APPENDIX A

North Fork Coeur d'Alene River Subbasin

Technical Appendix
and
Summary of Existing Information

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Summary of Existing Information and Knowledge within the North Fork Coeur d'Alene River Subbasin

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Abbreviations, Acronyms, and Symbols

§303(d)	refers to Section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section.
BMP	Best Management Practice
BURP	IDEQ Beneficial Use Reconnaissance Program
CdA	Coeur d'Alene
CWA	Federal Clean Water Act
CWE	IDL Cumulative Watershed Effects protocol
IDEQ	Idaho Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
FPA	Idaho Forest Practice Act
HUC	Hydrologic Unit Code(s) assigned by the USGS
IDFG	Idaho Department of Fish & Game
IDL	Idaho Department of Lands
IDWR	Idaho Department of Water Resources
m	meter
mm	millimeter
mg/L	milligrams per liter
North Fork	mainstem North Fork Coeur d'Alene River
North Fork Subbasin	
NRCS	National Resource Conservation Service
TMDL	Total Maximum Daily Load
µg/L	micrograms per liter
U of I	University of Idaho
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
WPN	Watershed Professionals Network
WY	Water Year

1.0 INTRODUCTION

This *Technical Appendix* provides detailed background information not included in the *Watershed Overview* Report. Most of this information was compiled as part of an interim *Summary of Existing Information*, but has been reformatted to compliment the final *Watershed Overview* Report, and provide the source and detail for key background information in the report.

2.0 WATERSHED DESCRIPTION

2.1 WATERSHED BOUNDARIES AND TERMINNOLGY USED IN THIS REPORT

The entire North Fork drainage basin is classified as a 4th field hydrologic unit (or cataloging unit) by the US Geological Survey (USGS). This drainage basin is assigned the 8 digit Hydrologic Unit Code (HUC) 17010301. The term North Fork subbasin (or subbasin) is used in this report to reference the 4th field drainage area. The term Coeur d'Alene River Basin (or basin) will be used to reference the drainage area comprised of three, 4th field HUCs: the North Fork, the South Fork Coeur d'Alene River (HUC = 17010302), and the Coeur d'Alene River proper plus Coeur d'Alene Lake (HUC = 17010303).

The U.S. Forest Service (USFS) has divided the North Fork subbasin into seven, 5th field watersheds with an associated 10 digit HUC (Table 1). When referencing these 5th field watersheds, the convention will be "abbreviated watershed name HUC" (e.g., Upper North Fork HUC). Each 5th field watershed has been further subdivided into 6th field subwatersheds with an associated 12 digit HUC (from two to four subwatersheds per 5th field HUC, Table 1 and Figure 1). The term 6th field HUC will be used when referencing a particular subwatershed in this report. IDEQ used somewhat different boundaries and divisions for their seven, 5th field HUCs used in the *North Fork Subbasin Assessment and TMDL* document (IDEQ, 2001). Unless explicitly specified, this *Technical Appendix* will use the HUC divisions delineated by the USFS.

3.0 CLIMATE AND CLIMATE DATA

This section of the Technical Appendix characterizes the climate within the North Fork Subbasin, describes how climatic conditions vary among the 5th and 6th field HUCs that comprise the subbasin, and describes what climatic data is available.

3.1 CLIMATIC RECORDS

Climatic records are available from several sources within the North Fork subbasin. Data is available through the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) cooperative station network, the Natural Resources Conservation Service (NRCS) snow course and SNOTEL[1] network, and the US Forest Service (USFS) Remote Automated Weather Stations (RAWS) network. Fifteen NOAA Co-op stations (Figure 1, Table 2), three SNOTEL stations (Table 3), 14 snow courses (Table 4), and three RAWS stations (Table 5) are (or were) located within or adjacent to the subbasin. Station inventories for the

[1] for SNOpack TELemetry

NOAA Co-op stations were reviewed. The following summaries of climatic parameters are derived from data available primarily from these stations

Table 1. Watershed, and subwatershed areas within the North Fork Subbasin.

5th-field HUC watersheds delineated by USFS, and (name used in this report)[a]	Area (mi^2)	6th-field HUC subwatersheds delineated by USFS	Area (mi^2)
1701030101: NF Coeur d'Alene River above Tepee Creek (Upper North Fork HUC)	102	170103010101: NF Coeur d'Alene River above Marten Cr	36.5
		170103010102: NF Coeur d'Alene River above Tepee & below Marten Cr	65.3
1701030102: Tepee Creek (Tepee Creek HUC)	144	170103010201: Tepee Cr above Trail Cr	34.7
		170103010202: Trail Cr	29.8
		170103010203: Tepee Cr below Trail Cr	19.4
		170103010204: Independence Cr	59.8
1701030103: Middle NF Coeur d'Alene River above Prichard Creek (Middle North Fork HUC)	123	170103010301: NF Coeur d'Alene River abv Yellowdog Cr & blw Tepee Cr	50.8
		170103010302: NF Coeur d'Alene River abv Prichard Cr & blw Yellowdog Cr	48.5
		170103010303: Lost Cr	24.2
1701030104: Shoshone Creek (Shoshone Creek HUC)	69	170103010401: Shoshone Cr above Falls Cr	41.7
		170103010402: Shoshone Cr below Falls Cr	13.6
		170103010403: Falls Cr	13.9
1701030105: Prichard Creek (Prichard Creek HUC)	98	170103010501: Prichard Cr above Eagle Cr	49.6
		170103010502: Eagle Cr	45.1
		170103010503: Lower Prichard Cr	3.5
1701030106: Lower NF Coeur d'Alene River below Prichard Creek (Lower North Fork HUC)	189	170103010601: Lower NF Coeur d'Alene River below Prichard Cr	85.6
		170103010602: Beaver Cr	42.3
		170103010603: Steamboat Cr	41.8
		170103010604: Cougar Gulch	19.3
1701030107: Little NF Coeur d'Alene River (Little North Fork HUC)	170	170103010701: Little NF Coeur d'Alene River above Cabin Cr	76.4
		170103010702: Little NF Coeur d'Alene River below Cabin Cr	93.8
Entire North Fork Subbasin			**895**

a: 5th field HUC boundaries established by the USFS differ somewhat than the 5th field boundaries and divisions used by IDEQ in their North Fork Subbasin Assessment and TMDL document (IDEQ, 2001). These differences are:

1. Upper North Fork HUC: IDEQ includes Independence Creek, USFS does not
2. Tepee Creek HUC: IDEQ does not include Independence Creek, USFS does
3. Middle North Fork HUC: IDEQ boundary for North Fork River is Yellowdog Creek to Tepee Creek, and does not include Lost Creek where USFS does.
4. Shoshone Creek HUC: IDEQ includes Lost Creek, USFS does not
5. Prichard Creek HUC: IDEQ includes Beaver Creek, USFS does not.
6. Lower North Fork HUC: IDEQ reach for North Fork River is from mouth to Yellowdog Creek. IDEQ does not include Beaver Creek, USFS does.
7. Little North Fork HUC: IDEQ and USFS are the same.

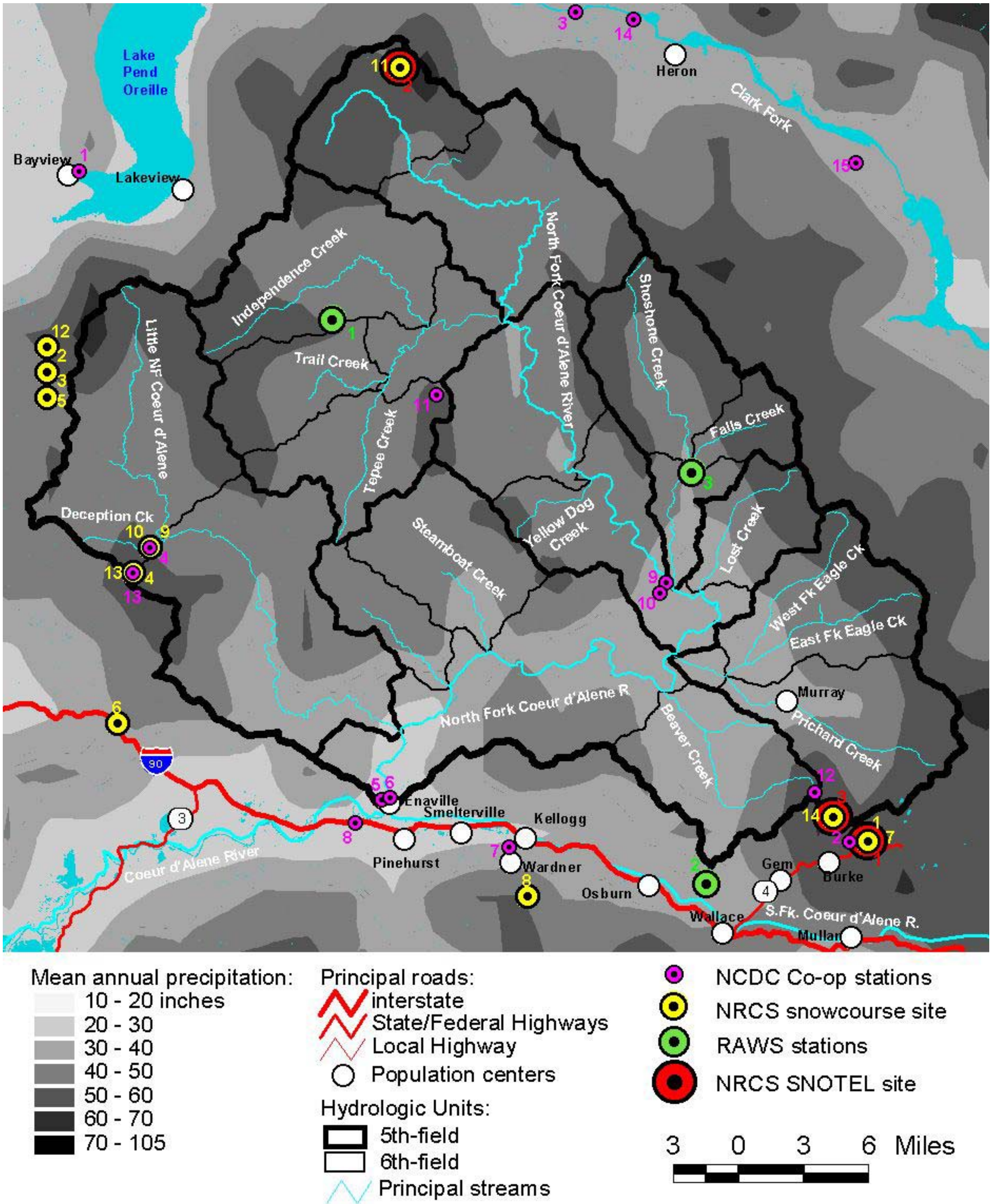

Figure 1. Mean annual precipitation, and locations of climate stations within and adjacent to the North Fork Subbasin.

Table 2. National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) cooperative weather stations within or adjacent to the North Fork Subbasin.

Map Label	Station # / Name	Elevation*	Period of Record	Monthly precipitation	Daily precipitation	Hourly Precipitation	15-minute precipitation	Monthly snowfall	Daily snowfall	Daily snow depth	Daily Min/Max air temp
1	100667: Bayview Model Basin	2,070 - 2,080	8/1948 - Present		X				X	X	X
2	101272: Burke 2 ENE	4,091	8/1948 - 11/1967		X				X	X	X
3	101363: Cabinet Gorge	2,182 - 2,260	11/1956 - Present		X				X	X	X
4	102422: Deception Creek	3,061	9/1936 - 3/1946		X				X	X	X
			8/1948 - 9/1972			X					
5	102966: Enaville	2,103 - 2,123	4/1976 - Present			X	X				
6	102971: Enaville 2	2,402	6/1972 - 3/1976			X	X				
7	104831: Kellogg	2,290 - 2,323	2/1905 - Present		X				X	X	X
8	104951: Kingston Ranger Stn	2,231	5/1/1953 - Present	**							
9	107358: Prichard 4 N	2,485 - 2,495	9/1975 - Present			X	X				
10	107420: Prichard		1/1/1931 - 12/31/1941	X				X			
11	108640: Spyglass Lookout	5,344	7/1/1953 - Present	**							
12	108896: Sunset Lookout	6,424	7/1/1953 - Present	**							
13	109862: Wolf Lodge Summit	4,652	8/1/1948 - 7/31/1950	X		X					
14	244084: Heron 2 Nw	2,240	2/1912 - Present		X				X	X	X
15	246183: Noxon Ranger Stn	2,182	7/1/1956 - Present	**							

