990	1991	1992
Annual Sediment Yield (Tons/Mile Square/Year)	199.8	134.4	8.4	23.7	41.3	81.3	81.5

At this monitoring site the annual sediment yield is variable, as the streamflow increases the suspended and bedload sediment load increases. Sediment pulses occasionally move downstream after a mass failure or other major sediment producing action occurs upstream. However, it is during the annual snowmelt peak discharge that sediment transport rates are predictably high and the duration of high sediment transport rates seems to be a function of the duration of bank full and higher streamflow. Graphs of relationship of total suspended sediment and bedload to stream discharge are displayed in Figure 3-6.

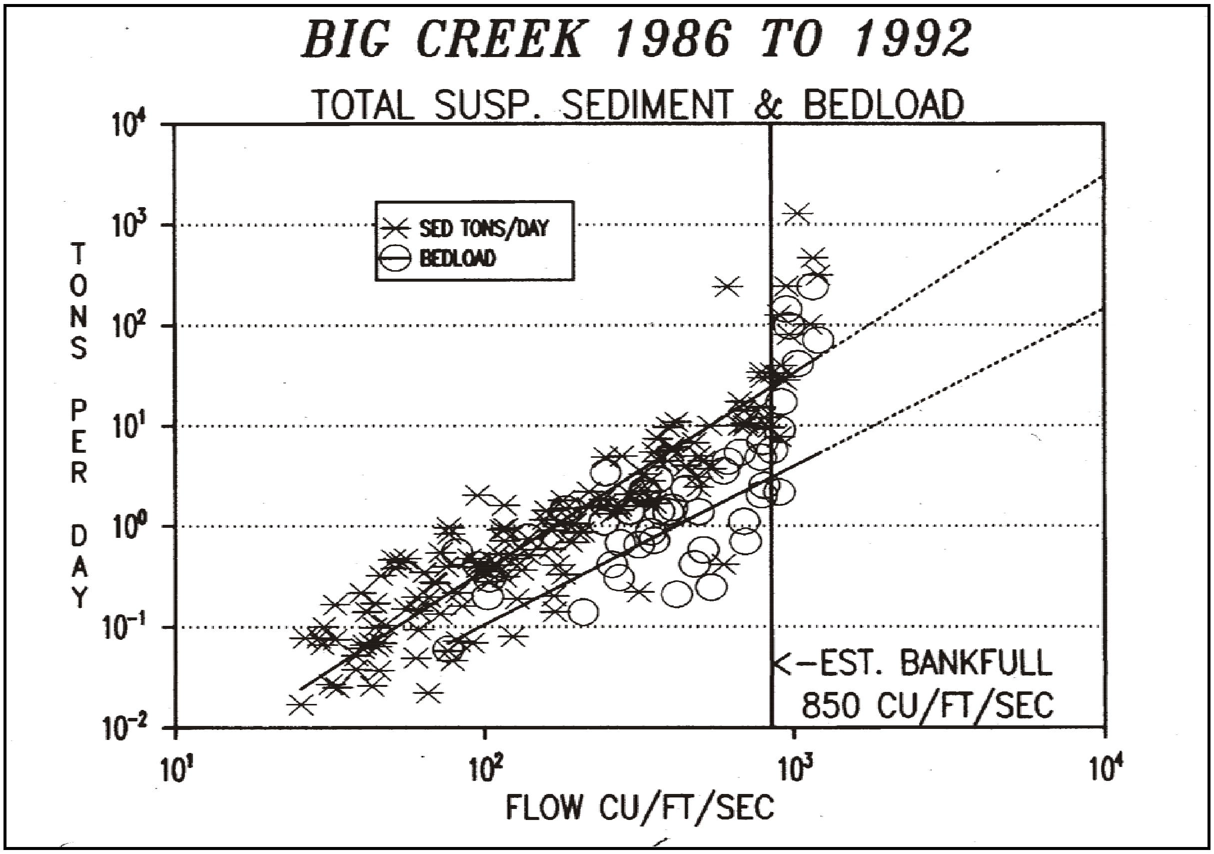

Figure 3-6: The total suspended sediment and bedload versus stream discharge in Big Creek for the years 1986 to 1992.

Suspended sediment/discharge samples were also collected at monitoring site (FL7007) located in the upper reaches of Big Creek, about one-half mile above Nicola Creek. Between 1979 and 1981, a total of 10 samples were gathered. Suspended sediment concentration was not significantly correlated with discharge from these data (Anderson 1988).

Water Quality Standards and Concerns

The State of Montana has classified the waters in Big Creeks as B-1. Waters classified as B-1 are suitable for drinking, culinary, and food processing purposes after conventional treatment. Water quality must also be suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply. Additional criteria specific to sediment are found within Section 17.30.623(2)(f) of Montana Water Quality Standards where it is stated that: "no increases are allowed above naturally occurring concentrations of sediment, settle-able solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife." Naturally occurring is as defined by MCA 17.30.602 (17), includes conditions or materials present during runoff from developed land where all reasonable land, soil, and water conservation practices (BMPs) have been applied. Reasonable practices include methods, measures or practices that protect present and reasonably anticipated beneficial uses.

The sediment built up within the stream channel through the late 1970s and 1980s became a concern because of its effects on the spawning bull trout population. In 1980, Montana Department of Fish, Wildlife, and Parks began sampling the substrate in Big Creek to determine the percentage of fine sediments in the stream channel. Between 1980 and 1990, the percentage of fine sediments in the substrate increased from 23% to 53% (see McNeil core data in Table 3-64). These factors lead to Big Creek being placed on the EPA 303 (d) list – of water quality limited streams. Under section 303 (d) of the Federal Clean Water Act, the Montana Department of Environmental Quality (DEQ) is required to identify water bodies that do not fully meet water quality standards, or where beneficial uses are threatened or impaired.

The DEQ's 1996 and 2000 303 (d) Reports - *Water bodies in need of Total Maximum Daily Load (TMDL) Development*, describe Big Creek as partially supporting the beneficial uses of aquatic life support and cold water fishery. The probable causes of this impairment on both the 1996 and 2000 303(d) lists can all be linked to sediment, with probable sources being linked primarily to silviculture practices.

In November 1999, the Flathead National Forest was notified by DEQ that a sufficient credible data review for the impaired listing of Big Creek had been completed. The review had concluded that there was sufficient data to make a use impairment decision. After discussions with the DEQ staff, Region-1 Forest Service staff, and the Flathead Forest Supervisor, a decision was made to complete a watershed restoration plan or the initial assessment and planning needed for a TMDL.

The entire Big Creek Basin was assessed in the watershed restoration plan because, the entire main stem of Big Creek is identified in the 303 (d) report as partially supporting beneficial uses; therefore requiring consideration of all potentially significant sediment sources to Big Creek throughout the watershed.

The initial watershed restoration plan was submitted to DEQ in 2001 for review, but before the plan could be finalized the Moose Fire occurred. An updated version of that plan was submitted to DEQ in March 2002. The watershed restoration plan satisfies TMDL development requirements of the DEQ for sediment and causes relating to sediment (habitat alterations, siltation, bank erosion, and fish habitat alterations). The Big Creek Watershed Restoration Plan March 2002 is in the process of being submitted to U.S. Environmental Protection Agency by DEQ for approval.

Geology/Landform/Stream Type Characterization of the Big Creek Watershed

Proterozoic meta-sedimentary rocks that consist mainly of calcareous argillite, dolomite, limestone and siltite underlie the Big Creek area. These rocks weather to form silty soils that are neutral to slightly alkaline with about 30 to 70 percent of the soil volume occupied by rocks. There is a volcanic ash surface present on surface of almost all the soils within the Big Creek basin. The ash is very light and porous and is enriched with organic matter, conditions that allow water to move into and through the soil reducing the occurrence of runoff and soil erosion.

Landform and vegetation are the dominant physical features that affect watershed processes in the Big Creek watershed. Landforms regulate how and where water flows across the landscape. Vegetation influences the erosion processes that occur within the landscape.

Landforms in the Big Creek watershed include both steep mountains and narrow valley bottoms. These landforms include structural breaklands, stream breaklands and steep alpine glaciated lands on slopes in excess of 60 percent. Glaciated lands, mountain slopes and ridges and valley bottoms are on the gentle to moderately sloping portions of the watershed.

Disturbances such as fire and timber harvest release nutrients from vegetation and soil. Many of the nutrients end up stored in the soil where they can be used by plants. Some nutrients find their way into streams and ultimately end up in Flathead Lake, which was a state priority for the establishment of a total maximum daily load (TMDL). The two primary nutrients of concern for Flathead Lake are nitrogen and phosphorus. The potential nutrient contribution for each individual landform is rated from low to high in the following landform descriptions. The nitrogen yield rating is based on the natural level of nitrogen in the soil, soil permeability and precipitation rate. The phosphorus yield rating is based on the natural level of phosphorus in the soil and the sediment hazard.

Another important component of these landforms are areas of sensitive soils. Sensitive soils typically have an excess of water in the soil, usually on a seasonal basis, but in some cases year around. These soils predominantly occur in the valley bottoms and are associated with riparian or wetland areas. When sensitive soils are in their natural undisturbed condition they act as temporary storage site for water, allowing it to slowly move down slope until it reaches springs, wetlands or streams or into groundwater if the underlying bedrock is permeable. When sensitive soils are disturbed by management activities such as road building or timber harvest the water can seep out of the soil and onto the road, skid trail or landing where it moves quickly down slope. Water that would have moved slowly to a stream through the soil profile is now quickly routed to a stream. This efficient routing of water increases water yields and the risk of sediment.

Table 3-60 describes the landform groups found within the Big Creek drainage. The project record contains a detailed discussion of the potential nutrient contribution associated with forest disturbances and the sensitive soils within each landform group.

Table 3-60: Landforms of the Big Creek Drainage

Landform Class	Acres/% of Big Creek drainage	Most Common Stream Type*	Expected Nitrogen Yield After Disturbance	Expected Phosphorous Yield After Disturbance
Valley Bottoms	5,031 / 8.6%	C	Moderate	High
Breaklands	13,370 / 22.8%	A	Moderate	High
Steep Alpine Glaciated Lands	31,312 / 53.5%	B	Moderate	High
Gently to Moderately Sloping Glaciated Lands	3,467 / 5.9%	A or B	Low	Moderate
Mountain Slopes and Ridges	5,360 / 9.2%	A	Moderate	Low

*Stream types as described in Applied River Morphology (Rosgen 1996): A Streams = Gradients from 4% to 10%; characterized by straight (non-sinuous), cascading reaches, with frequently spaced pools. B Streams = moderately steep streams with gradients from 2% to 4%; usually occupy narrow valleys with gently sloping sides. C Streams = low gradient systems (<2%), with moderate to high sinuosity and low to moderate confinement.

The Riparian Landtype Inventory of the Flathead National Forest (1995a) is a mapped inventory and description of the riparian and wetland areas, on the non-wilderness lands of the Flathead National Forest. The map unit descriptions include discussions of the riparian/wetland landscape settings, landforms, soils, vegetation, and stream characteristics. In the Moose Post-fire Project Area there are 4,293.5 acres of riparian/wetland landtypes in Big Creek and 196.5 acres in the North Fork of the Flathead Rive. There were approximately 1924.8 acres of that burned during the Moose Fire. Refer to project record Q-29 for a map of the riparian landtypes in the project area.

Previous Land Use Activities

The Big Creek watershed has had ongoing land management since the 1950s. The major activities have been timber harvest, road building, skid trail construction, and construction of ski runs. Watershed restoration activities such as road decommissioning erosion control projects have also been accomplished in the watershed. See Table 3-61 for a condensed timeline of management activities within Big Creek.

Table 3-61: Time Sequence of Past Management Activities in Big Creek

Approximate Date	Description of Management Activities
1950s to present (Primarily late 50's to late 70's)	Logging within the Big Creek watershed: Clearcut - 7,815 acres, Seed-tree – 450 acres, Shelterwood – 1,790 acres, Overstory Removal – 1,974 acres, Shelterwood Removal – 164 acres, Misc. Salvage – 2,298 acres, and Commercial Thinning – 150 acres. (Note some treatments occur on the same areas at different times, on both private and federal lands.)
1950	Main road constructed in upper Big Creek (Road #316)
1950s and 1960s	Road building associated with logging (~ 25 miles)
1974	Portion of Road #316 fails and is repaired
1975	Portion of Road #316 is closed and revegetated (upper Big Creek watershed)
1985	Clearing of forest for Big Mountain Resort ski runs associated with Chair 7.
1980s	Many upland and stream erosion control projects implemented (e.g. waterbars, grass seeding, shrub planting).
1990s	Road decommissioning accomplished (17 miles), continued upland soil erosion control projects, and large woody debris placement projects implemented.
2000-2001	Erosion control vegetation plantings (grasses, shrubs, and trees).

As part of the effects analysis the project area was divided into eighteen watershed analysis areas. Sixteen of these watershed analysis areas are true watersheds and/or basins, where the entire land area that collects and concentrates water is included in the watershed analysis area. Two of the watershed analysis areas are the assemblage of streams that flow directly into Big Creek or the North Fork of the Flathead River from the stream terrace or the break land landforms directly above the creek. These are called face drainages and they are typically 1st order streams. The analysis watersheds are labeled with either the primary stream name, or the primary stream they are tributary to. Refer to Map 3-11 for the delineations of the analysis watersheds. Table 3-62 summarizes the road system within Big Creek by analysis watershed. There are numerous road crossings of the stream network, but very little of the road system is located parallel to a stream in a riparian zone infringing upon the stream floodplain except where the roads cross the streams.

Table 3-62 also summarizes the percent of each analysis watershed that has some type of timber management activity. This is a characterization of the amount of ground disturbing activities in each watershed. Also Table 3-59 summarizes the existing percentage of each analysis watershed that is in Equivalent Clearcut Area (ECA). This is a characterization of the amount of the watershed that additional water yield can result from.

Table – 3-62: The Moose Post-fire Project analysis watersheds, their size, percentage of the Big Creek Basin, total miles of existing roads, road density, percentage of watershed having had timber management activities, and the percentage of each watershed harvested based upon equivalent clearcut area.

Analysis Watershed	Area (acres)	Percent of Big Creek Basin	Total Miles of Road	Road Density (mile/sq.mile)	Percent of Watershed with Some Type of Timber Management Activity α	Percent of Watershed Harvested Based on ECA Acreage β
Big Creek Face Drainages	6,490	12.4	30.3	3.0	38	5
Big Creek Trib.- 1	793	1.5	2.6	2.1	27	4
Big Creek Trib.- 2	560	1.1	1.5	1.7	13	3
Big Creek Trib.- 3	831	1.6	4.2	3.2	46	8
Elelehum Creek	3,239	6.2	12.2	2.4	27	4
Hallowat Creek	7,077	13.5	9.8	.9	18	4
Kletomus Creek	2,833	5.4	5.6	1.3	20	6
Kletomus Creek Trib. - 1	722	1.4	0	0	0	0
Langford Creek	2,683	5.1	5.1	1.2	16	1
Lookout Creek	2,220	4.2	14.4	4.2	29	11
Lower Hallowat Creek	4,867	9.3	19.3	2.5	38	12
Nicola Creek	3,208	6.1	14.3	2.9	42	15
Skookoleel Creek	5,537	10.5	11.7	1.4	13	6
Skookoleel Creek (East)	685	1.3	1.9	1.8	10	4
Upper Big Creek	7,393	14.0	23.1	2.0	41	11
Vogt Creek	852	1.6	12.9	9.7	82	16
Werner Creek	2,534	4.8	9.5	2.4	33	14
North Fork Face Drainages	1,363	-	5.2	2.4	4	4

α - This is the percentage of the watershed that has had any type of timber management activities including: clearcut, shelterwood harvest, seed tree harvest, salvage harvest, and commercial thinning.
β - This is the percentage of the watershed that has 100% forest vegetation removal, if all the various forest vegetation treatments were equated to clearcut (or a 100% forest cover removal).

Between January 1985 and August 1997, there were approximately 1800 acres of land transferred from private to federal ownership in the headwaters of Big Creek. This area was extensively logged during the 1960s and is included in the harvest area discussed in the previous paragraph. The Flathead National Forest now manages the entire Big Creek basin.

In the 1960's and 70's the construction of roads and logging skid trail networks associated with timber harvest on both national forest system and private lands, caused an increased sediment load to Big Creek. At the same time, there was an increase in water yield following the extensive timber harvest on national forest system and private lands. During the late 1970's and early 80's this increased water yield, in combination with the excess sediment supply, caused streambank instability and stream channel erosion. This resulted in stream channel widening and stream pool filling from bedload sediments that could not be transported by the stream. At that time the sediment supply exceeded transport capability in the upper basin of Big Creek. Where the gradient of Big Creek is low, particularly in the stretches with less than 4% slope, large quantities of sediments were deposited as point and mid-channel bars found upstream from organic debris in the stream such as individual logs or log jams.

Most of the past activity in the Big Creek drainage occurred in the headwaters; activities in the lower part of the watershed have been somewhat more spread out in time and location. Where management activities have been light or nonexistent in the upper reaches of Big Creek and its tributaries, stream channels are not eroding; rocks in the channels are covered with moss and algae, indicating low erosion. Since the major management activities in the 1960s and 1970s, Big Creek and its tributaries are gradually improving due to natural revegetation recovery and artificial rehabilitation. However, additional rehabilitation can hasten the return of the impaired portion of Big Creek to dynamic equilibrium. (Watershed Restoration Plan for Big Creek, North Fork of the Flathead River, Flathead National Forest, Kalispell, Mt., 2002a)

Stream Condition Surveys in the Big Creek Drainage

Pfankuch Stream Channel Rating

The Pfankuch stream channel rating was developed to "systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production" (USDA, 1978). This procedure uses a qualitative measurement with associated mathematical values to reflect stream conditions. The rating is based on 15 categories: six related to the bottom of the stream channel (the part of the channel covered by water yearlong), five related to the lower banks (covered by water only during spring runoff), and four related to the upper banks (covered by water only during flood stages). Streams rated *excellent (<38) or good (39-76)* are less likely to erode during high flow than streams in *fair (77-114)* or *poor (115+)* condition. Prime fish habitat usually occurs in streams with a *good* or *fair* rating; streams in *excellent* condition usually do not have adequate gravels for good spawning habitat.

The rating is evaluated at a spot or reach of stream. Each rating represents one point in time; therefore, a series of ratings must be made over several years to show the trend of stream stability; i.e., whether the stream is headed towards or away from dynamic equilibrium.

In the late 1970s, stream channels at selected sites in the Big Creek drainage were rated as *good* using the Pfankuch stream channel rating scale. Some of those same areas were rated as *fair* and *poor* in a 1992 survey. The *fair* and *poor* ratings of the 1992 survey are a result of sediment moving downstream into areas that had previously been rated as *good*. Over time with reductions in sedimentation from roads and harvest units, along with decreased water yield due to reforestation many of the *poor* stream reaches will slowly recover.

After the Moose Fire, during late October and early November, Pfankuch ratings were surveyed on the tributaries and the main stem of Big Creek within the fire boundary. These ratings were not intended to reflect any changes to the streams due to the fire (not enough time for the fire to influence sediment and other changes) rather they were done to compare the expected change in stream conditions following post-fire runoff events. In many cases, the lower elevation reaches were surveyed because they typically had the largest amount of burn area above them, and are the most sensitive to sediment increases. The main stem ratings were all f*air*; and the tributaries ranged from *good* to poor, with the majority being *fair*. The results of those surveys are reported in Table 3-63 along with the historic Pfankuch ratings for the same stream reaches.

Table 3-63: Post-fire (fall 2001) Pfankuch ratings for streams in the Moose Post Fire Project Area, and historic Pfankuch ratings associated with the same stream reaches.