Notes: * Stations showing a range of elevations have been moved at least once over the period of record
** NCDC lists these stations, however, they have no information on what data is available

Table 3. Natural Resources Conservation Service (NRCS) SNOTEL stations within or adjacent to the North Fork Subbasin.

map label	Station	Elevation	Period of Record
1	Humboldt Gulch (15B21S)	4,250	Snowpack & Daily Precipitation: 10/1/1981 - Present Min, Mean, Max Daily Air Temperature:10/1/1989 - Present
2	Mosquito Ridge (16A04S)	5,200	Snowpack & Daily Precipitation: 10/1/1981 - Present Min, Mean, Max Daily Air Temperature:10/1/1988 - Present
3	Sunset (15B09S)	5,540	Snowpack & Daily Precipitation: 10/1/1981 - Present Min, Mean, Max Daily Air Temperature:10/1/1989 - Present

Table 4. Natural Resources Conservation Service (NRCS) snow courses within or adjacent to the North Fork Subbasin.

Map label	Snow course	Elev	Period of Record (first-of-the-month measurements)	Status
1	Above Burke (Disc) (15B08)	4,100	1938 - 1991	Discontinued
2	Chilco Ridge (Disc) (16B08)	3,650	1961 - 1991	Discontinued
3	Conie Ridge (Disc) (16B07)	3,900	1961 - 1991	Discontinued
4	Copper Ridge (Disc) (16B02)	4,820	1936 - 1991	Discontinued
5	Corner Creek (16B09)	3,150	1961 - Present	Active
6	Fourth Of July Summit (16B03)	3,200	1923 - Present	Active
7	Humboldt Gulch (Disc) (15B21)	4,250	1961 - 1991	Discontinued; Replaced w/SNOTEL
8	Kellogg Peak (16B05)	5,560	1928 - Present	Active
9	Lower Sands Creek #2 (16B13)	3,120	1961 - Present	Active
10	Lower Sands Creek (Disc) (16B01)	3,120	1936 - 1993	Discontinued
11	Mosquito Ridge (Disc) (16A04)	5,200	1937 - 1996	Discontinued; Replaced w/SNOTEL
12	Sage Creek Saddle (16B06)	4,080	1961 - Present	Active
13	Skitwish Ridge (16B11)	4,850	1961 - Present	Active
14	Sunset (Disc) (15B09)	5,540	1921 - 1998	Discontinued; Replaced w/SNOTEL

Table 5. US Forest Service (USFS) Remote Automated Weather Stations (RAWS) within or adjacent to the North Fork Subbasin.

Map Id	Name	Elevation (ft)	Period of record	Precipitation	Temperature	Dew Point	Relative Humidity	Wind Speed	Wind Gust	Solar Radiation	Fuel Temperature	10 hr Fuel Moisture
1	Magee Peak	4856	9/2001 - Present	X	X	X	X	X	X	X	X	X
2	Nuckols	4000	9/2001 - Present	X	X	X	X	X	X	X	X	X
3	Shoshone Creek	*										

Notes: * Western Regional Climate Center indicates that there is a RAWS station at this location, however, they have no information on what data is available

3.2 PRECIPITATION

Digital maps of mean annual and monthly precipitation are available for the North Fork subbasin from the Oregon Climate Service (OCS, 1998). These maps are based on available precipitation records for the period 1961-1990. The maps were produced using techniques developed by Daly and others (1994), which use an analytical model that combines point precipitation data and digital elevation model (DEM) data to generate spatial estimates of annual and monthly precipitation. As such, these precipitation maps incorporate precipitation data from the local stations shown in Figure 1.

Mean annual precipitation within the North Fork subbasin varies primarily with elevation (Figure 1). Mean annual precipitation ranges from 23 to 67 inches, and averages 46 inches overall for the subbasin (Table 6). The lowest area of precipitation is within the river corridor of the Lower North Fork HUC. The area of highest precipitation occurs in the upper elevations of the Upper North Fork HUC.

Mean monthly precipitation for each 5th field HUC was also estimated using data available from the OCS (1998) (Figure 2). Variation in mean monthly precipitation values are reflected in elevational differences among the HUCs. Mean monthly precipitation is lowest in the month of July for all watersheds, ranging from 1.4 inches in the Lower North Fork HUC to 1.7 inches in the Tepee Creek HUC. December is the month with the highest values of mean monthly precipitation, ranging from 5.4 inches in the Lower North Fork HUC to 6.9 inches in the Upper North Fork HUC (above Tepee Creek).

Table 6. Mean annual precipitation (inches) in the North Fork Subbasin (OCS, 1998).