Stream Surveyed	Rosgen Stream Type for each Surveyed Stream Reach	Post-fire (2001/2002) Pfankuch Rating Class for each Surveyed Stream Reach	Historic Pfankuch Rating (Not by Stream Type)
Big Creek At Lookout Bridge (site #14) Below Confluence of Hallowat Creek (Section 33 site #6)	C3 C3	Fair Fair	(Lower Big Creek) 1976 - Good 1976 - Good 1976 - Good 1979 - Good 1979 - Good 1983 - Good 1994 - Good
Unnamed Creek (section 33 site #3)	A3	Good	1976 - Good 1979 - Fair
Unnamed Creek (Section 25 site #11)	A3	Good	
Unnamed Creek (Section 26 site #13)	A3	Good	
Elelehum Creek (Section 27 Site #8)	C3	Excellent	
Elelehum Creek (Section 27 Site #7)	C3	Good	1976 - Good 1979 - Good 1979 - Fair
Unnamed Creek (Section 24 site #9)	G3	Fair	
Unnamed Creek (Section 23 Site #10)	B4	Poor	
Unnamed Creek (Section 27 Site #4)	B4	Fair	
Langford Creek (Section 17 site #1)	B3	Poor	
Langford Creek (Section 20 site #2)	B3	Fair	1979 - Fair 1979 - Good
Lookout Creek (site #12)	B3	Fair	1976 - Good 1979 - Good
Hallowat Creek (Section 1 site #5)	C3	Fair	1979 - Good
Vogt Creek	B3	Poor	1981 - Fair

Riffle Stability Index

The riffle stability index (RSI) is a quantitative methodology used for assessing stream equilibrium and channel stability (Kappesser 1993). Kappesser suggests that an RSI value of 70 or higher is a warning sign for Idaho's belt geology streams, which are similar to those streams in the Flathead Basin. An RSI value greater than 90 indicates that a watershed is out of equilibrium with respect to the balance between sediment loads and water yields.

During the summer of 1993, riffle stability index measurements were made at nine sites in upper Big Creek from below the Lakalaho Creek junction upstream to within one-half mile of Road #1696 crossing. The RSI values ranged from 65 to 95, with eight sites having RSIs greater than 70, and three sites having RSIs greater than 90. The three sites with RSIs greater than 90 have a relatively high percentage of small particles, suggesting that sediment has accumulated in those areas. Also, the mean size of the largest moving particle for all sites was about 5.5 inches, a further indication that stream energy is high enough to move even large cobbles during annual peak flows. These results suggest that portions of Big Creek's channel is unstable and has a limited capacity to absorb additional water yield increases from hillslope development in the headwater basin.

There were 17 additional RSI sites measured in the fall of 2001 following the Moose Fire. This was done to be able to measure the effects on the stream channel stability of the wildfire and any other additional management activities. This data has not yet been summarized.

McNeil Core Sediment Measurements

The size range of streambed materials is indicative of the quality of fish spawning and incubation habitat. Increased fine sediments reduce pool depth (interstitial spaces needed for invertebrate production) and reduce embryonic survival of fry (Weaver and Fraley 1991). A McNeil corer (McNeil and Ahnell 1964) is used to collect streambed samples which are dried and sieve analyzed to determine the particle size distribution, and percentage of materials less than 6.5mm in diameter (fines). As part of the Flathead Basin Forest Practices - Water Quality, and Fisheries Cooperative Research Program, Fraley and Weaver established a correlation between the streambed fines and the bull trout survival in the Flathead River Basin. A statistically significant correlation was identified, that streambed fines greater than 35% resulted in decreased survival of bull trout (Weaver and Fraley 1991). Streams that have greater than 35% fines are considered *threatened* while streams with greater than 40% fines are considered *impaired*.

McNeil core samples have been taken in Big Creek since 1982. Table 3-64 reports the results of the McNeil core monitoring program. The increasing trend of fine streambed sediments starting in 1989 is thought to be the movement of the earlier upland erosion sediments through the streambed monitoring reach in lower Big Creek. After the flushing flows in 1992 there has been a decline in the streambed fines in this monitoring reach.

Table 3-64: McNeil Core samples (%fine sediment <6.4mm) in Big Creek.

Year	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
%< 6.4mm	23.8	32.6	28.2	27.8	28.7	21.6	29.1	40.3	48.4	53.4
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
%< 6.4mm	32.9	37.4	37.2	34.5	32.2	30.0	31.1	32.2	33.1	31.4

Note: samples for year 2001 have been gathered but the data was unavailable to the author at the time of analysis. It should be noted that there is only a small portion of the Moose Fire area above the McNeil Core monitoring reach. However, that area includes a thousand acre plus high burn severity/high erosion potential unnamed watershed directly above the monitoring reach. For this reason, in the short-term, one would expect the percent fines in the McNeil Cores to increase even though the planned restoration activities, and continued revegetation improvement in upper Big Creek should reduce the sedimentation levels.

Additional stream channel measurements such as width to depth ratios and pool frequencies for Big Creek are discussed in detail in the Fisheries section.

Non-point Pollution Source Inventory

Field examination, qualitative, and quantitative stream monitoring confirm that the source of sediments is from a combination of natural and man-caused upland and stream channel erosion. The following is a short narrative description of the current upland and in-stream sediment sources in the Big Creek. Most of these sediment sources have had, or are planned to have erosion control work done to them as a part of the Big Creek Watershed Restoration Plan (USDA, 2002a) and ongoing fire restoration activities.

Streambank Erosion: The mid to lower reaches of the main stem of Big Creek flows through glacial-fluvial deposits, in which the stream has down cut in excess of 100 feet since the retreat of the glaciers (10 -12,000 years before present). This down cutting of the stream has resulted in an abandoned Pleistocene age stream terrace, with a very steep (60-80% slope) terrace escarpment leading down to the current stream terrace and floodplain. These steep escarpment banks have large areas of un-vegetated eroding soil (typically non-cohesive). Some places along this escarpment the stream comes into contact with these areas during normal spring runoff or other peak flow events. During high flow periods the toe slopes of these exposed soil banks are eroded by the flowing stream, putting significant amounts of sediment into the stream. The author has observed streambank erosion in excess of one foot during a high flow event on these types of escarpments, along the North Fork of the Flathead River, which has higher erosion potentials than Big Creek. There are seven areas along the mainstream of Big Creek where the stream is impinging upon these escarpments, causing a major sediment source. The erosion of these terrace escarpments is a natural process. However, any additional peak flow caused by logging and road construction, causes the stream to be in contact with these sediment sources more often and for a longer duration than during pre-management times. The increased water yield in the lower portion of the basin due to the wildfire will increase the frequency and duration that several of these escarpments are in contact with the stream during peak flow events.

Skid Trail Rehabilitation: Skid trails to remove logs from cutting units were developed by cats and skidders during past timber harvest activities. Most of the skid trails developed in the past 20 years were water-barred when the skidding was completed. The placing of water-bars disperses the water before it is concentrated into a defined flow that causes erosion. Some of the earlier skid trails (both national forest and previously private lands) and/or the log landings have had very small streams (*skid-streams*) develop on them due to soil compaction and intercepted groundwater. These small skid-streams typically only run water during snowmelt or high intensity rainstorms, however, this does increase the peak flow response within the basin. The majority of these skid-streams have eroded away the fine textured soils within their stream bottoms and bank, causing them to be well armored by cobbles and stones, and typically well vegetated. Going back and constructing water-bars at this time would disturb the established vegetation and expose soil to be potentially eroded.

Upland Sediment Source Rehabilitation Placement: Within the Big Creek basin, there are several upland sites that are sediment sources to the streams. Most of these sites occur on moderately sloping to steep silty glacial till soils. When exposed these soils can produce significant amounts of suspended sediment. These upland erosion sites include old landings, skid trails, ski runs, and some natural or road associated mass failures. During the 2000 and 2001 field season there were several thousand shrubs and tree seedlings planted on eroding uplands and in skid trail streams to establish vegetation and reduce erosion. Following the Moose fire additional upland erosion sites may be apparent. These sediment sources will be reviewed for rehabilitation actions using Burned Area Emergency Rehabilitation funds.

I*n-Channel Large Woody Debris*: Prior to the 1990's and the implementation of the Montana Best Management Practices for Forestry and the Streamside Management Zone law, past timber harvest activities have included harvesting trees within riparian zones, or upland areas adjacent to riparian zones within one tree length of the stream. In some areas, this removal of trees has reduced the amount of large woody debris for current and/or future use in the stream channels. The large woody debris acts to reduce streamflow energy, trap sediments, and create pool habitat. In some areas, this reduction of large woody debris in the stream has increased the amount of bank erosion. During the mid 1990s there were several stream reaches where additional pieces of wood were added to the stream to augment the existing in-stream large woody debris. There will be monitoring conducted to determine the need for any additional large woody debris augmentation (Appendix E).

Log Jam Stabilization: There are several sites (5-6) along Big Creek where logjams (concentrated piles of large woody debris) in the stream are causing the stream to erode a new channel. The removal of portions of the logjams, in some cases, would in the short-term reduce the amount of channel erosion. However, there are sediments trapped behind these log jams. Therefore, the removal of the any woody materials from these log jams would be done in a manner to minimize any movement of the trapped sediments.

In some of the logjams, the woody materials are becoming rotten and weak. We plan to review these log jams with the Montana Department of Fish, Wildlife, and Parks to see if it would be beneficial and logistically possible, to remove portions of the trapped sediments before the logs jams are breached. The removal of these sediments would require the use of heavy equipment. Three of the major logjams were partially or totally burned during the Moose Fire. These sites will be reassessed whether or not any work is warranted.

Road Decommissioning: Beginning in the early 1980s road closures and road decommissioning was initiated primarily in order to improve wildlife habitat. However, there are long-term watershed improvements realized from these road management actions. Currently there are approximately 100 miles of year-around road closures in the Big Creek Basin. The Big Mountain Expansion EIS-ROD, 1995, has identified and authorized 35 miles of road decommissioning. Approximately 16 miles of these roads have been decommissioned in the recent past. For the 2002 field season there are 4.7 miles of decommissioning planned in upper Big Creek, and 8.2 miles in Skookoleel Creek. Additional road decommissioning will be needed to achieve desired wildlife resource objectives within the Big Creek basin (see Wildlife section of this chapter). The amount and location of these roads to be decommissioned, as well as the short-term and long-term water resource effects of the proposed decommissioning will be discussed later in the hydrology section.

Road Drainage Improvements - BMP implementation: There are segments of the existing road system that are to remain in use, which need improvements in the road surface drainage and stream drainage systems to meet current Montana State Best Management Practices and INFISH standards. These improvements are a foreseeable action addressed in another NEPA document. The work activities include up-sizing culverts (approximately 35-50), and adding more road cross-drains (culverts or drive thru dips). The road segments that need the work are primarily located along road numbers 316, 315, 1655, 1658, 5207, 5272, and 803, which represent more than 48 miles of roads. These improvement projects are planned to begin in the summer of 2002 and be completed in 2003.

There is a small road used by Winter Sports Inc. to access portions of the north side of the Big Mountain in the Chair 7 area. The road starts near the Summit House and ends on Big Creek Road #316. Shallow water bars have been installed in the road so as to not impede snow grooming. However, these water-bars are occasionally topped by runoff after a rainstorm, and some sediment reaches a tributary of Big Creek. Winter Sports Inc. has agreed to improve the water drainage from this road segment.

Sedimentation Effects to Water Quality

The amount of sediment routed to or eroded within a stream channel can affect the beneficial uses of water, and is frequently used as a measure of overall water quality. As stream channel size and shape have evolved to carry the historical sediment load, large increases in sediment yielded to a stream may exceed the stream's ability to transport the load (Dunne and Leopold 1978). As a result, sediment deposition will occur in the stream channel, especially in low-gradient sections of a stream, as point bars and mid-channel bars. This leads to a wider, shallower, less stable channel than pre-deposition conditions, and can have a detrimental effect to the fisheries resource by clogging spawning gravels. Increased sedimentation also impacts macro-invertebrates and other aquatic organisms. Bank erosion may also be increased, thus adding even more sediment to the load in the stream.

In managed forested areas, the main source of direct sediment is from road construction associated with timber harvest (Megahan and Kidd 1972). Channel alteration, road or other construction in or adjacent to live streams, and culvert or bridge installation may result in sediment being deposited directly into a stream. Tree falling is not usually considered a major cause of increased sediment. However, methods for removing harvested timber (such as tractor and cable yarding) can cause erosion, gouging of slopes, and alteration of soil characteristics and permeability.

Effects to Sediment Yield in Post-fire Situations

A wildfire has the potential to impact the soil to the limits of natural variability, including reduced soil aggregate stability, reduced permeability, increased runoff and erosion, and reduced organic matter/nutrient status. These combined effects will cause the runoff following a rain event to increase significantly, increasing the overland flow available to initiate soil erosion, either as sheet or rill erosion. The potential for erosion is highest on the steeper slopes that burned with a high burn severity[1]. Burn severity describes the effects of the fire on the soil hydrologic function (amount of surface litter, erodibility, infiltration rate, runoff response) and productivity. Generally there is a close correlation between these soil properties and the amount of heat experienced by the soil as well as the residence time of the heat in contact with the soil. Erosion potential can increase with salvage logging in some situations. The erosion potential decreases over time as the soil surface is revegetated and the soil aggregate stability is reestablished.

After the large fires in Yellowstone National Park during 1988, research was done on sediment increases following the fire. The largest post-fire sediment increases (load/volume runoff) occurred during the snowmelt period (April, May, June); the post-fire sediment increase ranged from 156% in April to 42% in June on the Yellowstone River. The spring runoff suspended sediment increase averaged 60% for a four-year period. There was one reported 100% increase in August (thunderstorm event) on a load per unit runoff basis. The summer season fire sediment increase averaged 30% for the rising streamflow period in the summer, and 7% for the falling streamflow period. (Ewing, 1996)

Ewing (1996) also reported a statistically significant increase in the measured total sediment discharge and the measured sediment concentration in the Yellowstone River. He also concluded that increased suspended sediment loads during snowmelt were small in comparison to post-fire summer events. Ewing stated, "the largest portion of the fire-related sediment is transported out of the burned watersheds during the highest runoff of the year. As burned sites revegetated and erosion diminishes, fine sediment may thus be progressively transported downriver by spring runoffs."

In the Entiat Experimental Forest of central Washington state, there were sediment increases of 8 to 10 times pre-fire levels in three 1.8 to 2.1 square mile watersheds (Helvey 1980).

The spring following the 1988 Red Bench Fire in the North Fork of the Flathead River just north of the Moose Fire area, TSS (total suspended solids) experienced 2 to 3 fold increases on Flathead National forest system lands and 5 to 10 fold increases on the Glacier National Park lands. In the burned watersheds, the TSS decreased after the first year but remained slightly higher throughout the five-year duration of the study (Hauer and Spenser 1998)

Locally, a study was done to measure the effects of logging and then prescribed fire on the soils in the Miller Creek area of the Flathead National Forest. DeByle and Packer (1972) reported that two or more times the overland flow was observed on the logged and burned plots versus the control plots. There was virtually no soil erosion on the un-

[1]The term 'burn severity' is used as a relative measure of the degree of change in a watershed that relates to the severity of the effects of the fire on the topsoil and the associated watershed conditions. Burn severity is delineated on topographic maps as polygons labeled high, moderate, and low. On low severity burn sites, the duff layer is typically only partially consumed by the fire and/or this is very little heating of the soil surface layer. The fire has not affected the soil hydrologic properties. Many unburned small roots are prevalent immediately below the soil surface, the mineral composition provided a degree of insulation that protected shallow fine roots and embedded seeds. Natural re-vegetation on these is typically very good.

On the high burn severity sites, the surface soil properties have been modified by the fire. In many of these sites, the surface soil structure has been broken down, and at the same time a hydrophobic layer (water repellent) may be established during the fire. The surface soil aggregate stability has been significantly reduced. Many of the soils once had moderate to fine granular soil peds in the surface layer. Now the surface soil has very few intact soil peds, the soil surface is essentially structureless (single grain). The lack of surface soil structure and lack of organic litter or duff allows for rain-impact erosion at the soil-air interface, reduced infiltration, and increase erosion and runoff. There are few viable roots/seeds in the upper several inches of the soil. The natural re-vegetation on these sites is typically very slow.

The moderate burn severity sites tend to show some slight indications of the surface soil structure break down, and a significant reduction in near surface fine root viability. Some hydrophobic soil conditions may occur under moderate burn severity sites, but it is usually quite spotty. (Ryan and Noste 1983) logged control plots, on logged and burned plots averaged 56 pounds per acre the first year following treatment; and 168 pounds per acre the second year following treatment. This run-off and erosion was attributed to reduced vegetative cover. The organic matter content of the sediments ranged from 12 to 44 percent in the treated plots. They noted that the overland flow and erosion from the logging/fire treatments versus the control should be the same by the fifth or sixth year.

Sedimentation Effects from the Moose Fire

Soils in the Moose Fire area under pre-fire conditions generally supported an organic duff layer. The surface layer of organic duff ranges from 1 to 4 inches in depth. The upper soil typically contains many fine plant roots, and many small pores and stable soil aggregates, which in combination facilitated rapid water infiltration and percolation. The pre-fire surface erosion rates were very low to non-existent in undisturbed portions of the watershed.

The low burn severity sites will naturally re-vegetate rapidly and have no/very low potential for soil erosion. The Moose Fire had several large areas of moderate burn severity with inclusions of smaller areas of high burn severity within these large burned patches. Most of the moderate and high burn severity occurred on shrub dominated sites, which typically have good natural re-vegetation potential following wildfire. The moderate burn severity sites are expected to re-vegetate rapidly. However, the high burn severity sites initially will have less vegetation re-growth (vegetation cover) to protect the surface soil from erosion, especially when compared to the low burn severity areas. Refer to the burn severity map, Map 3-10.

The post-fire aerial observations and follow-up ground investigations revealed that the vast majority of the moderate burn severity on the Flathead National Forest did not have very much potential to deliver sediment into a stream channel. The primary reasons for that interpretation is the expected natural re-vegetation response, and the general lack of expected soil erosion. The assumption of low rates of expected soil erosion is based upon the fact that the post-fire hydrophobic soil condition tends to ameliorate itself with 2 to 3 weeks with low intensity rain events which slowly wets the surface soil layers. (Refer to the Soils section for observations and conclusions regarding the post-fire hydrophobic soil conditions.) Under normal precipitation events we would not expect to see any severe soil erosion from the vast majority of hill-slopes in the burn area. We would expect the post-fire responses in most watersheds that had a significant percentage of their area in moderate or high burn severity to be the following: (1) an initial flush of ash into the creeks; (2) to some extent rill and some small gully erosion in the ephemeral drainages on the steep valley walls within the high burn severity. However, if intense rainstorms were to occur over the fire area significant erosion could be expected on some of the moderate and high burn severity sites. More than 30 tons per acre of soil erosion is estimated to occur with an intense rainstorm before all the post-fire hydrophobic soil conditions recover and the sites are revegetated.

The only area of significant upland soil erosion potential is a high burn severity area, located in steep to very steep hill-slopes (50-70% slope) in the SE1/4 of Section 34, the SW1/4 of Section 35, and NW1/4 of Section 3, of what is being called Skookoleel Creek East. This site has the potential for significant surface soil erosion to occur and for the eroded material to be delivered directly to creek, which would then be transported as sediment into the spawning gravel area in Big Creek, near the Skookoleel Bridge. (BAER Report, 2001a) During the BAER efforts there were several erosion reduction practices implemented in the Skookoleel Creek East area. There are not any proposed activities (Alternatives 2 thru 5) in any high burn severity sites, with the exception of approximately a ½ mile of road decommissioning in an unnamed drainage west of Lookout Creek.

None of the streambank escarpment mass failure sites or the unstable stream reach in lower Big Creek should have any significant increase in potential sediment yield due to the wildfire. These sources are basically unchanged from the fire, but they still need the restoration work planned prior to the fire. The exception to this is the large natural landslide directly west of the Big Creek Education Center, which was burned over during the wildfire. The burning of the shrub vegetation cover from this landslide has caused a significant increase in the raveling of loose soil material directly into Big Creek, increasing sedimentation.

Following the Moose Fire, many of the stream bottoms were examined in the field and it was the interpretation of the soil scientist/vegetation specialist that the riparian shrub component was still viable and would reestablish rapidly on the majority of the burned streams. This is especially true for the flatter, low elevation main stem stream-bottoms along Big Creek. However, several of the steeper, deeply incised perennial and ephemeral stream bottoms on Demers Ridge, and the unnamed drainage east of Skookoleel Creek burned with high or moderate burn severity. In these areas the natural re-vegetation of shrubs and trees is going to be significantly reduced for several years. This makes these draws very susceptible to channel erosion and debris torrents, with the right type of storm and/or snowmelt event.

Big Creek is a large Rosgen "C" channel with a well-developed floodplain and high width/depth ratio. Large woody materials are common across the floodplain, especially along the channel margins. This gives it a wide area for "storage" of products from upland or in-channel erosion. The coarser sediment from upstream should settle out in this area, leaving the finer sediment to travel downstream, and then probably only during the peak flow period.

The WEPP model was used to estimate the potential post-fire sedimentation during the post-fire assessment process. Two different situations were modeled for each soil map unit within the potential salvage area boundary: 1) Post-fire potential soil sedimentation rate (immediate post-fire) 11/1/01 thru 7/15/2002. And 2) the second growing season potential soil sedimentation rate 7/15/2002 thru 7/15/2003 with no salvage treatments applied.

The data input into the WEPP computer model includes the following parameters: local climate data, soil texture, treatment to the site, slope gradient, slope length, slope area, and percent cover on the site. The Flathead N.F. Landtype Survey (LT's) was used for primary input data into the WEPP model. The slope characteristics were developed from the landtype survey report and the topographic plot of the landtype survey for each map unit in the fire area. Other assumptions made during the modeling process are described herein: The climate data from Bigfork, Montana (South 12 miles) NOAA station was used as the climate to model the precipitation events. The percent cover (surface rock/vegetation cover) for a given soil map unit for either the current situation or for a future scenario was based upon the best professional judgment of the soil scientist, after discussions with the vegetation specialist. The time period modeled was for 30 years; therefore the reported soil erosion rate can be expected to be the maximum probable rate associated with a 25-year return interval storm. Refer to Table 3-65 for the estimated potential sediment from the Moose Fire burn area in Moose Post-fire Project Area using the WEPP erosion models.

Table 3-65: Potential Sediment Yield From Burned Lands in Moose Post-fire Area from the WEPP model for the first and second season using the 30-year average precipitation.

WEPP Potential Sediment 11/1/01 thru 7/15/2002, 30-YR Average Precipitation (tons)	WEPP Potential Sediment 7/15/2002 thru 7/15/2003, 30-YR Average Precipitation (tons)
125,423	36,369

To give the reader some relative measure of soil erosion in tons, one inch of eroded soil material from one acre is approximately 200 tons of eroded soil material.

The post-fire sediment yield for the Big Creek basin is entirely dependent upon weather events over the next two to three seasons until significant natural revegetation occurs. Based upon observations by the current and former Flathead National Forest soil scientists of other major fires in the ecosystem, with no major storm event the best-case scenario sediment yield from the fire area could be substantially less than the 125,423 tons predicted for the first year using the WEPP erosion model. However, if a high intensity rainstorm were to occur the WEPP estimate is very reasonable, based upon observations by the project hydrologist and soil scientist of burn areas that have had post-fire erosion events. Also, literature of post-fire erosion events reports erosion rates comparable to the WEPP estimates. (Debano et al. 1998, Sirucek 1987)

Using R1-WATSED the estimated post-fire sediment yield from the Moose fire burn area in Big Creek was also modeled. See project record Q-5. The estimate from WATSED is less than the WEPP estimates. For two reasons the WEPP estimated post-fire sediment yield is used in the remainder of this section: 1) WEPP estimates are more accurately reflect observed post-fire erosion events than WATSED, if an high intensity rainstorm were to occur; and 2) the WEPP estimates better reflects a worst case scenario than the WATSED estimate does.

Water Quantity - Water Yield

The relationship between removal of vegetation (timber harvest) and increases in water yield are well established (USDA 1976). The majority of the increase in water yield occurs during spring runoff (King 1989). Climate primarily determines the magnitude of large flood events (Dunne and Leopold 1978); however, land use practices have been shown to increase peak flows (Troendle and Kaufmann 1987). The reduction in tree density i.e. canopy cover, results in a reduction in the amount of transpiration of groundwater and also the amount of canopy interception of rainfall/snowfall which increases the amount of the precipitation available for runoff as stream flow. This is the water yield increase associated with timber harvest in a watershed. The amount of water yield declines as the tree canopy cover recovers with re-growth. The stands types/habitat types that primarily occur in the proposed units would normally be expected to have full vegetative-hydrologic recovery in approximately 90 years after a clearcut or stand replacement fire (Northern Region 1976) (Galbraith 1973).

Watersheds exhibit great natural variability in flow, and can accommodate some increase in peak flows without damage to stream channels and aquatic organisms. Increases in average high flows can cause a variety of channel effects, such as increases in channel width, depth, erosion, and sediment deposition. Substantial increases in peak flows generally lead to a subsequent increase in sedimentation. If the amount of water yield increase is too much for the capacity of the stream channel, there will typically be an increase in the amount of stream channel erosion.

McCaughey and Farnes (2001) monitored snow water equivalent for seven years in a natural dense canopy lodgepole stand and in an open meadow on the Lewis and Clark National Forest. They reported that there was 23% more snow water equivalent in the open meadows. The melt rates under the canopy was 47% of that in the open meadow setting; and the meadow site final melt-out was approximately 10 days earlier than the dense forest canopy site. Skidmore et al. (1994) studied snow accumulation and ablation rates on the forest floor in natural lodgepole pine forest, burned forest sites, and clearcuts, in southwestern Montana. The burned forest canopy (reduced by 90% cover) had 9% more snow water equivalent than the mature forest stand. There was a 57% increase in the ablation rate associated with the burned forest stand compared to the mature forest stand. They noted “the forest structure of the burn and of the clearcut produced similar snow accumulation and ablation responses.”

<u>Effects to Water Yield in Post Fire Situations</u>

Extensive literature exists indicating that stream flows are increased after fires, through a combination of evapo-transpiration reduction, soil-surface storage reduction, and snowmelt modification. The amount and duration of the water yield increase following timber harvest activities vary according to the size and the amount of canopy removal; while following a wildfire, the burn size and burn severity determine the water yield increase.

Farnes (2000) notes that “the peak flow on the Yellowstone River at Corwin Springs now occurs about two days earlier than before the fires of 1988.” He also reported that the maximum daily peak flow increased 2 to 6 percent. This is a basin where approximately 25 percent of the watershed area was burned in 1988. In addition, he reported that “it appeared that removing forest canopy from the lower one-third of a watershed would advance the melt in that zone and reduce the peak runoff by moving this melt water downstream prior to the peak runoff date” and “removal of forest canopy in the middle one-third of the watershed would probably increase the peak flow as a result of increased snow accumulation and melt in the openings.” Farnes et al. (2000), using the historic stream flow records for the Yellowstone and Madison Rivers prior to the 1988 Yellowstone Fires, generated modeled “non-burned” flow for the two rivers for the period 1988 to 1999 and then compared those flow values to the actual measured post-fire flow. For the Yellowstone River, their analysis showed the measured flow increased 7.1% more than forecast with the equation during the April through July period, it increased 1.3% for the August through September period, and the annual increase was 5.3%. For the Madison River, their analysis showed the measured flow increased 7.6% during the April through July period, it increased 4.9% for the August through March period, and the annual increase was 6.3%.

Molnau and Dodd (1995) observed that maximum snow water equivalents occur in the heavy burned canopy conditions. They observed that “the burned tree stems remaining on this site significantly influence wind pattern and snow deposition." They also reported that the mean air temperatures were found to be higher in *heavy burn* sites compared to *light burn* sites, and the lowest in undisturbed natural forest.

Water Yield Effects from the Moose Fire

The post-fire water yield increase above natural, due to a reduction in over-story vegetation from either historic timber management or the wildfire, was modeled for seventeen analysis watersheds within Big Creek. Refer to Table 3-66 for the results from R1-WATSED post-fire modeled percent water yield over natural conditions for each analysis watershed. For the watersheds that were either partly or entirely burned, the water yield increases above natural ranges from 17 to 56 percent. The water yield increase for the peak flow month above natural ranges from 21 to 80 percent, for the watersheds that either partly or entirely burned. In general stream channels with *fair* or *good* Pfankuch stream stability ratings are not at risk of increased channel erosion with water yield increases of less than 10% over natural conditions. Depending upon the channel type and the channel stability, water yield increases in the 10-15% range may cause increased channel erosion. By the time of implementation of the proposed salvage in Alternative 2 thru 5 there is reduction in the water yield increase of <1 to 4 percent in each of the analysis watersheds, due to vegetation recovery. See project record Q-5.

The North Fork face drainage analysis watershed was not modeled for water yield increase using WATSED because the face drainages are not true watershed basins. Because of the small size of the North Fork face drainage analysis area (1,363 acres), which is only 0.14% of the entire North Fork of the Flathead Basin, there would be no measurable change in water yield to the North Fork due to the burn forest in this area.

Table 3-66: Summary for the analysis watersheds in Big Creek which WATSED modeled post-fire water yield increase.

Analysis Watershed	Watershed Area (acres)	Post-fire Existing Annual Water Yield Increase Above the Natural Water Yield (%)	Post-fire Existing Increase in Annual Mean Water Yield for the Peak Flow Month (%)
Big Creek Trib.- 1	793	41	59
Big Creek Trib.- 2	560	40	58
Big Creek Trib.- 3	831	27	37
Elelehum Creek	3,239	35	48
Hallowat Creek	7,007	3	3
Kletomus Creek	2,833	16	21
Kletomus Creek Trib. - 1	722	38	50
Langford Creek	2,683	34	46
Lookout Creek	2,220	24	32
Lower Hallowat Creek	4,867	17	22
Nicola Creek	3,208	7	7
Skookoleel Creek	5,537	2	3
Skookoleel Creek (East)	685	37	52
Upper Big Creek	7,393	5	7
Vogt Creek	852	56	80
Werner Creek	2,534	7	8
Big Creek Face Drainages α	6,490	35 α	47α
Big Creek Basin (total)		14	18

α - Because these are face drainages that include both small watersheds as well as land that don't contribute runoff into a watershed, rather directly into the main-stem channel primarily by groundwater inflow, the estimated water yield increase is an over-estimate but is reported herein for some reference, and as and a portion of the Big Creek basin.

This increase in water yield has the most potential to cause increases in channel erosion in several of the small tributary streams to Big Creek. This is due to the combination of the following: 1) burned riparian vegetation, 2) burned large woody debris within the stream channel, 3) naturally erodible streambank materials, and 4) decreased response time of streamflow following a rain event.

Based upon the post-fire review of the most sensitive stream reaches within the post-fire project area there are three stream reaches that have significant risk of channel erosion due to water yield increase. These include the lower reach of Vogt Creek, and the lower 400 foot reaches (between Big Creek Road # 316 and the mainstem of Big Creek) of Big Creek Tributary #1 and the unnamed stream directly east of Big Creek Tributary #1.

Along the main stem of Big Creek there is some potential for increased streambank erosion in the *destabilized reach (*below Elelehum Creek and above Lookout Creek). But because there is not a large acreage of the watershed that is burned above this reach, the increased potential water yield increase/channel erosion is not expected to be very high. The lower Big Creek stream channel (below Lookout Creek) is much more stable; therefore, even with a higher percentage of the watershed above that reach being burned the overall risk to streambank erosion is not very great.

The BAER emergency treatments addressed the expected post-fire water flow at many road stream-crossing sites located in the moderate and high burn severity areas. Several culverts that were deemed undersized for the expected post-fire storm flows were up-sized. Also, several stream crossings had armored overflow dips installed in the road prism, to reduce erosion if a culvert were to plug.

Water Quality – Nutrient Levels

The best available information on the level of nutrients in the waters of the North Fork of the Flathead River is published in the Joint Water Quality and Quantity Committee Report – Flathead River International Joint Commission Study (1987). That report documents the majority of the nutrient studies done on the North Fork of the Flathead River. Herein are some quotations from that report that describe the nutrient relationships in the Flathead River: "waters of the Flathead River system contain very low amounts of the major nutrients, nitrogen and phosphorous. Autotrophic production in most lotic and lentic waters in the basin appear to be phosphorous limited, although nitrogen may also be present in sufficient quantity or in the required forms to support much productivity during late summer in some waters."

The relationship between suspended sediment and nitrogen and phosphorous levels was addressed. "Clearly, particulate forms of nitrogen and phosphorus are an order of magnitude higher when streams are in spate and carrying a large mass of suspended sediment. Standford reported a significant, positive correlation between suspended sediments solids and TP (total phosphorus) and TKN (total Kjeldahl nitrogen) at the Holt site on the Flathead River immediately upstream of the confluence Flathead Lake. "The soluble forms of phosphorus are also generally more concentrated during periods of high flow. Presumably, soluble phosphorus compounds (i.e., SP (soluble phosphorus) and SRP (soluble reactive phosphorus)) are leached or desorbed from particles suspended in the water column or flushed from groundwater." (Joint Water Quality and Quantity Committee Report – Flathead River International Joint Commission Study, 1987).

The relationship between total phosphorous and biologically available phosphorous was described. "Bio-availability was estimated by a kinetic approach, using radioactive tracers, and by algal assays (Ellis and Stanford 1986a,b,c, 1987). Both methods demonstrated that only about 10 percent of the sediment phosphorus (i.e., 10 percent of particulate P measured as total phosphorus minus soluble phosphorous) was bio-available (BAP - bio-available phosphorous). Thus, the rivers in the Flathead Basin carry a substantial load of biologically inert phosphorus during spring run-off." Joint Water Quality and Quantity Committee Report – Flathead River International Joint Commission Study, 1987).

Table 3-67 reports the phosphorus and nitrogen summary data for the North Fork of the Flathead River at the Canadian Border, and the Flathead River near Columbia Falls, derived from the International Commission Report, 1987. Note that the Flathead River at Columbia Falls is slightly downstream of the confluence of the North, Middle, and South Forks of the Flathead River. The lower station is reported in Table – 1 to give some perspective of the cumulative addition of nutrients from the headwaters of a basin to the pour point.

Table 3-67: Phosphorous and nitrogen water quality monitoring data from the North Fork of the Flathead River at the Canadian Border, and the Flathead River near Columbia Falls.

River Monitoring Site /Nutrient Parameter (milligrams/liter)	Mean	Number of Samples	Minimum	Maximum
North Fork of Flathead River at the Canadian Border				
Total Phosphorus	29.74	106	2.33	236.67
Soluble Reactive Phosphorus	1.75	47	1.00	7.90
Total Nitrogen	62.01	35	18.00	114.08
Ionic Reactive Nitrogen (nitrate, nitrite, ammonium)	20.55	38	4.00	76.94
Flathead River near Columbia Falls				
Total Phosphorous	17.31	28	2.00	151.00
Soluble Reactive Phosphorus	1.48	29	1.00	7.60
Total Nitrogen	166.70	9-29	58.20	589.00
Ionic Reactive Nitrogen (nitrite, nitrate, ammonium)	35.53	27-29	15.20	95.00

Effects to Nutrient Responses in Post Fire Situations

When a fire burns through down fuels there is an oxidation of many elements that then become available for leaching and/or aerial deposition into running or standing surface water (e.g. Big Creek and the North Fork of the Flathead River). Also, nutrients can be transported into streams, ionically attached to soil sediments, associated with increased post-fire soil erosion. The low burn severity sites have virtually no effect on the soil's physical or chemical properties. During the burning process, some nutrients in the grass and duff are released into the atmosphere; however, most remain in the ash and are rapidly reabsorbed into the topsoil (DeByle 1981). In these areas of concentrated woody fuels, soils directly under them can be heated enough to cause a slight reduction of some soil nutrients (e.g. nitrogen) and the microbe populations in the surface soil layer. This can have a short-term (2-3 year) reduction in vegetation cover on these sites following the fire, which in turn lead to small amounts of surface soil erosion. However, this eroded soil material is rarely transported more than a few feet downhill. These minimal short-term reductions in site productivity should be widely spaced (<5% estimated area) in the unit following the burn. In the same study an increased potential for soil nutrient leaching into the groundwater on high burn severity sites occurred during major precipitation events (Packer and Williams 1976).

There is the potential with a significant storm event and the associated erosion from the burn area, that increased nutrient levels could be measured above natural background variation in lower Big Creek. This relationship of post-fire increased sedimentation and nutrient levels was documented by 1989 in Red Meadow Creek (Hauer and Spenser 1990). Because of the dilution effect when Big Creek flows into the North Fork of the Flathead River, any increased nutrient level would probably not be able to be measured above the natural background variation with the North Fork of the Flathead River.

Debano et al. in Fire's Effects on the Ecosystems (1998) reports that several investigators following wildfire have found little effect of burning on ionic cation concentrations in run-off waters. At the same time he reports that others investigators have observed increased cation concentrations in stream flow following a wildfire. Typically, cations such as Ca, Mg, and K are converted into oxides, and are deposited as ash following a wildfire. These oxides are low in solubility until they react with CO2 and are converted into bicarbonate salt (Debano et al. 1998). The surface soils in the Flathead N. F. are typically derived from volcanic ash. They tend to have a very high cation exchange capacity, and are naturally low in levels of bicarbonate (Flathead Country – Land System Inventory, 1983). Therefore, in general the potential for cation leaching into ground or surface waters following the fire is probably low unless a major erosion event occurs.

Within the Flathead Basin the primary nutrients of concern that have been identified and studied, in relationship to timber harvest and fire activities, are phosphorus and nitrogen. In the Flathead Basin the primary concern with any nutrient increase in the headwater streams, is a potential for increasing the nutrient levels in Flathead Lake; which will lead to increased algae growth in the lake. This was specifically addressed in the Nutrient Management Plan and Total Maximum Daily Load for Flathead Lake, Montana (Montana Department of Environmental Quality, 2001), which identifies phosphorus and nitrogen as the primary nutrients of concern in the Flathead Lake basin.

Debano et al. (1998) reported “studies of soil leachate show increased levels of total Phosphorus due to burning, indicating accelerated mobilization of Phosphorus after burning. Phosphorus concentrations in overland flow can increase as a result of burning, although these increases are not always sufficient to alter the quality of streamflow.” Locally, the best study of nutrient increases following wildfire was done in the North Fork of the Flathead River following the September 1988 Red Bench Fire. Spencer and Hauer (1990, 1991) measured significant short-term increases in nutrients (nitrogen and phosphorus) in several streams following the Red Bench Fire. They stated that “based on the results from our laboratory experiments, we would expect streamwater SRP (soluble reactive phosphorus) concentrations to increase rapidly at first as labile phosphorus leached from the ash deposited in the stream, and then steadily decline as the available phosphorus source was depleted.” They measured up to a 40-fold increase in SRP in Lower Akokala Creek immediately following the wildfire, which then reduced to background levels 2-3 months later. The following spring run-off a ten-fold increase in SRP was noted in one stream with the remaining study streams having a 2 to 6-fold increase in the SRP levels. This was reduced to 2-3 fold by the fifth year following the fire (Hauer and Spenser 1998).

Hauer and Spenser (1998) reported a 25-fold increase in ammonium was noted in two streams during the fire, but the increase declined to background levels soon after the fire was out. They also measured a 3 to 7-fold increase in nitrate concentration the following spring in burned watersheds of Glacier National Park. By the fifth year of the study the nitrate levels were within the background range. A TN (total nitrogen) increase was observed of 0.5 to 8 times background in the study streams during the first spring run-off period. By the fifth year of the study differences from background were less distinct. They observed the correlation that the highest levels of nutrient increases correlated to those areas with the high burn severity.

Locally, a study was done to measure the effects of logging and then prescribed fire on the soils in the Miller Creek area of the Flathead National Forest. DeByle and Packer (1972) reported that an average of .7 pounds/acre of phosphorus, 3.1 pounds/acre of potassium, 16.1 pounds/acre of calcium, 4.0 pounds/acre of magnesium, and 1.7 pounds/acre of sodium was lost in surface run-off and sediment from logged/prescribed burned plots more then the control plots. They noted that the cumulative four year nutrient loss represents 0.5% phosphorus, 1.1% potassium, 1.5% magnesium, and 2.1% of the sodium that occurs in the top one foot of soil. Thus it would take 50 forest rotations, using similar logging and burning treatment at the end of each rotation, to fully deplete even the available sodium supply in the surface foot through man-caused disturbances.