5th-field HUC as delineated by USFS	6th-field HUC Name	Area-weighted mean	min	max
1701030101: NF Coeur d'Alene River above Tepee Creek	170103010101: NF Coeur d'Alene River above Marten Creek	54	47	67
	170103010102: NF Coeur d'Alene River above Tepee & below Marten Cr	48	39	59
1701030102: Tepee Creek	170103010201: Tepee Cr above Trail Creek	47	45	53
	170103010202: Trail Creek	49	45	55
	170103010203: Tepee Cr below Trail Creek	45	41	49
	170103010204: Independence Creek	49	41	57
1701030103: Middle NF Coeur d'Alene River above Prichard Creek	170103010301: NF Coeur d'Alene River abv Yellowdog Cr & blw Tepee Cr	45	39	61
	170103010302: NF Coeur d'Alene River abv Prichard Cr & blw Yellowdog	43	35	55
	170103010303: Lost Creek	47	37	59
1701030104: Shoshone Creek	170103010401: Shoshone Cr above Falls Creek	51	39	59
	170103010402: Shoshone Cr below Falls Creek	42	37	55
	170103010403: Falls Creek	54	39	59
1701030105: Prichard Creek	170103010501: Prichard Creek above Eagle Creek	47	33	61
	170103010502: Eagle Creek	48	33	61
	170103010503: Lower Prichard Creek	36	35	37
1701030106: Lower NF Coeur d'Alene River below Prichard Creek	170103010601: Lower NF Coeur d'Alene River below Prichard Creek	38	23	53
	170103010602: Beaver Creek	40	33	57
	170103010603: Steamboat Creek	45	33	53
	170103010604: Cougar Gulch	43	31	49
1701030107: Little NF Coeur d'Alene River	170103010701: Little NF Coeur d'Alene River above Cabin Cr	50	43	67
	170103010702: Little NF Coeur d'Alene River below Cabin Cr	43	27	55
Entire North Fork Subbasin		**46**	**23**	**67**

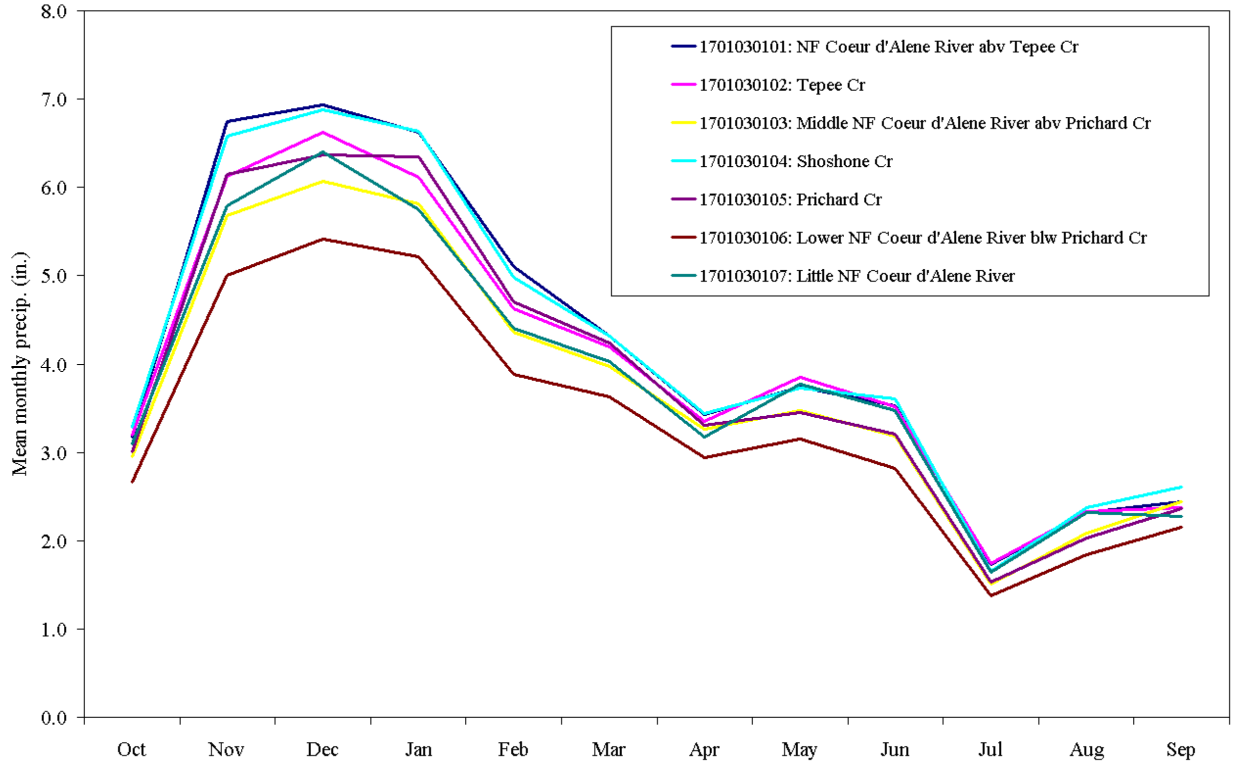

Figure 2. Mean monthly precipitation by 5th-field HUC within the North Fork Subbasin (OCS, 1998).

Year-to-year variability in precipitation was assessed using the long-term record from the Kellogg NCDC weather station (WRCC, 2005; Table 2, Figure 1). The Kellogg station has the longest continuous period of record for precipitation of any station in the vicinity of the North Fork subbasin. Total monthly precipitation data[2] were used to calculate total precipitation and by water year[3] (Figure 3).

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[2] Missing values in the Kellogg record were estimated using values from the nearby Wallace (POR 1907-1962) and Wallace Woodland Park (POR 1948-2003) stations, located approximately 11 miles ESE of the Kellogg station:

Monthly Precip (in.) @ Kellogg $= -0.008P_{Wallace}^2 + 0.6841P_{Wallace} + 0.3539$; $r^2 = 0.8417$

$= -0.0207P_{Wallace\ Woodland}^2 + 0.8747\ P_{Wallace\ Woodland} + 0.1323$; $r^2 = 0.8422$

[3] Water year is defined as October 1 through September 30. The water year number comes from the calendar year for the January 1 to September 30 period. For example, Water Year 1990 would begin on October 1, 1989, and continue through September 30, 1990. This definition of water year is recognized by most water resource agencies.