Increased nutrient loading associated with wildfire can stimulate primary production (e.g. algae growth). Hauer and Spenser (1998), and Gangemi (1991) described an increase in stream periphyton growth in one burned watershed in the Red Bench Fire area, compared to an unburned watershed. Hauer and Spenser (1998) reported “we did not observe noticeable increases in algae growth in our larger 3^{rd} and 4^{th} order study streams.”

3. Environmental Consequences

Chapter 2 identified two significant issues related to hydrology: Issue #3 regarding sediment from temporary roads, and Issue #5 related to RHCA widths. The Issue Indicators for these issues are *miles of temporary roads* and *sediment yield from temporary roads* for Issue #3; and *RHCA widths* and *changes in sediment yield attributable to RHCA widths* for Issue #5.

In addition, the following Effects Indicators were used to focus the analysis and disclose relevant environmental effects:

- Potential Sediment from Proposed Salvage Above Spawning Area (tons)
- Potential Sediment from Proposed Salvage Below Spawning Area (tons
- Total Potential Sediment from Proposed Salvage - Big Creek (tons)

- Qualitative Assessment of Nutrient Load Effects

- Number of culverts removed and sediment produced
- Proposal Sediment Yield Increase Above Natural (tons) from Proposed Road Management and Decommissioning
- Water Yield Increase from Proposed Salvage

There are two aspects related to water resources that are vulnerable to fire and management activities: First, is water quantity, and second is water quality. A change in water quantity is one environmental consequence of the wildfire, and potentially an effect of the proposed action Alternative 2 thru 5. An increase in water yield from individual watersheds in Big Creek and/or from the entire Big Creek basin is a concern because with an increase in water yield there is an associated increase in potential for channel erosion. Water quality is assessed by both the chemical and physical properties of the water. A change in water quality is an environmental consequence of both the wildfire, and several of the proposed actions in Alternative 2 thru 5. There are two primary possible effects to the water quality there is potential for increased sediment, and for increases in nutrient content in the groundwater/surface water.

Direct and Indirect Effects Common to all Alternatives

Rain on Snow Event Risk

During the EIS scoping process for this project a concerned public asked for an analysis of risk of additional water yield from the proposed salvage during rain-on-snow (ROS) events. The U.S. Geological Survey flow records for the North Fork of the Flathead River at Glacier Rim was reviewed to determine the number of annual peak flow events tied to ROS events. There is an 80-year record for this monitoring station that was examined. All of the annual peak flow discharges occurred during spring snowmelt events, mid May thru mid June. That is not to say that spring precipitation events that coincided with the snowmelt did not increase the snowmelt rate. This was the situation that occurred in June 1964 that caused a flood event. Hauer (1991) did an analysis of historic streamflow in the North Fork of the Flathead River as compared to precipitation and temperature records. He stated the following “From this data it was concluded that, indeed the onset and rising limb of spring runoff is primarily driven by increasing temperatures.” Therefore, these types of events are somewhat rare for the geographical location of the project area.

Mac Donald and Hoffman (1995) discussed the causes of peak flow ROS and rain-on-spring-snowmelt events in six basins of Northwestern Montana and Northeastern Idaho concluded, “… there was no apparent correlation between the magnitude of peak flows and the amount of forest harvest.” In 1996, the Plum Creek Timber Company employed a consultant to model ROS events in the Swan River Valley. The basins they modeled were Goat and Squeezer Creeks. This analysis estimated a 4.9% increase in runoff from a ROS event for a 25-year return interval storm, and 4.5% increase for a 100-year return interval storm. These modeled increased runoffs are the amount of increase above the level for a fully forested situation versus the current forested situation for Goat and Squeezer Creeks. (Plum Creek, 1997) The amount and type of timber harvest in the lower elevations of Goat and Squeezer Creeks are qualitatively similar to the amount of harvest in the lower elevation portions of Big Creek prior to the wildfire. Because of the reduction in canopy cover from the effects of the wildfire there is potential for increased snow deposition. Based upon the wildfire effects to the vegetation there would be an increase in the effects of a ROS event in Big Creek. The combination of the wildfire effects to the vegetation, and the slight increase in snow deposition due to post-fire timber salvage, there would be an increase in the effects of a ROS event in Big Creek. The proposed salvage harvesting may result in a minor portion of that increased risk, but it would contribute slightly to increased peak flow if a ROS event were to occur in the next few years until some significant forest regeneration growth has occurred. The additional peak flow increase could have a risk of increasing the amount of channel erosion during a typical ROS event in the project area.

Alternative 1 – No Action

There are no direct effects from salvage harvest activities to the water resources in the post fire project area if Alternative 1, the No Action alternative is implemented. This is because no ground disturbing activities would be implemented with this alternative; therefore there would be no direct effect to the water quantity or quality from a direct federal action.

There is primarily one possible indirect effect to the water resource of the area if Alternative 1 is implemented. The Big Creek Geographic Unit – Ecosystem Analysis at the Watershed Scale (1999) discussed forest fuel buildup in the headwaters area of Big Creek. The no action, Alternative 1 would possibly increase the risk of both fuel buildup and wildfire in the headwaters area, due to increased insect potential (spruce and fir beetles) in the fire area that could spread. Another large wildfire in the headwaters of Big Creek would increase water, sediment, and nutrient yield in the headwaters streams, possibly causing additional effects downstream to Big Creek. Occasionally a riparian area burns during an unplanned wildland fire. If a riparian area burns there is a short-term increase in the water temperature of the streams until the riparian vegetation re-sprouts, and grows to a sufficient height to shade portions of the stream again. Concurrently, there would be an increase in the amount of snags to become large woody debris within the stream channels.

There are no direct effects from road management activities to the water resources in the post fire project area if Alternative 1 the No Action alternative is implemented. This is because no ground disturbing activities would be implemented with this alternative; therefore there would be no direct effect to the water quantity or quality from a direct federal action.

There are primarily three possible indirect effects to the water resource of the area if Alternative 1 is implemented. There would be a long-term decrease in sediment and water yield increase associated with existing roads that would be foregone if the road decommissioning proposed in Alternatives 2, thru 5 were not implemented. Also, the risk of culvert failures would increase without the road decommissioning proposed in Alternative 2 thru 5. With the non-implementation of the Spruce and Douglas-fir beetle pheromones traps and trap trees there would be an increased risk of some of the remaining live mature and old growth Spruce trees in the non-harvested and non-burned riparian bottoms being killed. This would increase the amount of riparian vegetation that is in an early successional stage in the Big Creek riparian area. Over time this can have effects on channel stability in some riparian valley bottom settings.

Direct and Indirect Effects Common to All Action Alternatives

Salvage Logging

Water Yield Effects

As discussed in the water yield effects of the Moose Fire section, WATSED was used to model water yield increase in each of the analysis watersheds (Refer to Table 3-63). The existing post-fire condition was modeled using a combination of the acreages of the unburned natural forest stands, the unburned stands with some type of timber management (i.e. crown removal), the burned natural and managed stands, and the miles of existing roads. The analysis watersheds that were either partly or entirely burned during the Moose Fire, have an estimated annual water yield increase above natural that ranges from 17 to 56%; and the unburned analysis watersheds have an estimated annual water yield increase above natural that ranges from 2 to 7%.

Again WATSED was used to analyze any possible effect to water yield increase due from the proposed salvage units in Alternatives 2 thru 5. The acreage of a proposed salvage unit was subtracted from the burned acreage in the same watershed in order not to double account for the removal of the vegetation. The results of the annual water yield increase with the implementation of Alternative 2 thru 5 were compared to the post-fire annual water yield increase for each of the twelve analysis watersheds where salvage is proposed. In each case the existing annual water yield increase was *reduced* by the time the proposed salvage would be implemented under Alternative 2 thru 5. The results of this analysis showed that there was no water yield increase due to the proposed salvage harvest. There are two reasons that no increase in annual water yield is associated with the proposed salvage activity. First, there is no change in the amount of live canopy remaining from the fire-killed forest to a post-fire salvage harvest unit. Note for the purposes of the water yield modeling, 98% of the crown cover was assumed to be removed in the burned forest stands. This assumption was based upon extensive walk-thru field reviews (fall 2001 and spring 2002) of the burned stands by the silviculturists, and the hydrologist. And second, there is a year and a half vegetative recovery from the time of the wildfire to the approximate time of the majority of the proposed salvage to occur. Therefore, there is some very slight vegetation recovery modeled, which reduces the water yield increase. By the estimated time of implementation of the proposed salvage in Alternative 2 thru 5, there is reduction in the water yield increase of <1 to 4 percent in each of the analysis watersheds due to vegetation recovery. See project record Q-5.

Sediment Yield Effects

Following a wildfire there is an increased potential for soil erosion and the associated sedimentation to occur. The increased erosion potential would increase the sedimentation rate for the basin until the vegetation cover has recovered. Refer to the WEPP analysis in Sedimentation Effects from the Moose Fire section and Table 3-62.

The salvage logging of some of the burned trees in Big Creek would slightly reduce the amount of natural vegetation cover from the grasses, forbs and shrubs that have sprouted since the fire. The yarding of the burned logs causes some ground disturbance resulting in less vegetation cover on those sites for one to two seasons, than would have been present without the salvage logging. (This interpretation is based upon field observations of the soil scientist and the hydrologist.) This reduction in vegetation cover in the salvage logging units increases the potential for soil erosion. The amount of reduction in vegetation cover would depend on the yarding system. Aerial yarding with a helicopter and skyline cable system would have the least disturbance/reduction in vegetation, and ground based skidding without down fuel layer would have the most. The salvage logging would also increase the potential of wind scour in the salvage units. This would slightly decrease the snow depth and snow water equivalent in the cutting units causing a slightly dryer site until the trees and large shrubs grown to several feet in height.

The potential sediment from the Alternative 2, 3, 4 and 5 salvage harvest proposal were analyzed using the WEPP erosion models. The WEPP model was used to analyze the comparative differences between various conditions of alternative treatments (i.e. the amount of vegetative cover). Three different situations were modeled for each soil map unit within the potential salvage area boundary: 1) the post-fire (11/1/01 to 7/15/02) potential sedimentation rate; 2) the second growing season(7/15/02 to 7/15/03) potential sedimentation rate with no salvage treatments applied; and 3) the second growing season (7/15/02 to 7/15/03) potential sedimentation rate with various proposed salvage treatments applied (Alternative 2-5).

The output from situations 2 and 3 allows a comparison of the soil erosion/sedimentation risk associated with and without a salvage treatment on a given landtype. The last step is to sum the potential sedimentation for all the proposed units on all the various landtypes, under the various treatment scenarios. This analysis was then done for areas above and below the bull trout spawning reach in Big Creek. Refer to the project record Q -10 for the assumptions made for soil conditions, burn severity, climate, vegetation recovery rates, sediment delivery ratios and post salvage fuel treatments.

The potential sedimentation from the temporary roads and landings was modeled using WEPP – Roads. This additional potential sediment from the temporary road and helicopter landings construction was added into the spreadsheet results for Alternatives 2, 3 and 4. The sediment yield increase from the temporary road would be limited until the road is recontoured and revegetated after it's use. The summation of those calculations is listed in Table 3-67. The reader may note that the total treated acreage is slightly less in Table 3-65 than in the description of alternatives, because the mid-point percentages of the leave patches were accurately calculated for each individual proposed unit.

Table 3-68: Potential Sediment Yield (WEPP model) From Burned Area and Proposed Post-fire Salvage, and Road/Landing Construction

	Year 1 Post-fire Potential Sediment from Burn Area β (11/1/01 to 7/15/02) (tons)	Year 2 Post-fire Potential Sediment from Burn Area β (7/15/02 to 7/15/03) (tons)	Total Proposed Salvage (acres)	Total First Year Potential Sediment from Proposed Salvage (tons)	Proposed Salvage Above Spawning Area (acres)	First Year Potential Sediment from Proposed Salvage Above Spawning Area (tons)	Proposed Salvage Below Spawning Area (acres)	First Year Potential Sediment from Proposed Salvage Below Spawning Area (tons)
Alternative 2 & 5	125,423	36,369	2,615	509	537	102	2,078	407
Alternative 3	125,423	36,369	2,311	448	371	78	1,940	370
Alternative 4	125,423	36,369	1,970	391	314	62	1,656	329

β - Includes the burn area within the Moose Post-fire project area only.

The potential sediment from the proposed salvage is significantly less than from the burned area. For Alternative 2 & 5 with has the highest potential sediment from salvage activities, it is .4% of the year one potential sediment from the burned area, and 1.4% of the year two potential sediment from the burn area.

Nutrient Yield Effects

The level of nutrients in the groundwater and the streamflow of Big Creek will increase from pre-fire base levels to an elevated level due to the fire. Hauer and Spenser (1998) reported that the highest levels of nutrient increase correlated to those areas with high burn severity (refer to affected environment section for more details). Because less than half of the Big Creek watershed area burned, and the majority of the unburned area is in the higher precipitation zone, nutrient increase caused by the fire should be on the lower portion of Hauer and Spenser's reported ranges for soluble reactive phosphorus (SRP) and nitrate increases.

Because of the effect of increased sedimentation and slightly decreased ground cover due to the salvage logging, there may be a slight increase in the level of nutrients (i.e. nitrogen and phosphorus) caused by the proposed salvage logging. The primary change within a salvage unit is to increase the amount of finer (smaller) limbs and trunks in contact with the ground, which can enhance their potential for nutrient leaching. The increase in nutrient levels due to the salvage logging would be small compared to the increase caused by the wildfire. The rationale for this conclusion is: First, there is some removal of biomass available for nutrient contribution with the removal of the logs (stems). Smaller limbs, twigs, and needles that have been partially or totally consumed by the wildfire, are the portions of the tree that have the most nutrients that are readily releasable following timber harvest activities (Page-Dumrose,1991). Second, the salvage logging would not significantly change the chemical and water absorption characteristics of the post-fire surface soils. Third, typically after a fire the natural process of blowdown increases the amount of limbs on the ground over time. And fourth, the amount of increase in sedimentation due to the salvage harvest is relatively small compared to the increased erosion/sedimentation from the uplands and the stream channels due to additional runoff caused by the wildfire. The nutrient levels post-fire and post-salvage harvest should be less in the Big Creek drainage than what Hauer and Spenser (1998) reported for their watersheds that entirely burned with a high burn severity.

The potential for leaching of soil nutrients into the groundwater is slightly increased for the first 2-3 years following the fire. The probability of leaching is reduced significantly in soils with high cation exchange capacity and moderately well drained soil permeability characteristics. The majority of the soils in the proposed units are derived from glacial till and have these characteristics. There are some soils in the valley bottom landtypes where proposed units occur that have somewhat excessively drained subsoils. These sites would have a slightly greater risk of leaching nutrients; even through the topsoil has a high cation exchange capacity. As mentioned above, the soil types where high burn severity occurred are the most susceptible to excess leaching following fire. None of the proposed salvage areas occur on high burn severity sites with the exception of a very small portion of unit 7.

The amount of potential nutrient increase from the salvage combined with temporary road/landing construction in Alternative 2 thru 5 (no road construction in Alternative 4) would probably not be discernable from the nutrient increase due to the wildfire. The combined wildfire and post-fire salvage nutrient levels should not cause a significant increase in the periphyton (algae) growth in Big Creek or directly downstream of Big Creek in the North Fork of the Flathead River. Based upon the pre-fire measured mean levels of total nitrogen (.073 mg/liter) and total phosphorus (.007 mg/liter) for Big Creek, a post-fire short-term ten-fold increase in the total nitrogen and total phosphorus levels should not increase the levels of those parameters in the North Fork of the Flathead River beyond their natural range of variability. This is primarily due to the 18-fold increase in streamflow when Big Creek combines with the North Fork. The overall increase in nutrient levels should not be measurable above natural variation once Big Creek combines with the North Fork of The Flathead River.

Beschta Report

Several public comments referred to a report by a group of aquatic scientists from the northwest, making recommendations on wildfire and salvage logging, call The Beschta Report. Many of their recommendations are applicable to the Moose Post-fire project. Most of the concerns identified in the Beschta et al. (1995) report are addressed in the design of the various alternatives (e.g. helicopter logging, RCHA width, road decommissioning), required design features (e.g. soil skid trail requirements), or implementation of Montana Forestry Best Management Practice and The Montana Streamside Management Zone law requirements. For a more extensive discussion on the Beschta report refer to Appendix D.

Road Management

The Moose Post Fire Project EIS proposes to change the road management scenario on some of the roads within the project area. The different road management categories/scenarios that are proposed in the EIS are the following: a) restrict the seasons of use, b) close the road yearlong with a gate, c) close the road yearlong with a berm, or d) decommission the road. Each of these road management scenarios affects the water quality and water quantity in a slightly different way.

Roads that are gated and open seasonally may have an increased or decreased sedimentation potential when compared to a season long open road. The seasonally closed road surface is exposed to the same rain and snowmelt events to erode the surface as a yearlong open road. The amount of sedimentation depends on the drainage structures built into the road prism and the amount of maintenance the road surface and the drainage structures receive. Typically, when the roads are used and not graded then rutting occurs, which usually concentrates water flow causing increased road surface erosion and sedimentation. Usually, seasonally open roads receive less maintenance than roads that are open yearlong and therefore, in general, would have a slightly higher potential for sedimentation. However, in some situations roads that are open yearlong and receive heavy use and regular road grading, can have higher sediment yields because of the input of sediment following grading, especially when the ditches are cleared out with a grader. This type of road management easily allows for periodic inspection and maintenance of culverts, ditches, and cross-drain culverts, which reduces the risk of culvert plugging/failures and associated sedimentation potential. This road management scenario does not change the water quantity delivered to a stream from the road system.

When a road is restricted year long with a gate, typically some re-vegetation of the roadbed occurs with grass and brush species in this area. The amount of the re-vegetation on the roadbed is determined by the amount of administrative road use, the type of vegetation on the site, and the soil moisture conditions in that locale. In general, this scenario results in less erosion from the road surface and ditches. However, occasionally when this category of road is used for administrative purposes rutting can occur; if the road is not maintained then increased sedimentation can result from this gated yearlong road situation. This type of road management easily allows for periodic inspection and maintenance of culverts ditches, and cross-drain culverts, which reduces the risk of culvert plugging/failures and associated sedimentation potential. This road management scenario does not change the water quantity delivered to a stream from the road system.

When a road is restricted year-long with a berm, the culverts may or may not be removed depending on whether or not the road is to remain on the forest's road system, and if any high risk culverts (prone to plugging and/or failure) are present. If a road is to remain on the road system there are no culverts removed unless a high-risk culvert is identified. This scenario allows for the monitoring and inspection of remaining culverts; however, both the monitoring and the mechanical maintenance of these culverts is made more difficult/expensive with a berm in place. Therefore, the long-term risk of culvert plugging/failure and the associated sedimentation potential is increased as compared to the road management scenarios utilizing gates. Once the road is bermed the roadbed is allowed to re-vegetate, the potential road prism soil erosion/sedimentation is significantly reduced. This road management scenario does not change the water quantity delivered to a stream from the road system.

When a road is decommissioned the following is done: 1) the road surface has water bars installed to decrease water concentration and movement that causes soil erosion from the road surface; 2) the removal of all culverts at perennial and intermittent stream crossings to eliminate the possibly of a culvert failure; and 3) the seeding of all or portions (depending on soil type and natural vegetation type) of the roadbed to initiate re-vegetation and reduce soil erosion. The road-decommissioning scenario reduces the long-term potential for direct road associated soil erosion/sedimentation better than the other road management scenarios. (Kootenai National Forest, 1995) There are three direct effects of road decommissioning. The first effect is a short-term (usually <4 hours) sediment input during the removal of a culvert, as the fine sediments in the bottom of the streambed under the culvert are washed downstream until the streambed is naturally armored. The second effect typically occurs with the first spring peak flow event following the decommissioning. At that time there will be some erosion of the lower streambanks portion of the stream channel at the removal site. This short-term increase in sediment varies with the soil materials the culvert is in and the slope of the land at the culvert site. In general, steep slopes result in more exposed soil for erosion to occur from. Also, in general, the less the coarse fragment content, and the finer the soil the soil texture, the more potential for soil erosion.

The timing of culvert removals and application of BMP measures can minimize the effects of road decommissioning activities. When possible, the staggering of culvert removals over more than one season in a single watershed would reduce the amount of sediment entering a stream at any given season. Following a culvert removal, the use of erosion control matting and shrub planting for streambank stabilization would reduce additional erosion and sedimentation.

The third effect of road decommissioning is that the amount of ditch-intercepted groundwater that is delivered to the stream is dramatically reduced. This is because during the decommissioning process water bars with ditch blocks are installed to intercept road-surface and ditch runoff. After the water bars are installed, only very short ditch sections directly above a stream crossing are funneling ditch water into the stream. Decreasing the amount of ditch-intercepted groundwater decreases the amount of water that flows into the stream channels during peak flow events (e.g. spring snow-melt); therefore, with less water flowing in the channel there is less *stream power* to cause streambank erosion.

An analysis was done to display the possible effects from a culvert removal in comparison to the effects of a culvert being plugged and a portion of the road prism being eroded. The depth of roadbed over the top of a culvert is directly proportional to the slope of the streambed at the installation site. The steeper the installation site, the more surface area exposed to erosion with either a culvert removal or a culvert failure. For this comparison, three culvert installations were analyzed; on nearly level ground, a very steep installation, and a typical moderate slope installation. Actual field measurements of culvert installations and many erosion monitoring observation measurements were used in the calculations. Three different scenarios were analyzed: 1) A culvert removal in non-erosive soil conditions, with all best management practices applied; 2) A culvert removal in erosive soil conditions, with limited best management practices applied; and 3) A culvert is plugged and the road prism directly above a culvert is eroded downstream. The surface area exposed for each scenario was calculated and then multiplied by the erosion depth to obtain a volume of eroded material.

The reader should note three conditions concerning this analysis. First, the volume of eroded material in the typical glacial till soils of this area would yield approximately 60 percent suspended sediment and 40 percent bedload sediments. Second, the scenario represented by erosion caused by a plugged culvert is conservative because none of the streambank erosion that typically occurs directly below a failed culvert was modeled; only the volume of soil materials in the eroded road prism directly over the culvert is reported. Streambank erosion in these situations is extremely variable depending on site characteristics, for that reason it was not modeled. Third, in some cases when a culvert becomes plugged, the water may go down the road some distance before eroding the road fill-slope. Again, this is an extremely variable situation and was not modeled for that reason. Refer to Table 3-69 for the comparison of the total volume of eroded soil material for each scenario.

Table 3-69: A Comparison of Total Weight/Volume of Eroded Soil Materials from a Culvert Removal Site versus a Culvert Failure and the Associated Road Prism Erosion.

Culvert Depth	Culvert Removal Best Case Scenario For Soil Erosion	Culvert Removal Worst Case Scenario For Soil Erosion	Culvert Plugged the Road Prism Above the Culvert is Eroded Away
Shallow Depth (4.1 ft.)	4.6 tons (3.1 cu. yds.)	11.0 tons (8.1 cu. yds.)	7.4 tons (5.0 cu. yds.)
Moderate Depth (6.3 ft.)	4.4 tons (2.9 cu. yds.)	13.5 tons (9.1 cu. yds.)	17.2 tons (11.5 cu. yds.)
Deep Depth (15.8 ft.)	12.5 tons (8.4 cu. yds.)	50.7 tons (34.1 cu. yds.)	202.4 tons (136.3 cu. yds.)

[1]Depth is measured from the top of the outside shoulder of the road, vertically to the bottom of the culvert.

Fuel Treatments

There is no measurable change in water yield from the proposed fuels treatments (Big Creek Administration site – 129 acres, Big Creek campground – 39 acres, and Coal Creek bench private land inter-face – 67 acres). The reasons for this is the small acreages treated, the small reduction in total live vegetation cover, and the drier precipitation zone (20-30 inches/year) the treatment areas are in. See project record Q-5 for the water yield analysis of the fuel treatments. as discussed for the salvage harvest units.

The ground skidding of the commerial products has some slight potential to produce soil erosion; however due to the nearly flat or slightly sloping land, the distance to the stream, and the amount of ground vegetation to filter any soil ersion, there should be no mearsureable sediment enter any stream channel from this proposed activity. The WEPP soil erosion model was used to estimate the soil erosion/sediment potential from the fuel treatments. See project record Q-33 for this analysis.

The burning of hand piles of fuels (limbs and small trees) causes small patches of moderate to high burn severity where the fuel loads on the forest floor are concentrated. In these areas of concentrated woody fuels soils directly under can be heated enough to cause a reduction of some soil nutrients (e.g. nitrogen) and the microbe populations in the surface soil layer. This can have a short-term (2-3 year) reduction in vegetation cover on these sites following the fire, which in turn lead to small amounts of surface soil erosion. But this eroded soil material is rarely transported more than a few feet downhill. These are minimal short-term reductions in site productivity should be widely spaced in the unit following the burn. (Packer & Williams 1976)

The proposed fuel treatments would not any measurable effect to the water quality, water quantity or stream channels in Big Creek, Coal Creek, or the North Fork of the Flathead River.

Beetle Funnel Traps/Use of Pheromones/Trap Trees

This proposal would require the felling and removal of a limited number of live Douglas-fir trees. Because of the limited number of live trees to be cut and removed at a later time, there would be no measurable increase in water yield. Because of the probable locations on the landscape for the removal of the Douglas-fir trees, there is no risk of any measurable sediment reaching a stream from this limited yarding activity. Therefore, the proposed spruce beetle and Douglas-fir beetle treatments would not any measurable effect to the water quality, water quantity or stream channels in Big Creek, or the North Fork of the Flathead River.

Alternative 2

Salvage Logging

The direct effects of Alternative 2 to the water resource vary with the proposed actions associated with the salvage harvest activities in the 75 units (2,704 treated acres), the temporary road (.9 mile) and the landings (10-15 utilizing approximately 10 acres) constructed across the project area.

Water Yield Effects

The water yield increase effects from the proposed Alternative 2 salvage logging are as discussed in the direct and indirect effects common to all action alternatives section. There is no water yield increase associated with the proposed salvage activities.

The field review of the stream channels in the project revealed that all the streams being affected by the proposed salvage timber harvest are in *Good* or *Fair* Pfankuch stream stability classes, with one exception, Vogt Creek. (Table 3-60). Channels in the *Good* class are capable of handling more water yield increase with no major adverse effects. The channels in the *Fair* class are at a increased risk of channel erosion from the additional water yield. Vogt Creek had major channel erosion occur in the lower reaches this spring during the snowmelt period. The Pfankuch stream rating for Vogt Creek is *Poor* , which means that additional water yield increases could cause additional channel erosion.

Based upon the post-fire review of the most sensitive stream reaches within the post-fire salvage project there are three streams that have significant risk of channel erosion due to water yield increase. These include the lower reach of Vogt Creek, and the lower 400 foot reaches (between Big Creek Road # 316 and the main stem of Big Creek) of Big Creek Tributary #1 and the unnamed stream directly east of Big Creek Tributary #1.

On a post-fire study in the Kootenai National Forest, Molnau and Dodd (1995) observed that open clearcuts received more precipitation to the ground than light burn, which received more than undisturbed forest. “The reduction of forest canopy due to fire and timber salvage results in increased precipitation reaching the forest floor.” They also noted that during snowmelt events driven by air temperature that “the greatest mean water delivery to the soil occurred in the heavy burn, followed closely by the open site (clearcut).” Based upon this local literature there should be similar amounts of water yield coming from a moderate to high fire severity site, and a post-fire salvage site. Portions of the proposed units #17, #18, # 21, # 22, #72, and #73 are uphill of the high risk reaches in Big Creek Tributary #1, the unnamed tributary to Big Creek. Portion of units #63, #64, #65, and #66 are above the high-risk reach in Vogt Creek. The proposed salvage should not cause any additional increased risk to channel erosion than the post-fire water yield increase in these three channel reaches. The reasons for this interpretation are the following: 1) the high percentage of the units with moderate to high fire severity; 2) the amount of leave patches in the units #18 (10-25%), #72 (20-40%), # 63 thru #65 (10-20%), #73 (15-25%), #66 (40-60%) 3) the amount of unburned or low burn severity in the riparian zones to act as a buffer, especially Vogt Creek; 4) all of the units except # 21 are helicopter or cable units therefore having low soil disturbance potential; and 5) during the 2002 post-fire snowmelt on moderate burn severity sites it was observed that, increased amounts on snags or limbs on the ground decreased the concentration of overland flow.

The proposed Alternative 2 salvage and fuel treatment units would not cause any measurable change in annual water yield increase from the existing post-fire level. There would not be any change to the risk of stream channel erosion due to water yield increase from the salvage logging and fuel treatments proposed under Alternative 2.

Sediment Yield Effects

The Alternative 2 proposed salvage harvest, temporary road construction, and helicopter landings would have a short-term negative impact to the water quality due to the increase in delivered sediment to Big Creek of approximately 509 tons the first year following the salvage harvest (Table 3-68, WEPP modeling). The amount of the sediment yield from the salvage is reduced rapidly as the sites achieve significant vegetative cover in 2 to 3 years following the wildfire. The salvage activities slightly reduced the amount of vegetation cover due to the yarding of the logs. Of the 509 tons total, 102 tons are potentially delivered to Big Creek above the bull trout spawning reach (Table 3-68). The amount of potential sediment from the Alternative 2 proposed salvage is 1.4% of the potential sediment from the fire area in the second year following the wildfire.

The majority of any sedimentation from the proposed salvage logging activities would be small particle size materials (silt and clay size) that would become suspended sediment rather than the larger particles that become bedload sediment. A large percentage of the suspended sediment would be transported through Big Creek into the North Fork of the Flathead River; however, there is potential for portions of this eroded material to be deposited within the Big Creek channel. The potential deposition should be a small percentage of the total potential sediment because of the additional post-fire water yield transporting sediment downstream. The proposed units having the highest potential for sediment reaching a stream are unit 21, 50, 52, 56, 54, 64, and 65. All of these units are below the bull trout spawning reach in Big Creek. All applicable forestry BMPs would be applied during the logging operations. See Appendix C in the EIS for the listing of the appropriate project-specific BMPs and Chapter 2 features common to all Alternatives. Because all appropriate BMPs would be applied to the proposed construction activities, Alternative 2 meets the Clean Water Act, the Montana Water Quality Law, and the Forest Plan.

Nutrient Yield Effects

The nutrient yield effects from the proposed Alternative 2 salvage logging are as discussed in the direct and indirect effects common to all action alternatives section. The overall increase in nutrient levels associated with the proposed salvage activities should not be measurable above natural variation once Big Creek combines with the North Fork of the Flathead River.

Road Management

With the implementation of Alternative 2, there would be 18 miles of road that is currently open yearlong changed to a more restrictive road management category; either open seasonally, closed yearlong with a gate, closed yearlong with a berm, or decommissioned.

Alternative 2 proposes 56 miles of road decommissioning. There are net long-term positive effects to water quality and water quantity with the reduction of open roads when a road is decommissioned. The positive effect to water quality would be the reduced area of road surface and ditch that contributes eroded soil particles as suspended sediment to the stream systems. This reduction is accomplished when the water bars are installed on the decommissioned road. The other positive long-term effect to the water quality is the reduction in the risk of culvert failure, and the associated sediment with that event.

Road decommissioning is estimated to involve 40 culvert removals in perennial and ephemeral streams. There may be some additional culvert removals needed if ephemeral streams not currently mapped are encountered. For each potential culvert removal site the culvert depth class (shallow, moderate, deep) was estimated based upon landform, slope, and knowledge of the district hydrologist. The best-case scenario culvert removal soil erosion/sediment yield from Table 3-68 was assumed for all the removal sites in Big Creek, because of the soil type present there. The number of culvert removals by depth class was multiplied by the erosion rate per site to give a total potential sediment yield. See Table 3-70 for the results of these calculations.

Table 3-70: Estimated number of culvert removals associated with the Alternative 2 proposed road decommissioning in Big Creek, and the related sediment yield from this activity.

Culvert Removals (Depth)	Alternative 2	Sediment Yield (Tons)
Shallow	2	9.2
Moderate	14	61.6
Deep	24	300.0
Totals	**40**	**370.8**

In Alternative 2, there are 4 miles of road proposed to be open seasonally, which is 3 miles less than currently exists. As discussed earlier, typically open seasonally roads get less maintenance than open yearlong roads. This sometimes results in slightly higher road surface erosion. Therefore, in general, a 3-mile decrease in the open seasonally road mileage would have a slight positive effect to water quality. There would not be a change to the water quantity situation.

In Alternative 2, there are 52 less miles of road closed yearlong with a gate than the existing situation. Almost all of those miles are being converted to decommissioned roads under Alternative 2. The effect of this road management change would be to decrease the water quantity delivered to a stream from the road system. Also, after the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction from the road that is gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process. There are a few miles of this class that would be converted to a bermed road. This would also have the effect of slightly decreasing the sedimentation level, due to the increased vegetation on the bermed road surface.

The only other category of road management that increases in mileage under Alternative 2 is the restricted yearlong with a berm class. In Alternative 2, there are 39 miles of road proposed to be restricted yearlong with a berm, which is 4 miles more than currently exists. Restricting roads yearlong with a berm greatly increases the effort and cost for periodic inspection and maintenance of any remaining culverts. The roadbed would re-vegetate at some point in time, making the road impassable to machinery unless removal of the brush takes place. Therefore, the long-term risk for culvert failure and associated sedimentation is increased. As displayed in Table 3-69, the volume of eroded material from a culvert plugging/failure can be very significant. There is no change as far as the water quantity with this change in road management.

All of the roads in the closed yearlong with a berm class are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning. Rather, an inspection of the road drainage structures would be done and any high-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity in culverts of bull trout or west-slope cutthroat trout streams. If needed, water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure diverting stream flow down the road surface, causing increased erosion/sedimentation. This road management scenario allows the road surface to re-vegetate, which significantly reduces mid-term sedimentation.

The existing road management situation and the post Alternative 2, 3, 4 and 5 road management scenarios were modeled using WATSED. The sediment modeling was done for the same twelve watersheds as the timber salvage modeling, plus six other watersheds that did not have any timber management proposed, only road decommissioning. Roads that were to be decommissioned, or roads that were previously open (yearlong or seasonally) that were proposed to be closed yearlong with a bermed, had lower sediment yields due to increased mitigation coefficients in the WATSED model, than roads than were open yearlong or open seasonally. There was a five-year schedule assumed for the proposed road decommissioning; this was prior to the proposed seven-year implementation schedule being developed. This two-year difference in implementation timeframe would not change modeled total sediment yields displayed in Table 3-71. The results of the existing and Alternative 2 thru 5 road management scenario modeling are displayed in Table 3-71.

Under Alternative 2 there is a long-term decrease in the annual sediment yield below the existing level, associated with the proposed road decommissioning in each of the thirteen analysis watersheds where work is proposed. Therefore Alternative 2 has a long-term positive effect on the sediment load to Big Creek (345 tons annual reduction), as compared to the no-action Alternative 1. The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under Alternative 2 is 371 tons.

Table 3-71: The post-fire annual sediment yield increase above natural, and the Alternatives 2 thru 5 estimated annual sediment yield increase above natural associated with the proposed road decommissioning.

Analysis Watershed	Post-fire Exist. Sediment Yield Increase Above Natural (tons) (same year as Alt-2 thru 5 roads treatments Implemented)	Alt-2&3 ∞Treated Road Miles	Alt-2&3 Road Proposal Sediment Yield Increase Above Natural (tons)	Alt-4 ∞Treated Road Miles	Alt-4 Road Proposal Sediment Yield Increase Above Natural (tons)	Alt-5 ∞Treated Road Miles	Alt-5 Road Proposal Sediment Yield Increase Above Natural (tons)
Big Creek Face Drainages	657	11.2	614	17.8	597	11.2	614
Big Creek Trib.- 1	93	1.6	88	2.3	81	1.6	88
Big Creek Trib.- 2	-	-	-	-	-	-	-
Big Creek Trib.- 3	94	.9	81	4.2	72	.9	81
Elelehum Creek	253	5.2	232	12.1	207	5.2	232
Hallowat Creek	84	7.2	66	7.8	58	7.2	53
Kletomus Creek	286	2.2	279	2.2	279	2.2	257
Kletomus Creek Trib. - 1	-	-	-	-		-	-
Langford Creek	241	-	241α	1.8	252	-	241α
Lookout Creek	189	9.4	130	9.7	120	9.4	130
Lower Hallowat Creek	418	9.4	393	9.7	392	9.4	369
Nicola Creek	113	4.5	92	7.0	91	4.5	95
Skookoleel Creek	64	5.8	49	5.8	49	5.8	49
Skookoleel Creek (east)	-	-	-	-		-	-
Upper Big Creek	108	5.7	83	5.7	83	5.7	90
Vogt Creek	108	5.7	88	9.8	90	5.7	88
Werner Creek	154	1.7	81	8.7	53	1.7	80
North Fork Face Drain.	-	-	-	-		-	-
Total	2,862		2,517		2,424		2,467

∞ **-** Treated road miles include roads that are proposed to be decommissioned, and road that were previously open (seasonally, or yearlong) that are proposed to be closed yearlong with a berm or gate. Both actions have reductions in sedimentation potential**.**

α - These values included in the table for the Langford Creek watershed so the total value for each alternative could be compared more easily.

Alternative 3

Salvage

The direct effects of Alternative 3 to the water resource vary with the proposed actions associated with the salvage harvest activities in the 67 units (2,704 treated acres), the road (.9mile), and landings (10-15 utilizing approximately 10 acres) constructed across the project area.

Water Yield Effects

The water yield increase effects from the proposed Alternative 3 salvage logging are as discussed in the direct and indirect effects common to all action alternatives section. The discussion of water yield increase effects of Alternative 3 is exactly the same as described for Alternative 2. There is no water yield increase associated with the proposed salvage activities.There should not be any change to the risk of stream channel erosion due to water yield increase from the salvage logging and fuel treatments proposed under Alternative 3.

Sediment Yield Effects

The Alternative 3 salvage harvest, temporary road construction, and landing construction actions would have a short-term negative impact to water quality due to the increase in sediment from the salvage harvest activity and the temporary road/landing construction, with an estimated first year potential sediment yield of 448 tons of delivered sediment to Big Creek (WEPP modeling, Table 3-68). Also from Table 3-68, there is potentially 78 tons of the total 448 tons, which are potentially delivered to Big Creek above the spawning reach. The sedimentation potential from the salvage units decreases significantly as each salvage unit's vegetation cover is increased.

Due to the width of RHCAs along streams, potential sediment sources are a considerable distance from stream channels. Therefore, the majority of any sedimentation from the proposed salvage logging activities would be small particle size materials that would become suspended sediment rather than the larger particles that are not carried into the channel to become bedload sediment. A large percentage of the suspended sediment would be transported through Big Creek into the North Fork of the Flathead River; however there is potential for portions of this eroded material to be deposited within the Big Creek channel. The proposed units having the highest potential for sediment reaching a stream are unit 21 and 50 (Big Creek Face Drainages), units 52, 56 and 54 (Lookout Creek), and units 64 and 65 (Vogt Creek). All of these units are below the bull trout spawning reach in Big Creek. The amount of potential sediment from the Alternative 3 proposed salvage is 1.2% of the potential sediment from the fire area in the second year following the wildfire (see Table 3-68).

All applicable forestry BMPs would be applied during the logging operations. See Appendix C in the EIS for the listing of the appropriate project-specific BMPs and Chapter 2 Design Criteria Common to All Alternatives. Because all appropriate BMPs would be applied to the proposed construction activities, Alternative 2 meets the requirements of the Clean Water Act, the Montana Water Quality Law, and the Forest Plan.

Nutrient Load Effects

The nutrient yield effects from the proposed Alternative 3 salvage logging are as discussed in the direct and indirect effects common to all action alternatives section. The overall increase in nutrient levels associated with the proposed salvage activities should not be measurable above natural variation once Big Creek combines with the North Fork of The Flathead River.