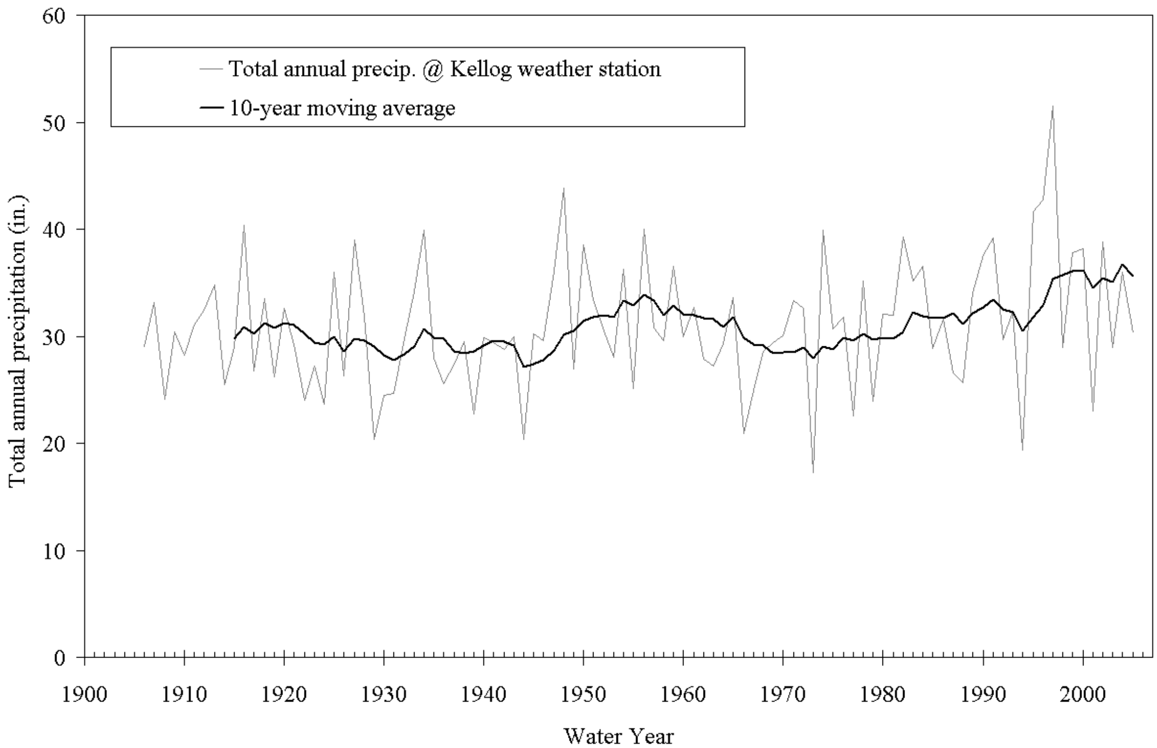


Figure 3. Annual precipitation record for the Kellogg weather station (WRCC, 2005).

The two primary patterns of climatic variability that occur in the Pacific Northwest are the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). The two climate oscillations have similar spatial climate fingerprints, but very different temporal behavior; PDO events persist for 20-to-30 year periods, while ENSO events typically persist for 6 to 18 months (Mantua, 2001). Several studies (Mantua *et al*., 1997; Minobe, 1997; and Mote *et al*., 1999) suggest that five distinct PDO cycles have occurred since the late 1800's:

1. 1890-1924 (cool/wet)
2. 1925-1946 (warm/dry)
3. 1947-1976 (cool/wet)
4. 1977 –1995 (warm/dry)
5. 1995–present (cool/wet)

The long-term precipitation record available for the Kellogg weather station was used to evaluate whether or not local trends follow the documented PDO cycles. These data were processed as follows:

1. The mean and standard deviation was calculated for annual precipitation in each zone over the period of record.

2. A standardized departure from normal was calculated for each year by subtracting the mean annual precipitation from the annual precipitation for a given year, and dividing by the standard deviation.

3. A cumulative standardized departure from normal was then calculated by adding the standardized departure from normal for a given year to the cumulative standardized departure from the previous year (the cumulative standardized departure from normal for the first year in a station record was set to zero).

This approach of using the cumulative standardized departure from normal provides a way to better-illustrate patterns of increasing or decreasing precipitation over time by reducing year-to-year variations in precipitation, thus compensating for the irregular nature of the data set. Values for the cumulative standardized departure from normal increase during wet periods and decrease during dry periods.

Results for the Kellogg station are given in Figure 4. Precipitation patterns from the Kellogg station do not follow the regional trends discussed above. There appears to have been a warm/dry period from at least the early 1900's that lasted until approximately 1946 (Figure 4). A short cool/wet phase followed from 1946 to approximately 1961, followed by a short warm/dry phase up until the early 1970's. We appear to still be in the cool/wet phase that began in the 1970's.