Road Management

With the implementation of Alternative 3, there would be 23 miles of road that is currently open yearlong changed to a more restrictive road management category; either open seasonally, closed yearlong with a gate, closed yearlong with a berm, or decommissioned. The vast majority of those open roads are proposed for road decommissioning. Alternative 3 proposes 56 miles of road decommissioning. There are net long-term positive effects to water quality and water quantity with the reduction of yearlong open roads, such as when a road is decommissioned as described under Alternative 2. Also the reduction in the risk of long-term culvert failure is associated with road decommissioning. There are the same short-term sediment increases associated with the culvert removals during road decommissioning.

Road decommissioning is estimated to involve 40 culvert removals in perennial and ephemeral streams. There may be some additional culvert removals needed if ephemeral streams not currently mapped are encountered. For each potential culvert removal site the culvert depth class (shallow, moderate, deep) was estimated based upon landform, slope, and knowledge of the district hydrologist. The best-case scenario culvert removal soil erosion/sediment yield from Table 3-69 was assumed for all the removal sites in Big Creek because of the soil type present there. The number of culvert removals by depth class was multiplied by the erosion rate per site to give a total potential sediment yield. See Table 3-72 for the results of these calculations.

Table 3-72: The Estimated number of culvert removals associated with the Alternative 3 proposed road decommissioning in Big Creek, and the related sediment yield from this activity.

Culvert Removals (Depth)	Alternative 3	Sediment Yield (Tons)
Shallow	2	9.2
Moderate	14	61.6
Deep	24	300.0
Totals	**40**	**370.8**

There are nine miles of road proposed for decommissioning that are also snowmobile routes (Glacier View R.D. Snowmobile Access Information Map – January 2002). The decommissioning activities on these routes would be designed to accommodate safe and reasonable snowmobile use. There are potentially 10 to 15 culvert-crossing sites where alternate procedures and structures may be implemented. These may include upsizing the existing culvert to INFISH standards and reducing the depth of fill on top of the culvert. Also, utilizing a half round open bottom culvert, or a snowmobile bridge may be an alternative. In a few cases the original culvert may be left in place and a portion of the fill on top of the culvert removed. These actions at the 10-15 sites may reduce the estimated sediment yield slightly in Table 3-69. Under the proposed actions in Alternative 3 there would be an increased risk of culvert failure on culverts that would not be removed when some roads are converted into snowmobile trails, as compared to Alternatives 2, 4, and 5 where all culverts are removed. However, there would be a positive effect with the removal of a portion of the road prism at culvert crossings on snowmobile trails, thus reducing the amount of soil material to erode if a culvert were to fail.

In Alternative 3, there are 19 miles of road proposed to be open seasonally, which is 12 miles more than currently exists. As discussed earlier, typically, open seasonally roads get less maintenance then open yearlong roads. This sometimes results in slightly higher road surface erosion than a maintained open yearlong road. Therefore, in general a 12-mile increase in the open seasonally road mileage would have a slight negative effect to the water quality. There would not be a change to the water quantity situation.

In Alternative 3, there are 53 less miles of road closed yearlong with a gate than the existing situation. Almost all of those miles are being converted to decommissioned roads under Alternative 3. As discussed earlier, road decommissioning decreases water quantity delivered to a stream from the road system. Also, after the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction from the road that is gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process. There are a few miles of this class that would be converted to a bermed road. This would also have the effect of slightly decreasing the sedimentation level, due to the increased vegetation on the bermed road surface.

The only other category of road management is the closed-yearlong with a berm class. In Alternative 3, there are 30 miles of road proposed to be restricted yearlong with a berm, which is 6 miles less than currently exists. All of those roads go into the decommissioned category, and have the effects described in the previous paragraph. The closed yearlong with a berm road management scenario greatly increases the effort and cost for periodic inspection and maintenance of any remaining culverts. The decrease in miles of bermed road reduces the risk of culvert failure slightly.

The existing road management situation and the post Alternative 3 road management scenarios was modeled using WATSED. The results of that analysis are displayed in Table 3-71.

Under Alternative 3 there is a long-term decrease in the annual sediment yield below the existing level associated with the proposed road decommissioning in each of the thirteen analysis watersheds where work is proposed. Therefore Alternative 3 has a long-term positive effect on the sediment load to Big Creek (345 tons annual reduction), as compared to the no-action Alternative 1. The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under Alternative 3 is 371 tons.

Alternative 4

Salvage

The direct effects of Alternative 4 to the water resource vary with the proposed actions associated with the salvage harvest activities in the 74 units (2,294 treated acres) across the project area, along with the construction of 10-15 helicopter landings utilizing approximately 10 acres.

Water Yield Effects

The water yield increase effects from the proposed Alternative 4 salvage logging are as discussed in the direct and indirect effects common to all action alternatives section. The discussion of water yield increase effects of Alternative 4 is exactly the same as described for Alternative 2. There is no water yield increase associated with the proposed salvage activities.There should not be any change to the risk of stream channel erosion due to water yield increase from the salvage logging and fuel treatments proposed under Alternative 4.

Sediment Yield Effects

The Alternative 4 salvage harvest, temporary road construction, and landing construction actions would have a short-term negative impact to water quality due to the increase in sediment from the salvage harvest activity and the temporary road/landing construction of approximately 391 tons of delivered sediment to Big Creek (WEPP modeling, Table 3-68). Of that 391-ton total, 62 tons are potentially delivered to Big Creek above the spawning reach (Table 3-68). The sedimentation potential from the salvage units is significantly decreased as vegetation cover in the next 2 to 3 years increases.

Due to the width of RHCAs along streams, potential sediment sources are a considerable distance from stream channels. Therefore, the majority of any sedimentation from the proposed salvage logging activities would be small particle size materials that would become suspended sediment rather than the larger particles that are not carried into the channel to become bedload sediment. A large percentage of the suspended sediment would be transported through Big Creek into the North Fork of the Flathead River; however there is potential for portions of this eroded material to be deposited within the Big Creek channel. The proposed units having the highest potential for sediment reaching a stream that were identified for Alternative 2 and 3 (21, 50, 52, 65) still occur in Alternative 4, however because the unit size is less, and there is a wider stream-side buffer zone, there should be significantly less risk of sediment reaching a stream from these units. All of these units are below the bull trout spawning reach in Big Creek. The amount of potential sediment from the Alternative 4 proposed salvage is 1.1% of the potential sediment from the fire area in the second year following the wildfire (see Table 3-68).

All applicable forestry BMPs would be applied during the logging operations. See Appendix C in the EIS for the listing of the appropriate project-specific BMPs and Chapter 2 features common to all Alternatives. Because all appropriate BMPs would be applied to the proposed construction activities, Alternative 2 meets the requirements of the Clean Water Act, the Montana Water Quality Law, and the Forest Plan.

Nutrient Yield Effects

The nutrient yield effects from the proposed Alternative 4 salvage logging are as discussed in the direct and indirect effects common to all action alternatives section. The overall increase in nutrient levels associated with the proposed salvage activities should not be measurable above natural variation once Big Creek combines with the North Fork of The Flathead River.

Road Management

With the implementation of Alternative 4, there would be 41 miles of road that is currently open yearlong changed to a more restrictive road management category. The category of road management scenario that increases in all grizzly bear sub-units is decommissioned roads. There are 87 miles of road decommissioning in the Alternative 4 road management proposal. There are net long-term positive effects to water quality and water quantity with the reduction of yearlong open roads, such as when a road is decommissioned. The positive effect to the water quality would be the reduced area of road surface and ditch that contributes eroded soil particles as suspended sediment to the stream systems. This reduction is accomplished when the water bars are installed. .

Road decommissioning is estimated to involve 62 culvert removals in perennial and ephemeral streams. There may be some additional culvert removals needed if ephemeral streams not currently mapped are encountered. For each potential culvert removal site the culvert depth class (shallow, moderate, deep) was estimated based upon landform, slope, and knowledge of the district hydrologist. The best-case scenario culvert removal soil erosion/sediment yield from Table 3-69 was assumed for all the removal sites in Big Creek, because of the soil type present there. The number of culvert removals by depth class was multiplied by the erosion rate per site to give a total potential sediment yield. See Table 3-73 for the results of these calculations.

Table 3-73: The Estimated number of culvert removals associated with the Alternative 4 proposed road decommissioning in Big Creek, and the related sediment yield from this activity.

Culvert Removals (Depth)	Alternative 4	Sediment Yield (Tons)
Shallow	10	46.0
Moderate	22	96.8
Deep	30	375.0
Totals	**62**	**517.8**

In Alternative 4, there are 23 miles of road proposed to be open seasonally, which is 16 miles more than currently exists. As discussed earlier, typically, open seasonally roads get less maintenance than open yearlong roads. This sometimes results in slightly higher road surface erosion. Therefore, in general, a 16 mile increase in the open seasonally road mileage would have a slight negative effect to the water quality. There would not be a change to the water quantity situation due to this road management change.

In Alternative 4, there are 63 less miles of road closed yearlong with a gate than the existing situation. Almost all of those miles are being converted to decommissioned roads under Alternative 4. The effect of this road management scenario change would be to decrease the water quantity delivered to a stream from the road system. Also, after the short-term sediment increase from the culvert removal associated with road decommissioning there would be a long-term sediment yield reduction from the road once waterbars are installed and the road is bermed. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process. There are a few miles of this class that would be converted to a bermed road. This would also have the effect of slightly decreasing the sedimentation level, due to the increased vegetation on the bermed road surface.

Under Alternative 4 there are 23 miles of road are proposed to be closed yearlong with a berm, which is 13 miles less then currently exists. The closed yearlong with a berm road management scenario greatly increases the effort and cost for periodic inspection and maintenance of any remaining culverts. Roadbed re-vegetation with brush at some point in time makes the road impassable to machinery without removal of the brush. Therefore the long-term risk for culvert failure and associated sedimentation is increased. Because of this the Alternative 4 road management proposal would have less risk of culvert failure than the existing situation. There is no change as far as water quantity with the Alternative 4 proposal for the bermed roads.

All of the roads closed yearlong with a berm are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning. Rather, an inspection of the road drainage structures would be done and any high-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity in culverts of bull trout and/or westslope cutthroat trout streams. Water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure diverting stream flow down the road surface, causing increased erosion/sedimentation. This road management scenario allows the road surface to re-vegetate, which significantly reduces mid-term sedimentation.

The existing road management situation and the post Alternative 4 road management scenarios were modeled using WATSED. The same assumptions were made as described in the Alternative 2 discussion. The results of the WATSED analysis are displayed in Table 3-71.

Under Alternative 4 there is a long-term decrease in the annual sediment yield load below the existing level associated with the proposed road decommissioning in each of the thirteen analysis watersheds where work is proposed. Therefore Alternative 4 has a long-term positive effect on the sediment load to Big Creek (438 tons annual reduction), as compared to the no-action Alternative 1. The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under Alternative 4 is 518 tons.

Alternative 5

Salvage

The effects to the water resources; sediment yield, water yield, and nutrient yield, are the same as described for Alternative 2. This is because the proposed timber salvage, temporary roads and landings construction proposals are the same for Alternative 5 as they are for Alternative 2.

Road Management

With the implementation of Alternative 5, there would be 19 miles of road that is currently open yearlong that would be in a more restrictive road management category. The category of road management scenario that increases in all grizzly bear sub-units is decommissioned roads. There are 57 miles of additional road decommissioning with Alternative 5 road management proposal. There are net long-term positive effects to the water quality and water quantity with the reduction of yearlong open roads when a road is decommissioned. The positive effect to water quality would be the reduced area of road surface and ditch that contributes eroded soil particles as suspended sediment to the stream systems. This reduction is accomplished when the water bars are installed.

In Alternative 5, there are 57 miles of road decommissioning proposed. Based upon the best available information the estimated number of culvert removals in perennial and ephemeral streams is 40. There may be some additional culvert removals needed if ephemeral streams not currently mapped are encountered. For each potential culvert removal site the culvert depth class (shallow, moderate, deep) was estimated based upon landform slope and knowledge of the district hydrologist. The best-case scenario culvert removal soil erosion/sediment yield from Table 3-69 was assumed for all the removal sites in Big Creek, because of the soil type present there. The number of culvert removals by depth class was multiplied by the erosion rate per site to give a total potential sediment yield. See Table 3-74 for the results of these calculations.

Table 3-74: The Estimated number of culvert removals associated with the Alternative 5 proposed road decommissioning in Big Creek, and the related sediment yield from this activity.

Culvert Removals (Depth)	Alternative 2	Sediment Yield (Tons)
Shallow	2	9.2
Moderate	14	61.6
Deep	24	300.0
Totals	**40**	**370.8**

In Alternative 5, there are 4 miles of road proposed to be open seasonally, which is 3 miles less than currently exists. As discussed earlier, typically, open seasonally roads get less maintenance than open yearlong roads. This sometimes results in slightly higher road surface erosion. Therefore, in general a 3- mile decrease in the open seasonally road mileage would have a slight positive effect to the water quality. There would not be a change to the water quantity situation.

In Alternative 5, there are 52 less miles of road closed yearlong with a gate than the existing situation. Almost all of those miles are being converted to decommissioned roads under Alternative 5. The effect of this road management scenario change would be to decrease the water quantity delivered to a stream from the road system. Also, after the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction from the road that is gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process. There are a few miles of this class that would be converted to a bermed road. This would also have the effect of slightly decreasing the sedimentation level, due to the increased vegetation on the bermed road surface.

The only other category of road management that increases in mileage under Alternative 5 is the closed-yearlong with a berm class. Under Alternative 5 there are 39 miles of road proposed to be restricted yearlong with a berm, which is 4 miles more than currently exists. The closed yearlong with a berm road management scenario greatly increases the effort and cost for periodic inspection and maintenance of any remaining culverts. Roadbed re-vegetation with brush at some point in time makes the road impassable to machinery without removal of the brush. Therefore, the long-term risk for culvert failure and associated sedimentation is increased. As displayed in Table 3-69 the volume of eroded material from a culvert plugging/failure can be very significant. There is no change as far as water quantity with this change in road management.

All of the roads in the closed yearlong with a berm are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning. Rather, an inspection of the road drainage structures would be done and any high-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity in culverts of bull trout and/or westslope cutthroat trout streams. In addition, if needed, water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure diverting stream flow down the road surface, causing increased erosion/sedimentation. This road management scenario allows the road surface to re-vegetate, which significantly reduces mid-term sedimentation.

The existing road management situation and the post Alternative 5 road management scenarios were modeled using WATSED. The same assumptions were made as described in the Alternative 2 discussion. The results of the WATSED analysis are displayed in Table 3-71.

Under Alternative 5 there is a long-term decrease in the annual sediment yield below the existing level, associated with the proposed road decommissioning in each of the thirteen analysis watersheds where work is proposed. Therefore Alternative 5 has a long-term positive effect on the sediment load to Big Creek (395 tons reduction), as compared to the no-action Alternative 1.

Summary of Direct and Indirect Effects for each Alternative

Table 3–75 is a summary of the results of the issue indicators analysis, along with results of the additional effect indicators.

Table 3-75: Summary of the Issue Indicators and Effect Indicators for Alternative 1 thru 5

Issue Indicators	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Potential 1st Year Sediment (tons) from New Temporary Roads (miles)	0	.5 tons 0.9 miles	.5 tons 0.9 miles	0	.5 tons 0.9 miles
Riparian Habitat Conservation Areas	NA	Standard Widths Applied	Standard Widths Applied	Extended Widths Applied (more filtration and less potential sediment)	Standard Widths Applied
Effect Indicators	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**
Potential 1st Year Sediment Yield Increase-Salvage Logging (tons)	Post-fire 1st Year Potential Sediment from Burn Area 125,423 tons	Post-fire 1st Year (125,423), Plus Salvage Sediment Increase 505 tons (102 tons above spawning)	Post-fire 1st Year (125,423), Plus Salvage Sediment Increase 444 tons (78 tons above spawning)	Post-fire 1st Year (125,423), Plus Salvage Sediment 391 tons (62 tons above spawning)	Post-fire 1st Year (125,423), Plus Salvage Sediment 505 tons (102 tons above spawning)
Potential 1 Year Sediment Yield Increase –Road Decommissioning	Post-fire 1st Year Potential Sediment from Burn Area 125,423 tons	Post-fire 1st Year (125,423), Plus Road Decom. 510 tons (268 tons above spawning)	Post-fire 1st Year (125,423), Plus Road Decom. 510 tons (268 tons above spawning)	Post-fire 1st Year (125,423), Plus Road Decom. 657 tons (355 tons above spawning)	Post-fire 1st Year (125,423), Plus Road Decom. 510 tons (268 tons above spawning)
Potential Annual Sediment Reduction – Road Decommissioning	None	345 tons/year	345 tons/year	438 tons/year	395 tons/year
Potential Water Yield Increase	Existing Post-fire Condition	Existing Post-fire Condition (no change)	Existing Post-fire Condition (no change)	Existing Post-fire Condition (no change)	Existing Post-fire Condition (no change)
Potential Nutrient Yield Increase	Post-fire	Slight increase Above Post-fire Highest of Alternatives	Slight Increase Above Post-fire Mid Range of Alternatives	Slight increase Above Post-fire Lowest of Alternatives	Slight Increase Above Post-fire Highest of Alternatives

Cumulative Effects

For each alternative the cumulative effects to water quality and water quantity are described for the Moose Post Fire Project Cumulative Effects Area.

Cumulative Effects Analysis Area

As described earlier, the stream flow of the North Fork of the Flathead River is significantly greater than the flow of Big Creek. Typically, there is approximately 18 times the water flow in the North Fork of the Flathead River than in Big Creek during spring snowmelt flow. The North Fork has naturally high levels of sediments being transported downstream in the spring due to extensive erosion of glacial outwash terraces and stream terraces. The larger flow volume and velocity of the North Fork River dilutes the effect of any additional input from Big Creek very soon after their confluence. Many of the nutrients that are of concern bond to the suspended soil particles, some of which are deposited within the stream channel and floodplains downstream of Big Creek. Therefore, there is a reduction in nutrient transport from Big Creek as the waters move downstream. For these reasons there is virtually no statistically significant measurable effect of any proposed management activity to water quality or water quantity, once Big Creek combines with the North Fork of the Flathead River. Because of that situation the cumulative effects area that was used for this analysis is the area of the Big Creek basin above the confluence point with the North Fork of the Flathead River.

Past Actions

Past Timber Management and Road Building

All past road construction and past timber harvest was summarized by analysis watershed to reflect the amount of man-caused disturbance in the Big Creek Basin. This was addressed in the affected environment section.

Big Mountain Ski Area

There are 7 downhill ski runs constructed in upper Big Creek as part of the Big Mountain Ski Area. These runs are essentially permanent clearcuts in the headwaters area of Big Creek. There is increased water yield associated with these runs, and that would continue into the future. The acreage of the ski runs was included in the timber harvest acreage in the watershed affected environment section Table 3-62. There were sedimentation and nutrient increases associated with the construction of these runs. With the revegetation of these runs with grasses, forbs, and shrubs the amount of soil erosion and nutrient leaching was reduced significantly. There are potentially 9 runs planned and approved for construction under the Big Mountain Ski and Summer Resort Final EIS (1995). A portion of these runs would probably be constructed in the next two years. If these ski runs are constructed there would be a short-term increase in soil erosion and nutrient leaching potential until revegetation occurs. There is a long-term increase in water yield due to the removal of the trees that would not decrease with time.

Road Decommissioning

There were approximately 17 miles of road in upper Big Creek and Skookoleel decommissioned in the past five years. There were the short-term sediment increases associated with road decommissioning as discussed earlier in the document. All of the stream crossings where culverts were removed on these roads have revegetated and stabilized since the decommissioning.

The Moose Fire

The Moose Fire was the primary natural disturbance to the Big Creek watershed since a 1964 flood event. The effects of the Moose Fire were evaluated in the hydrology affected environment section.

Fire Suppression

The fire suppression activities on the Moose Fire included both ground and aerial attack of the fire, using hand lines, cat lines, fire retardant and water drops from aircraft. Either Fire-Trol or Phos-Chek retardant was deployed with air tankers in the Big Creek watershed between August 16, 2001 and late September 2001. Protocols for the use of retardant restrict application within 300’ of streams. To the best of our knowledge, drift of the retardant affected a small area of one ephemeral draw; no retardant reached any perennial stream channels. Therefore, any changes to the water quality in Big Creek due to the fire retardant should be undetectable. The project record Q-34 contains further information concerning the use of retardants on the Moose Fire.

Based upon best available information there were no fuel spills associated with the fire suppression activities in any riparian area or stream channel.

Firelines were constructed within RHCAs in several locations, including Hallowat Creek, where several short sections of hand line were constructed across the creek. Some sediment likely entered the creek during the construction of these lines, but the amount would have been very small (estimated to be in the low hundreds of pounds) and impossible to detect. Some logjams were also sawn through to create a fuel break across the stream.

The failure of these debris dams would not contribute new sediment to the stream but might cause the redistribution of trapped sediment that could deposit in spawning gravel downstream. However, post-fire observations identified that many large woody debris pieces have fallen into the stream, and these should stabilize woody aggregations within this channel reach.

About 15 miles of firelines were constructed in the Big Creek watershed. Of this amount, approximately 8 miles were hand line and 7 miles were constructed with mechanized equipment. We know of one mechanized line built within the Big Creek RHCA that may have contributed sediment to the stream. During rehabilitation of this line, the stream bank gave way under an excavator and it entered Big Creek. The operator was forced to walk the machine down the creek a short distance before finding a spot where a low bank allowed him to exit the stream. Some additional excavator work occurred near streams to rehabilitate pumping sites. These activities likely all contributed small amounts of sediment to the streams (estimated to be in the low hundreds of pounds). All firelines were rehabilitated as soon as was fire conditions made it safe to do so. Rehabilitation included replacing disturbed soil, covering the soil with slash and debris, and the construction of waterbars on slopes. There should be no measurable amount of sediment from the constructed firelines. Inspection of the rehabilitated lines took place in the fall of 2001, and monitoring would continue in the summer of 2002 to insure that the firelines are not channeling sediment to the stream network.

The existing road network was also utilized as fireline in parts of the watershed, requiring the removal of existing vegetation and some soil disturbance, particularly on roads that had been administratively closed for several years. This activity affected the Elelehum Creek (7 crossings), Lookout Creek (6 crossing), and Kletomus Creek (1 crossing). This work may result in very small amounts of additional sediment at the fourteen stream crossing sites. Only the portion of the road prism directly 30-40 feet upslope of the stream crossing would be a potential sediment source, because the entire road was water-barred after the suppression activities. The potential sediment from each stream crossings based upon the WEPP erosion model would be 14.7 pounds per year until revegetation occurs.

Burned Area Emergency Rehabilitation (BAER) Projects

In the fall of 2001, the BAER team directed the replacement of three culverts that were considered at high risk of failing as a result of the high peak flows anticipated in the spring of 2002, in Big Creek (project record V-9). One culvert was located on the Big Creek Road # 316 approximately 1 mile east of the junction with the Elelehum Road # 5272. The other two culverts were in ephemeral channels in Langford Creek at the base of Demers Ridge. All of these culvert replacements contributed sediment to the stream channel. Based upon Table 3-76 the estimated erosion /sedimentation from culvert replacements, these three culverts could potentially yield 2.2 tons of sediment to the three stream channels.

In conjunction with these three culvert replacements and several potential overflow situations in Lookout Creek, large drain dips were constructed in the roads near the culvert sites to act as overflow channels in the event of culvert failure. The drain dips are designed to allow floodwaters to flow across the road prism rather than down the road, thus minimizing erosion of the road surface. Construction of the drain dips did not contribute measurable amounts of sediment to the streams, as they were some distance removed and down slope of the culvert sites.

The channel of the unnamed creek referred to as “Skookoleel North” was diverted through a ditch to flow into a wetland area next to Big Creek in order to help filter sediment before it reaches the stream. This drainage is thought to be at high risk of suffering significant erosion due to the fire intensity and steep terrain. The construction was done when the stream was not flowing. The sediment potential from this channel excavation would be approximately the same as for a best-case scenario shallow depth culvert decommissioning (Table 3-69), or 4.6 tons of sediment.

The BAER actions also included the placement of numerous straw wattles, fiber mats, and loose straw material to help trap sediment and reduce erosion in areas of high burn intensity. This was done primarily in Skookoleel North and at the culvert replacement sites.

Foreseeable Actions

Of the identified reasonably foreseeable actions, there are only seven actions that would potentially have any measurable effect to water quantity or quality they include the following: 1) the proposed culvert replacements, 2) the proposed Best Management Practices (BMPs) road drainage improvements, 3) the trail maintenance work, 4) the Moose Peak Burn, 5) routine road maintenance, 6) road decommissioning as a result of past planning decisions, and 7) Big Mountain Resort – BMP work. These are discussed in the following section. The foreseeable actions with no effects to the water quality or quantity include: 1) the noxious weed treatments, 2) recreation activities, 3) special products activities (e.g. mushroom picking), and 4) fire woodcutting. This interpretation is based upon following the label instructions for proper use of any herbicide, and that woodcutters follow the limitations associated with the wood gathering permits.

Culvert Replacements

For this proposed project, the primary direct effects to the water resource is the potential increase in sedimentation directly associated with either the culvert replacement process, or the Best Management Practices (BMPs) road drainage improvements.

The following is an estimate of the total amount of erosion and associated sedimentation that occurs during the process of replacing and/or up-sizing a culvert. The erosion material comes from two different sources. First, the area beneath a culvert in the streambed that is exposed to water-flow during the removal process, and second, the side-slopes of the road prism that are excavated during the replacement process. Unless a stream is dry there is some erosion that occurs in the streambed during the replacement process even with de-watering, due to the seepage of groundwater around or under the stream block. The second source is when the road side-slopes become bare ground following the excavation; even with erosion control and sediment reduction measures installed there is a probability that some erosion would occur before these bare ground surfaces become re-vegetated. Because both of these erosion areas are within or directly next to a stream, any fine eroded soil material may immediately become suspended sediment.

This short-term increase in sediment varies with the soil materials the culvert is in and the slope of the land at the culvert site. In general, the steeper the site the more soil exposed to erosion. Also, in general, the less the coarse fragment content, and the finer the soil texture, the more potential for soil erosion. This is especially true with saturated soils that occur in the bottom of perennial streams. Based upon observations by the Flathead N.F. soil scientist and hydrologist, estimates for the amount of soil erosion from the stream bottom and road side-slopes were developed. These estimated erosion rates were then multiplied by the exposed surface area for various widths and depths of culvert replacements to develop the estimated erosion/sediment potential. Refer to Table 3-76 for the estimated erosion/sedimentation for various culvert replacement scenarios.

Table 3-76: Estimated total erosion/sedimentation that occurs during a culvert replacement process, for both shallow and deep sites, during both a normal replacement scenario and a worst-case scenario.

Culvert Width - Erosion Scenario	Estimated Erosion/Sedimentation Flatter/Shallow Site	Estimated Erosion/Sedimentation Steeper/Deep Site
2 Foot – Dry Normal Resize	.3 Tons/Culvert	1.2 Tons/Culvert
2 Foot – Wet Normal Resize	.6 Tons/Culvert	1.9 Tons/Culvert
2 Foot – Wet Worst Case Resize	.8 Tons/Culvert	2.7 Tons/Culvert
3 Foot – Dry Normal Resize	.4 Tons/Culvert	1.3 Tons/Culvert
3 Foot – Wet Normal Resize	.7 Tons/Culvert	2.4 Tons/Culvert
3 Foot – Wet Worst Case Resize	1.1 Tons/Culvert	3.5 Tons/Culvert
4 Foot – Dry Normal Resize	.4 Tons/Culvert	1.4 Tons/Culvert
4 Foot – Wet Normal Resize	.9 Tons/Culvert	2.9 Tons/Culvert
4 Foot – Wet Worst Case Resize	1.4 Tons/Culvert	4.4 Tons/Culvert
5 Foot – Dry Normal Resize	.5 Tons/Culvert	1.5 Tons/Culvert
5 Foot – Wet Normal Resize	1.1 Tons/Culvert	3.4 Tons/Culvert
5 Foot – Wet Worst Case Resize	1.7 Tons/Culvert	5.3 Tons/Culvert

Each culvert in the upper Big Creek basin above the confluence with Hallowat Creek was examined for signs of erosion or deposition upstream or downstream of the culvert, due to an undersized culvert. The rust lines were measured for each culvert. These rust lines represent an approximation of the bankfull or the 1.5 to 2 year return interval flow for the stream. For the purpose of initial estimate of the culverts that need to be upsized to meet INFISH requirements any culvert with the height of the rust line greater than 33% of the culvert diameter was assumed to need upsizing. The modeling of estimated water flow for various return interval events (e.g. 50-year flow, 100-year flow) is being done concurrently with this assessment. Each culvert would be re-examined in the field and flow estimations reviewed before a culvert would be replaced in order to insure the need for replacement, and minimize the amount of sediment produced from the replacement process.

The culverts in the Lower Big Creek within the Moose Fire area have not had the field measurements completed on them. This would be done after the spring snowmelt period. The district hydrologist and the road system engineer estimated based upon field reviews and professional judgment which culverts would need upsizing in the Moose Fire area.

Each of the culverts estimated to need replacement was plotted on a map (available in the project record). Then, for each potential replacement sites the following items were estimated: 1) size of replacement culvert, 2) if the site was a “shallow” or “deep” culvert site, 3) whether the stream at the culvert site was dry, or had stream flow during the potential replacement time-frame, and 4) if due to streambed materials there would be major seepage at the site associated with de-watering. These four estimates were based upon photos of the upper basin sites, and knowledge of the district hydrologist. Based upon these four criteria each potential culvert replacement site was given a potential sediment yield from Table 3-76 the estimated erosion/sedimentation associated with a culvert replacement.

Culvert replacements and BMP improvements in Big Creek and Coal Creek is being addressed separately from this EIS, with activities expected to begin in the summer of 2002 and be completed in 2003. The number of culverts to be replaced depends upon the road management alternative decided in this EIS. If access management Alternatives 2, 3 and 5 is chosen, there were 77 culverts identified for potential replacement. Based upon the estimated replacement culvert size and the depth of the road prism the estimated soil erosion/sedimentation from Table 3-76 was summed for the 77 culvert replacements. The replacement of these 77 culverts would result in the potential release of approximately 127.7 tons of sediment into the tributary streams of Big Creek. Potentially 3 to 5 of the identified culvert replacements would occur on roads that were identified for potential use during the post-fire salvage logging, and would be decommissioned at a later date.

Under access management Alternative 4, there were 61 culverts identified for potential replacement. The replacement of these 61 culverts would result in the potential release of approximately 95.2 tons of sediment into the tributary streams of Big Creek. The vast majority of this sediment is associated with the direct replacement process and the remainder from the disturbed road prism side-slopes until they have revegetated.

Under access management Alternatives 2, 3, and 5 there are 61 potential culvert replacements that occur above the spawning reaches of Big Creek. The replacement of all of those culverts would have potential sediment of 80.8 tons that could be delivered into the spawning reaches of Big Creek.

Under access management Alternative 4, there are 50 potential culvert replacements that occur above the spawning reaches of Big Creek. The replacement of all of those culverts would have potential sediment of 69.5 tons that could be delivered into the spawning reaches of Big Creek.

These estimates are based upon the assumption that each culvert is replaced with a larger capacity culvert. However, in some cases especially on crossing sites with deep fills there is an opportunity to install a second “overflow” culvert, above the pre-existing culvert. This type of installation would yield significantly less sediment because only the road prism side-slopes are a sediment source. This type of installation would only be done on a limited number of sites that have certain landform, channel type, and soil material characteristics.

BMP Improvements

The primary BMPs that are proposed to be done are directly associated with improving water drainage from the surface of roads, and improving the filtering of sediment coming from road surface and ditch drainage. These BMP projects primarily include installation of new cross-drain culverts, drive-thru-dips, sediment retention structures (silt fencing, straw wattles, slash filter windrows). There are three different road management situations in Big Creek and Coal Creek where road drainage BMPs are being installed. First, roads that are open yearlong or seasonally. There are 83.3 miles of those types of roads in Big Creek and 10.1 miles in Coal Creek. Second, there are 24.0 miles of roads in Big Creek and 3.3 miles in Coal Creek that are proposed to be bermed under the Moose Post Fire Project Alternative's 2, 3, and 5; only snowmobile traffic would be allowed on them. Before these roads are bermed any needed BMP improvements would be accomplished. Third, there are 22.3 miles of roads that are proposed to be used for salvage logging in the Moose Post Fire Project and then be decommissioned.

There should be no measurable amounts of erosion/sedimentation associated with any slash filter windrow, or silt fence installation. There should be no measurable amounts of erosion/sedimentation deliverable to a stream associated with the installation of drive-thru-dips, except for the drive-thru-dips that are constructed very near to a stream channel.

Based upon the a map review of the roads with BMPs improvements proposed, there are 55 stream crossings in Upper Big Creek above the Moose Fire that could have sedimentation potential from the construction of the drive-thru-dips. Of these 55 stream crossings (none within fire boundary) 16 are on "flatter/shallow" sites that have more potential for some sedimentation because of the shorter filter distances from the road surface to the stream, than the "steeper/deep" stream crossing. There are 51 stream crossings in Lower Big Creek, 44 of those within the Moose fire boundary. Nine of the 51 stream crossings in Lower Big Creek are "flatter/shallow" crossing sites.

Based upon WEPP erosion modeling the installation of a drive-thru-dip at approximately 30 feet on each side of the stream crossing would yield approximately 11.1 pounds per year of sediment for a "flatter/shallow" site, and 14.7 pounds per year for a "steeper/deeper" site. The construction of the drive-thru-dips would potentially increase the sediment budget of Upper Big Creek by .04 tons, and the sediment budget of lower Big Creek by .04 tons. Accounting for that increase, the long-term reduction from the installation of the drive-thru-dip at the stream crossing sites would be potentially 3.6 tons per year in Upper Big Creek, and 3.5 tons per year in lower Big Creek.

Trail Maintenance

There are approximately 22.2 miles of trails to be maintained in the Big Creek and Coal Creek watersheds and along a portion of the North Fork River in areas directly above the river. There are approximately 24 water-bars that would be replaced within 100-150 feet of a stream channel. There are very low levels of soil erosion that occur with the maintenance activities associated with the digging-in of replacement water-bars. The estimated sediment entering a stream from this activity using WEPP is estimated to be 96 pounds (.05 ton) for all 24 sites.

Moose Peak Prescribed Burn

A decision was signed in August 1998 to prescribed burn approximately 2000 acres of grassland/woodland sites in the Moose Lake area. This has not been implemented to date and is planned to be delayed at least a couple of years, due to the Moose Fire and to allow for consideration of changed conditions and new information. The prescription for these burn units would typically result in the majority of a prescribed fire burn having a low burn severity causing virtually no effect on the soil's physical or chemical properties. During the burning process, some nutrients in the grass and duff are released into the atmosphere; however, most remain in the ash and are rapidly reabsorbed into the topsoil (DeByle 1981).

However, prescribed burns such as the ones proposed for the Moose Lake area would have some small patches of moderate and high burn severity where the fuel loads on the forest floor are concentrated. In these areas of concentrated woody fuels soils directly under can be heated enough to cause a reduction of some soil nutrients (e.g. nitrogen) and the microbe populations in the surface soil layer. This can have a short-term 2-3 year reduction in vegetation cover on moderate burn severity sites, and up to a 4-6 year reduction on high burn severity sites. The reduction in vegetation cover can cause small amounts of surface soil erosion but there should not be any delivered. But this eroded soil material is usually transported only a few feet downhill (3-10 feet estimated). These are minimal short-term reductions in site productivity that are very widely spaced in the burn unit (Packer and Williams 1976).

To summarize, there are some very local short-term effects from prescribed fire treatments that have very low probability of affecting the water quality or quantity in any measurable way.

Routine Road Maintenance

There are approximately 25.5 miles of road in the Big Creek that would have routine road maintenance (primarily road blading and culvert cleaning) accomplished on them. The road blading would typically occur annually, and the culvert cleaning is done on an as needed basis. These roads have 17 stream crossings associated with this road maintenance. Using the WEPP – road erosion model an estimate of erosion from the road surface and potential sediment entering a stream channel was completed for the roads proposed for routine maintenance. The project record includes those WEPP runs. A worst-case scenario of the amount of soil erosion leaving the road surface is estimated to be 4.5 tons. And the amount of sediment potential reaching a stream course from the road blading is 3.5 tons.

Big Mountain Resort - BMP Improvements

There is a small road used by Winter Sports Inc. to access portions of the north side of the Big Mountain in the Chair 7 area. The road starts near the Summit House and ends on Big Creek Road #316. Shallow water bars have been installed in the road so as to not impede snow grooming. However, these water-bars are occasionally topped by runoff after a rainstorm, and some sediment reaches a tributary of Big Creek. Winter Sports Inc. has agreed to improve the water drainage from this road segment. There would be no measurable amount of sediment from the construction of these water-bars, due to the filtering effect of the grass and forbs on the ski runs.

Road Decommissioning

There are two road segments, one in Skookoleel Creek and one in Werner Creek that are planned for road decommissioning in the summer of 2002. This decommissioning is covered under the Big Mountain Expansion Decision. The best-case scenario culvert removal soil erosion/sediment yield from Table 3-69 was used to estimate the amount of sediment yield from these removal sites. The number of culvert removals by depth class was multiplied by the erosion rate per site to give a total potential sediment yield. All of these culvert removals are above a portion of the spawning reach in Big Creek. See Table 3-77 for the results of these calculations.

Table 3-77: The estimated number of culvert removals and associated sediment yield from road decommissioning in Big Creek, under the Big Mountain EIS decision.

Culvert Removals (Depth)	Big Mountain EIS – Under Decision	Sediment Yield (Tons)
Shallow	1	4.6
Moderate	5	22.0
Deep	9	112.5
Totals	**15**	**139.1**

In total, the foreseeable actions would have some short-term effects to the water quality within the basin; however, in the long-term there would be an overall positive effect to the water quantity and quality within the cumulative effects analysis basin.

Alternative 1 – No Action

Past Actions: The past actions described earlier in this section include: past road construction, past timber harvest, past road decommissioning, construction of the ski runs, the Moose Fire, the fire suppression activities for the Moose Fire, and the Burned Area Emergency Rehabilitation for the Moose Fire.
Foreseeable Actions: The foreseeable actions that may affect the water resources were described earlier in this section and include: 1) the proposed culvert replacements, 2) the proposed Best Management Practices (BMP's) road drainage improvements, 3) the trail maintenance work, 4) the Moose Peak Burn, 5) routine road maintenance, and 6) road decommissioning as a result of past planning decisions (Big Mountain Expansion EIS, 1995).

Proposed Action: There are no proposed actions on federal lands under this Alternative 1. Given a conservative precipitation/runoff event, the combined post-fire background, and foreseeable actions sediment yield for the 2004 snowmelt period would equal approximately 1,306 tons/day for a five-day period. The 1,306 tons/day sediment load is a 2% greater daily sediment yield than was measured in Big Creek during a May 1986 peak flow event. The 1986 event was the 22nd highest flow event in the North Fork since the streamflow records were kept. A major storm event could result in the maximum-modeled erosion/sedimentation from the burned lands to occur. This would yield approximately 125,000 tons delivered to the stream channels in Big Creek within a one to two day period. This would be the highest observed sediment load for Big Creek.

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for Big Creek basin. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for Big Creek. Given a significant storm/soil erosion event, the sediment yield for Big Creek could exceed the measured natural range of variation. This interpretation is based upon past monitoring reports, literature, and professional judgment.

A cumulative effect decrease to the long-term sediment and water yield would be foregone if the road decommissioning proposed in Alternatives 2, 3, 4, and 5 were not implemented.

Alternative 2

Past Actions: The past actions are the same as described for Alternative 1.

Foreseeable Actions: The foreseeable actions are the same as described for Alternative 1.