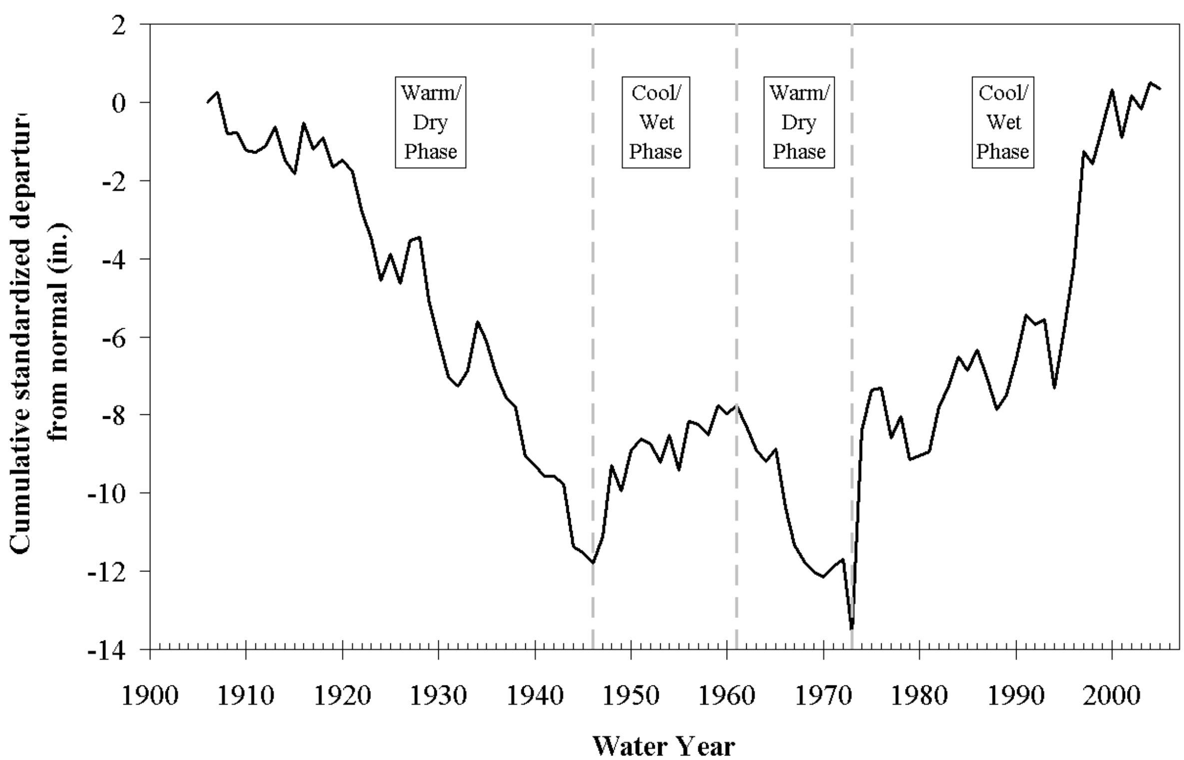


Figure 4. Cumulative standardized departure from normal of annual precipitation for the Kellogg weather station. Local PDO cycles are shown as vertical dashed lines

3.3 AIR TEMPERATURE

The longest-term air temperature record in the vicinity of the North Fork subbasin is from the Kellogg weather station (Figure 5). Mean monthly air temperature data were used to calculate mean annual air temperature values by water year. Ten-year moving average values show trends in annual air temperatures that are consistent with the local PDO cycles illustrated in Figure 4.

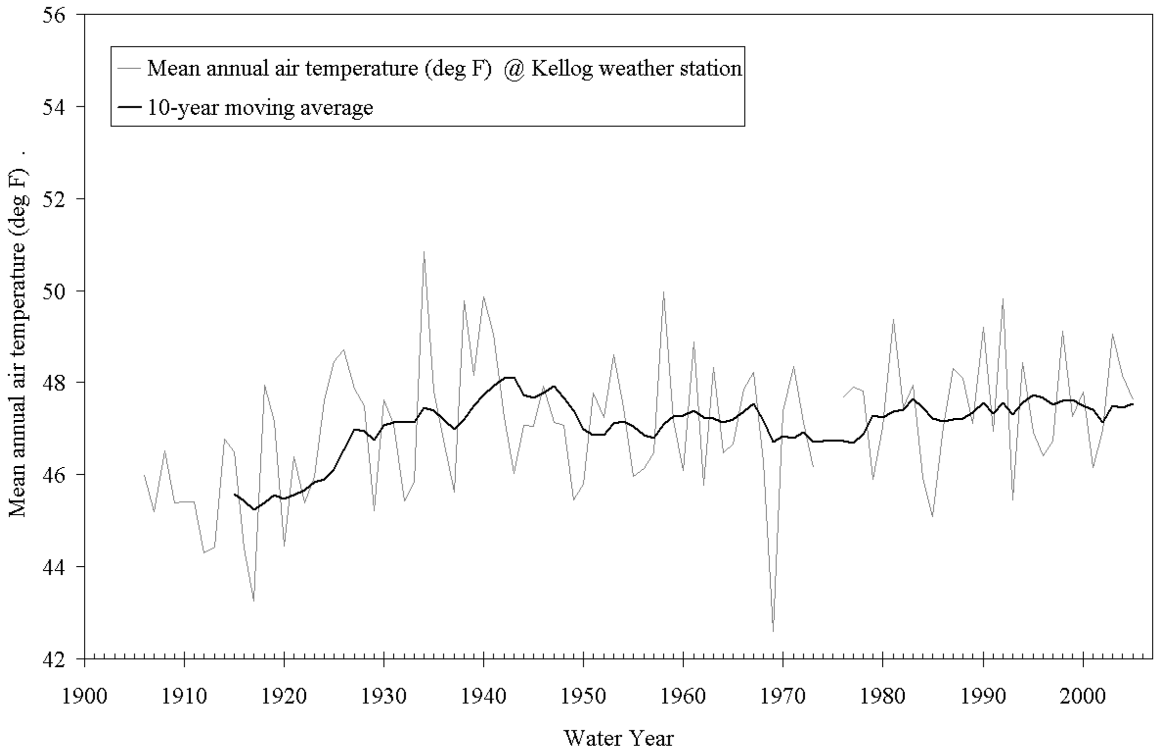


Figure 5. Mean annual air temperature over the period of record at the Kellogg weather station (WRCC, 2005).

Monthly air temperatures vary with season and elevation. Records from the Kellogg weather station is representative of lower elevation conditions within the North Fork subbasin, while the Mosquito Ridge SNOTEL site is perhaps representative of higher elevational portions of the subbasin (Figure 6). Minimum air temperatures occur in the months of December and January, and maximum temperatures occur in the months of July and August. Temperature fluctuations are greatest at the lower elevation Kellogg station. This may be due to the longer period of record for the Kellogg station (1905-present; Table 2) as compared to the Mosquito Ridge site (1988 – present; Table 3) which covers a period of apparently increasing air temperatures (Figure 5).

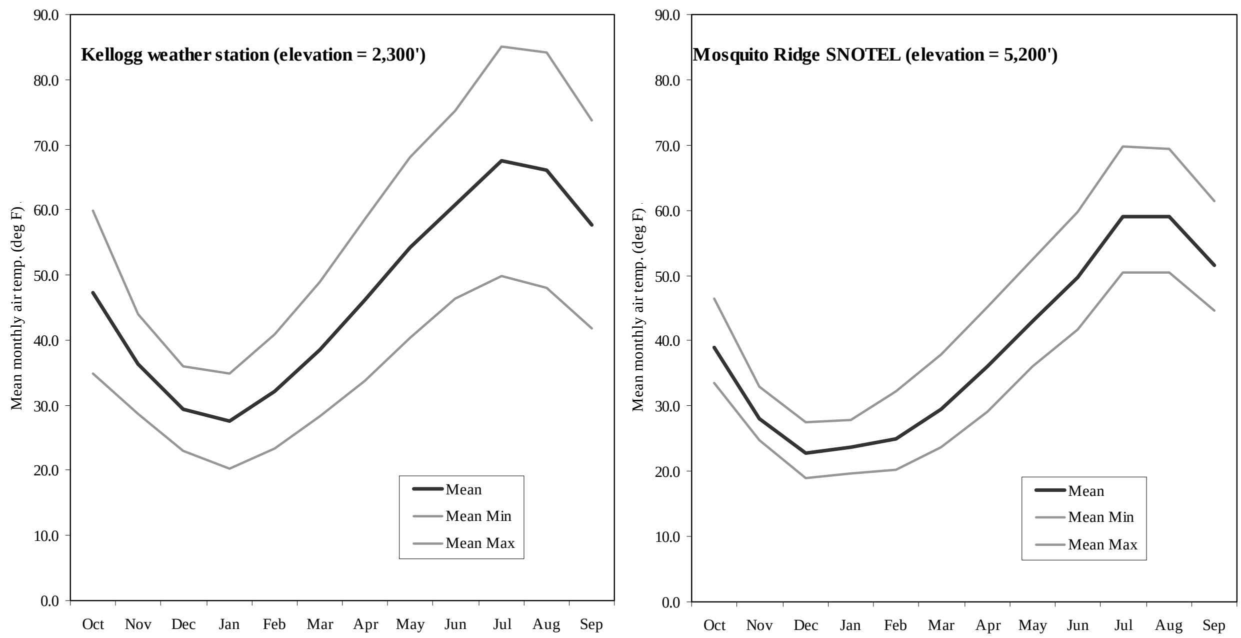


Figure 6. Mean monthly, mean minimum monthly, and mean maximum monthly air temperatures at the Kellogg weather station (left chart) and Mosquito Ridge SNOTEL (right) (WRCC, 2005; NRCS, 2005).

3.4 SNOWPACK

Data on snowpack[4] are available from several stations in the vicinity of the North Fork subbasin (Figure 1, Table 3, Table 4). A snowpack is generally in place from October to July in the higher elevation areas of the subbasin, reaching its maximum depth during the months of March and April (Figure 7). Snowpack is generally proportional to elevation, however, snowpack decreases from west to east across the subbasin (see Figure 7, Mosquito Ridge and Sunset stations), and is probably proportional to annual precipitation (Figure 1).

[4] Depth of snow on the ground, expressed in terms of snow water equivalent or SWE

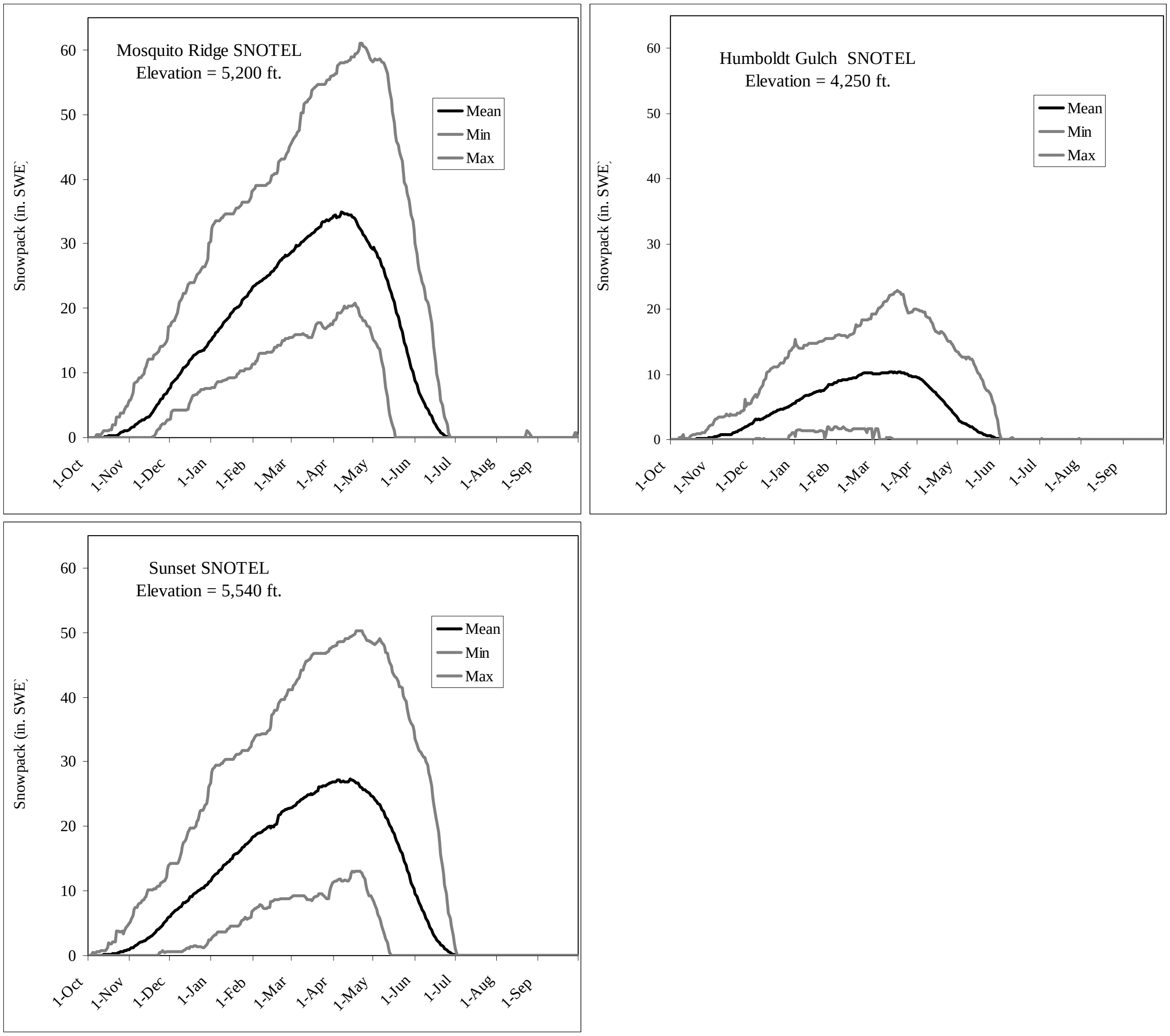


Figure 7. Mean, minimum and maximum snowpack (in inches of snow-water equivalent) at three climate stations in the vicinity of the North Fork Subbasin. Refer to Figure 1 and Table 3 for location and data availability.