Proposed Actions: The Alternative 2 proposed salvage harvesting, road/landing construction, and road decommissioning would not have any measurable increases in water yield. Rather, the level of post-fire water yield increase diminishes by the time the salvage harvest and road decommissioning would be implemented.

The proposed salvage harvest and road/landing construction under Alternative 2 would increase the sediment loading in twelve analysis watersheds, for a total of approximately 509 tons in the entire Big Creek watershed. The road decommissioning would have a positive long-term effect of decreasing water yield and reducing sedimentation (345 tons/year), after the initial short-term sediment increase (510 tons) during the culvert removal/stream readjustment time. The risk of culvert failure would also decrease with the proposed road decommissioning. This overall positive effect would occur in Big Creek Face Drainages, Big Creek Trib #1 & #3, Elelehum Creek, Hallowat Creek, Kletomus Creek, Lookout Creek, Lower Hallowat Creek, Nicola Creek, Upper Big Creek, Vogt Creek and Werner Creek analysis watersheds. The effect of the sediment yield increase from the Alternative 2 proposed actions would not cause any of the individual analysis watersheds or the combined Big Creek watershed to become functioning-at-risk. Refer to Table 3-78 for a listing of the Big Creek watershed existing post-fire sediment yield, the additional sediment yield from the Alternative 2 proposed actions and other foreseeable actions.

Table 3-78: The summary of the sediment producing activities in Big Creek including: background, foreseeable actions, and Alternative 2 proposed actions.

Sediment Producing Activity	Tons of Sediment
Annual Sediment Yield for Non-burned Portion of Big Creek[1]	529
Year-1 Post-fire Potential Sediment from Burned Portion of Big Creek	125,423
Annual Road Maintenance Potential Sediment in Big Creek	4
Total Short-term Potential Sediment Increase from Big Mtn. EIS Road Decommissioning	139
Annual Potential Sediment from Installation of BMP's Structures	<0.1
Total Short-term Potential Sediment from Culvert Replacements	122
First Year Potential Sediment from Alt-2 Proposed Salvage[2]	509
Total Short-term Potential Sediment Increase from Alt-2 Road Decommissioning	510
Annual Long-term Potential **Decrease** Sediment from Alt-2 Road Decommissioning[3]	345

[1] Note that the small face drainage flowing directly into the North Fork River that is adjacent to Big Creek, and that is a portion of the project area is included in the Big Creek calculations for this table.
[2] Note that the sediment yield from salvage harvesting decreases rapidly as revegetation occurs.
[3] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Given a conservative precipitation/runoff event, the combined post-fire background, proposed Alternative 2 actions, and foreseeable action sediment yield for the 2004 snowmelt period would equal approximately 1,422 tons/day for a five day period. The 1,422 tons/day sediment load is an 11% greater daily sediment yield than was measured in Big Creek during a May 1986 peak flow event. The May 1986 peak flow event was the 22nd highest flow event measured on the North Fork of the Flathead River in the 80 years streamflow records have been kept. Therefore, there have probably been several peak flow events that have occurred on Big Creek with greater streamflow and greater sediment loads than the measured May 1986 event. However, a major storm event could result in the maximum-modeled erosion/sedimentation from the burned lands to occur. This would yield approximately 125,000 tons delivered to the stream channels in Big Creek within a one to two day period. This would be the highest observed sediment load for Big Creek.

Due to the effect of increased sedimentation and slightly decreased ground cover associated with the salvage logging proposed in Alternative 2, there should be a slight increase in the level of nutrients i.e. nitrogen and phosphorus. This nutrient increase should be very small in comparison to the nutrient increase caused by the wildfire. In combination the amount of potential nutrient increase from the Alternative 2 timber salvage and road/landing construction would not be discernable from the nutrient increase due to the wildfire. And the overall increase in nutrient levels should not be measurable above natural variation once Big Creek combines with the North Fork of The Flathead River

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for Big Creek basin. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for Big Creek. Given a significant storm/soil erosion event, the sediment yield for Big Creek could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

Alternative 3

Past Actions: The past actions are the same as described for Alternative 1.

Foreseeable Actions: The foreseeable actions are the same as described for Alternative 1.

Proposed Actions: The Alternative 3 proposed salvage harvesting, road/landing construction, and road decommissioning would not have any measurable increases in water yield. Rather, the level of post-fire water yield increase diminishes by the time the salvage harvest and road decommissioning would be implemented.

The proposed salvage harvest and road/landing construction under Alternative 3 would increase the sediment loading in ten analysis watersheds, for a total of approximately 448 tons in the entire Big Creek watershed. The road decommissioning would have a positive long-term effect of decreasing water yield and reducing sedimentation (345 tons/year), after the initial short-term sediment increase (510 tons) during the culvert removal/stream readjustment time. Under the proposed actions in Alternative 3 there would be an increased risk of culvert failure on culverts that would not be removed when some roads are converted into snowmobile trails, as compared to Alternatives 2, 4, and 5 where all culverts are removed. However, there would be a positive effect with the removal of a portion of the road prism at culvert crossings on snow mobile trails, thus reducing the amount of soil material to erode if a culvert were to fail. This overall positive effect would occur in Big Creek Face Drainages, Big Creek Trib #1 & #3, Elelehum Creek, Hallowat Creek, Kletomus Creek, Lookout Creek, Lower Hallowat Creek, Nicola Creek, Upper Big Creek, Vogt Creek and Werner Creek analysis watersheds.

The effect of the sediment yield increase from the Alternative 3 proposed actions would not cause any of the individual analysis watersheds or the combined Big Creek watershed to become functioning-at-risk. Refer to Table 3-79 for a listing of the Big Creek watershed existing post-fire sediment yield, the additional sediment yield from the Alternative 3 proposed actions and other foreseeable actions.

Table 3-79: The summary of the sediment producing activities in Big Creek, including background, foreseeable actions, and Alternative 3 proposed actions.

Sediment Producing Activity	Tons of Sediment
Annual Sediment Yield for Non-burned Portion of Big Creek[1]	529
Year-1 Post-fire Potential Sediment from Burned Portion of Big Creek	125,423
Annual Road Maintenance Potential Sediment in Big Creek	4
Total Short-term Potential Sediment Increase from Big Mtn. EIS Road Decommissioning	139
Annual Potential Sediment from Installation of BMP's Structures	<0.1
Total Short-term Potential Sediment from Culvert Replacements	122
First Year Potential Sediment from Alt-3 Proposed Salvage[2]	448
Total Short-term Potential Sediment Increase from Alt-3 Road Decommissioning	510
Annual Long-term Potential **Decrease** Sediment from Alt-3 Road Decommissioning[3]	345

[1] Note that the small face drainage flowing directly into the North Fork River that is adjacent to Big Creek, and that is a portion of the project area is included in the Big Creek calculations for this table.
[2] Note that the sediment yield from salvage harvesting decreases rapidly as revegetation occurs.
[3] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Given a conservative precipitation/runoff event, the combined post-fire background, proposed Alternative 3 actions, and foreseeable actions sediment yield for the 2004 snowmelt period would equal approximately 1,410 tons/day for a five day period. The 1,410 tons/day sediment load is a 10% greater daily sediment yield than was measured in Big Creek during a May 1986 peak flow event. The May 1986 peak flow event was the 22nd highest flow event measured on the North Fork of the Flathead River in the 80 years streamflow records have been kept. Therefore, there have probably been several peak flow events that have occurred on Big Creek with greater streamflow and greater sediment loads than the measured May 1986 event. However, a major storm event could result in the maximum-modeled erosion/sedimentation from the burned lands to occur. This would yield approximately 125,000 tons delivered to the stream channels in Big Creek within a one to two day period. This would be the highest observed sediment load for Big Creek.

Due to the effect of increased sedimentation and slightly decreased ground cover associated with the salvage logging proposed in Alternative 3, there should be a slight increase in the level of nutrients i.e. nitrogen and phosphorus. This nutrient increase should be very small in comparison to the nutrient increase caused by the wildfire. In combination the amount of potential nutrient increase from the Alternative 3 timber salvage and road/landing construction would not be discernable from the nutrient increase due to the wildfire. And the overall increase in nutrient levels should not be measurable above natural variation once Big Creek combines with the North Fork of The Flathead River.

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for Big Creek basin. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for Big Creek. Given a significant storm/soil erosion event, the sediment yield for Big Creek could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

Alternative 4

Past Actions: The past actions are the same as described for Alternative 1.

Foreseeable Actions: The foreseeable actions are the same as described for Alternative 1.

Proposed Actions: The Alternative 4 proposed salvage harvesting, road/landing construction, and road decommissioning would not have any measurable increases in water yield. Rather, the level of post-fire water yield increase diminishes by the time the salvage harvest and road decommissioning would be implemented.

Alternative 4 has the least increased sediment yield from salvage harvest due to the smallest amount of proposed treated acres, and the wider RHCA's. The proposed salvage harvest and road/landing construction under Alternative 4 would increase the sediment loading in ten analysis watersheds, for a total of approximately 391 tons in the entire Big Creek watershed. The road decommissioning would have a positive long-term effect of decreasing water yield and reducing sedimentation (438 tons/year), after the initial short-term sediment increase (657 tons) during the culvert removal/stream readjustment time. The risk of culvert failure would also decrease with the proposed road decommissioning. This overall positive effect would occur in Big Creek Face Drainages, Big Creek Trib #1 & #3, Elelehum Creek, Hallowat Creek, Kletomus Creek, Lookout Creek, Lower Hallowat Creek, Nicola Creek, Upper Big Creek, Vogt Creek and Werner Creek analysis watersheds. Alternative 4 has the greatest short-term sediment impact to Big Creek watershed from road decommissioning, with the greatest long-term reduction in annual sediment yield.

The effect of the sediment yield increase from the Alternative 4 proposed actions would not cause any of the individual analysis watersheds or the combined Big Creek watershed to become functioning-at-risk. Refer to Table 3-80 for a listing of the Big Creek watershed existing post-fire sediment yield, the additional sediment yield from the Alternative 4 proposed actions and other foreseeable actions.

Table 3-80: The summary of the sediment producing activities in Big Creek, including background, foreseeable actions, and Alternative 4 proposed actions.

Sediment Producing Activity	Tons of Sediment
Annual Sediment Yield for Non-burned Portion of Big Creek[1]	529
Year-1 Post-fire Potential Sediment from Burned Portion of Big Creek	125,423
Annual Road Maintenance Potential Sediment in Big Creek	4
Total Short-term Potential Sediment Increase from Big Mtn. EIS Road Decommissioning	139
Annual Potential Sediment from Installation of BMP's Structures	<0.1
Total Short-term Potential Sediment from Culvert Replacements	95
First Year Potential Sediment from Alt-24Proposed Salvage[2]	391
Total Short-term Potential Sediment Increase from Alt-4 Road Decommissioning	657
Annual Long-term Potential **Decrease** Sediment from Alt-4 Road Decommissioning[3]	438

[1] Note that the small face drainage flowing directly into the North Fork River that is adjacent to Big Creek, and that is a portion of the project area is included in the Big Creek calculations for this table.
[2] Note that the sediment yield from salvage harvesting decreases rapidly as revegetation occurs.
[3] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Given a conservative precipitation/runoff event, the combined post-fire background, proposed actions, and foreseeable action sediment yield for the 2004 snowmelt period would equal approximately 1,403 tons/day for a five day period. The 1,403 tons/day sediment load is a 9% greater daily sediment yield than was measured in Big Creek during a May 1986 peak flow event. The May 1986 peak flow event was the 22nd highest flow event measured on the North Fork of the Flathead River in the 80 years streamflow records have been kept. Therefore, there have probably been several peak flow events that have occurred on Big Creek with greater streamflow and greater sediment loads than the measured May 1986 event. However, a major storm event could result in the maximum-modeled erosion/sedimentation from the burned lands to occur. This would yield approximately 125,000 tons delivered to the stream channels in Big Creek within a one to two day period. This would be the highest observed sediment load for Big Creek.

Due to the effect of increased sedimentation and slightly decreased ground cover associated with the salvage logging proposed in Alternative 4, there should be a slight increase in the level of nutrients i.e. nitrogen and phosphorus. The level of nutrient increase should be less than Alternatives 2, 3, and 5; because there is less ground disturbing activity proposed in Alternative 4. This nutrient increase should be very small in comparison to the nutrient increase caused by the wildfire. In combination the amount of potential nutrient increase from the Alternative 4 timber salvage and road/landing construction would not be discernable from the nutrient increase due to the wildfire. And the overall increase in nutrient levels should not be measurable above natural variation once Big Creek combines with the North Fork of The Flathead River

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for Big Creek basin. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for Big Creek. Given a significant storm/soil erosion event, the sediment yield for Big Creek could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

Alternative 5

Past Actions: The past actions are the same as described for Alternative 1.

Foreseeable Actions: The foreseeable actions are the same as described for Alternative 1.

Proposed Actions: The proposed action under Alternative 5 for the salvage harvest, road and landing construction is the same as Alternative 2. The road management proposal for Alternative 5 has 9 miles less open yearlong road, 5 miles less road closed yearlong with a berm, 5 miles more closed yearlong with a gate, and 9 more miles open seasonally than proposed with Alternative 2.

The effects to water yield, sedimentation yield, and nutrient yield are virtually identical for Alternative 2 and Alternative 5. The only difference is that Alternative 5 would have slightly less risk of a culvert failure because of the less miles of road closed yearlong with a berm. And Alternative 5 has 50 tons/year (395 tons/year) more reduction in long-term sediment production from the decommissioning of roads than Alternative 2. This is because some of the roads to be decommissioned under Alternative 5 occur on more erosion prone landtypes. The estimated 2004 daily sediment load is the same for Alternative 5, which is an 11% greater daily sediment yield than was measured in Big Creek during a May 1986 peak flow event.

The effect of the sediment yield increase from the Alternative 5 proposed actions would not cause any of the individual analysis watersheds or the combined Big Creek watershed to become functioning-at-risk. Refer to Table 3-78 for a listing of the Big Creek watershed existing post-fire sediment yield, the additional sediment yield from the Alternative 5 proposed actions and other foreseeable actions.

Table 3-81: The summary of the sediment producing activities in Big Creek including: background, foreseeable actions, and Alternative 5 proposed actions.

Sediment Producing Activity	Tons of Sediment
Annual Sediment Yield for Non-burned Portion of Big Creek[1]	529
Year-1 Post-fire Potential Sediment from Burned Portion of Big Creek	125,423
Annual Road Maintenance Potential Sediment in Big Creek	4
Total Short-term Potential Sediment Increase from Big Mtn. EIS Road Decommissioning	139
Annual Potential Sediment from Installation of BMP's Structures	<0.1
Total Short-term Potential Sediment from Culvert Replacements	122
First Year Potential Sediment from Alt-5 Proposed Salvage[2]	509
Total Short-term Potential Sediment Increase from Alt-5 Road Decommissioning	510
Annual Long-term Potential **Decrease** Sediment from Alt-5 Road Decommissioning[3]	395

[1] Note that the small face drainage flowing directly into the North Fork River that is adjacent to Big Creek, and that is a portion of the project area is included in the Big Creek calculations for this table.
[2] Note that the sediment yield from salvage harvesting decreases rapidly as revegetation occurs.
[3] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for Big Creek basin. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for Big Creek. Given a significant storm/soil erosion event, the sediment yield for Big Creek could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

4. Regulatory Framework and Consistency

Clean Water Act

Section 313 of the Clean Water Act requires that Federal agencies comply with all substantive and procedural requirements related to water quality. Under Section 303 of the Clean Water Act, States have the primary responsibility to develop and implement water quality programs, which include developing water quality standards and Best Management Practices (BMPs). State water quality standards are based on the water quality necessary to protect beneficial uses.

Environmental Protection Agency policy requires each state to implement a Non-degradation Policy. Under this policy, water quality must be maintained to fully support existing beneficial uses. Existing water quality that is higher than the established standards must be maintained at the existing level unless the board of health and environmental sciences determines that a change in water quality is justifiable due to social and/or economic reasons (CFR Vol. 48, No. 217, 131.12, Nov, 8, 1983; Montana Water Quality Act, Section 75-5.)

Montana State Water Quality Law

As listed in ARM 17.30.608 (1) the State of Montana has classified the waters in Big Creeks as B-1. Waters classified as B-1 are suitable for drinking, culinary, and food processing purposes after conventional treatment. Water quality must also be suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply. Additional criteria specific to sediment are found within Section 17.30.623(2)(f) of Montana Water Quality Standards where it is stated that "(N)o increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids, which would or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife". Naturally occurring is as defined by MCA 17.30.602 (17), includes conditions or materials present during runoff from developed land where all reasonable land, soil, and water conservation practices (BMPs) have been applied. Reasonable practices include methods, measures or practices that protect present and reasonably anticipated beneficial uses.

The state water quality law relates to the Clean Water Act and the maintenance of beneficial water uses through the use of BMPs. The BMPs are designed to prevent soil erosion and protect water quality, as well as help prevent soil damage. In a memorandum of Understanding with the State of Montana, the Forest Service has agreed to follow Best Management Practices (BMPs) during timber harvest and road construction activities. The Moose Post-fire Project would utilize all applicable BMPs during project design and implementation as described in Best Management Practices for Forestry in Montana – 1997. Also Forest Service - Soil and Water Conservation Practices (FSH 2509.22) would be combined with Montana State BMPs for incorporation into project design and implementation to ensure that soil and water resources are protected. The project specific BMPs are identified in the Appendix C of the Draft EIS.

The DEQ's 1996 and 2000 303 (d) Reports - *Water bodies in need of Total Maximum Daily Load (TMDL) Development*, describe Big Creek as partially supporting the beneficial uses of aquatic life support and cold water fishery. The probable causes of this impairment on both the 1996 and 2000 303(d) lists can all be linked to sediment, with probable sources being linked primarily to silviculture practices. The transmittal to DEQ of The Watershed Restoration Plan For Big Creek, North Fork of the Flathead River, March 2002, satisfies TMDL development requirements for sediment and causes relating to sediment (habitat alterations, siltation, bank erosion, and fish habitat alterations) for Big Creek.

Montana Streamside Management Zone (SMZ) Law

By definition in ARM 36.11.312 (3), the majority of the streams in Big Creek meet the criteria for a class 1 stream. There are some first order ephemeral streams that meet the criteria of a class 2 or 3 stream based upon site-specific criteria. All alternatives would meet at a minimum SMZ buffer zone requirement. In most situations because of the INFISH, the RHCA width requirements and/or the expanded RHCA buffer width, the required SMZ buffer width is expanded significantly.

Consistency With Forest Plan Standards

The Flathead Forest Plan directs under Forest-wide Management Direction that: 1) Develop watershed activity schedules for key watersheds. 2) Maintain an inventory of non-wilderness areas needing soil and water restoration. Complete restoration projects as funds permit. 3) Best Management Practices would be applied during Forest Plan implementation to ensure that Forest water quality goals are met. And under Management Area specific water and soils direction to: 1) Maintain long-term water quality to meet or exceed State water quality standards. To ensure meeting these standards, surface-disturbing activities would be monitored where this need is identified. 2) Refer to Forest-wide standards under Water and Soils for Best Management Practices, Landtype Guidelines, and standards applicable to projects or activities within this Management Area. 3) All Project proposals would be analyzed and evaluated to determine the potential water quantity and quality impacts. Mitigation measures would be developed to minimize adverse impacts. These water and soils standards were reviewed for all proposed management activities on management areas MA 9, MA 13, MA 13a, MA 15, and MA 18. All proposed management actions in all the alternatives meet these forest plan standards.

INFISH Standards

The INFISH (1995) Standards are discussed in detail in the fishery assessment. All units were designed to meet the RHCA requirements under the Flathead Forest Plan as amended by INFISH to protect the stream channel and maintain water quality and the aquatic habitat.

Wetlands

Wetlands are protected under Executive Order 11990. This act directs federal agencies to "minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands...". There are no activities proposed in any of the alternatives of the Moose Post-fire Project that directly affect any lotic or lentic wetlands in Big Creek or along the North Fork of the Flathead River in the project area. Therefore all alternatives would meet Executive Order 11990.

Regulatory Consistency

All of the proposed alternatives would meet Clean Water Act, Montana State Water Quality Standards, and Forest Plan Water Standards.