4.0 HYDROLOGY

The purpose of this section of the *Technical Appendix* is to: 1) describe what hydrologic data is available for the North Fork Subbasin, 2) characterize the hydrologic regime within the subbasin, with specific emphasis on the peak-flow generating processes in the area, 3) describe how hydrologic conditions vary among the 5th and 6th field HUCs that comprise the subbasin, and 4) characterize the peak flow history within the subbasin.

4.1 HYDROLOGIC RECORDS

The US Geological Survey (USGS) identifies six stream gages within the North Fork subbasin (Figure 8, Table 7). In addition, the US Forest Service (USFS) has operated 5 gages within the subbasin, with an additional two gages (Maries Creek and Upper Wolf Lodge Creek) located immediately west of the subbasin divide (Figure 8, Table 7). Of the five USGS gages, only two are currently active (#12411000, NF Coeur d'Alene River above Shoshone Ck; #12413000, NF Coeur d'Alene River at Enaville). The remaining three USGS gages all have a very short period of record, and are likely to be of very limited utility for any modeling efforts that may occur as part of this present study. Six of the seven USFS stream gages are currently active; the exception being the Shoshone Creek gage which was discontinued in 1996 following a large storm event which damaged the gage.

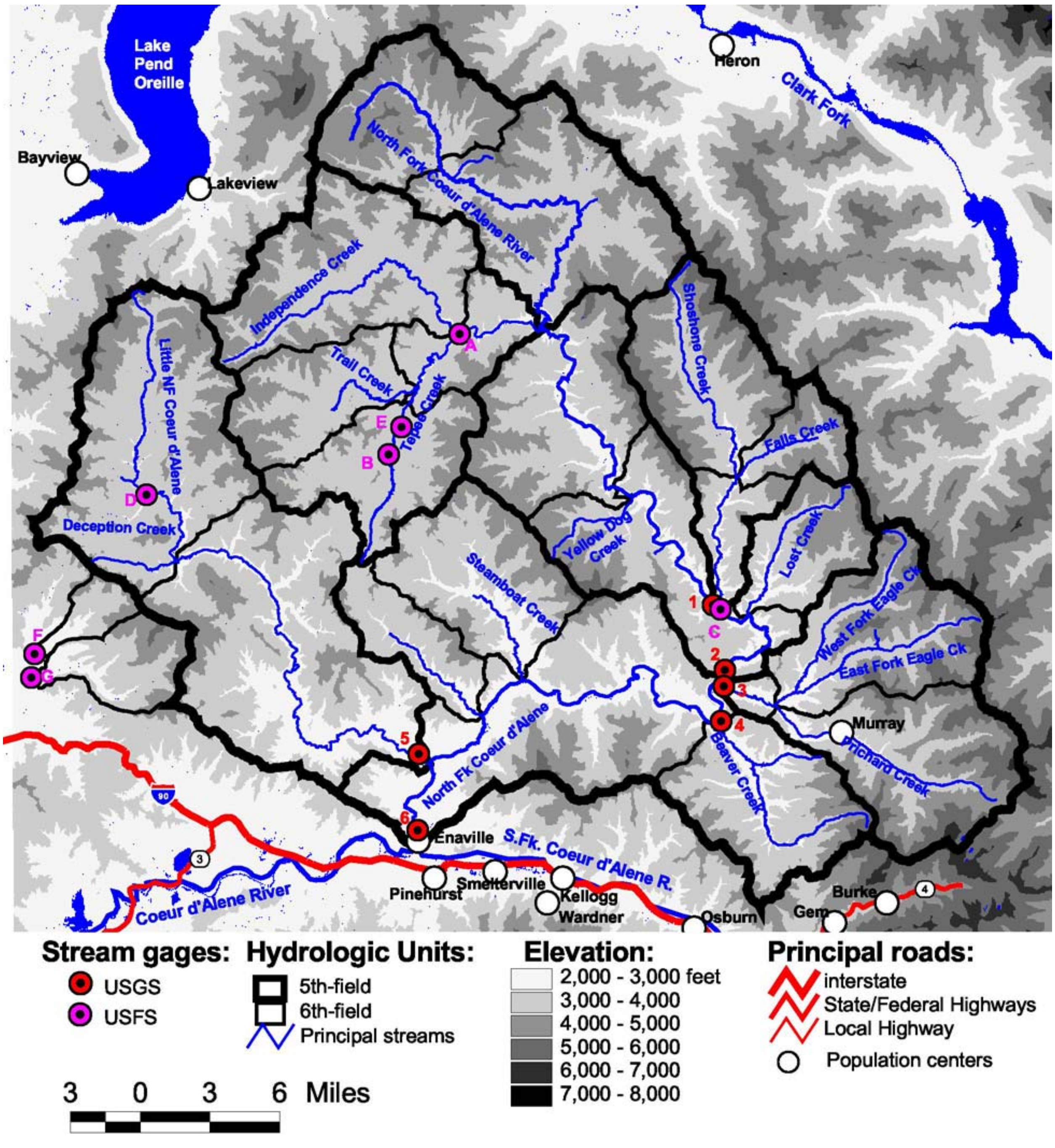


Figure 8. Stream gages within and adjacent to the North Fork Subbasin.

Table 7. USGS and USFS stream gages in the North Fork Subbasin

Map label	Station	Drain. area (mi²)	Elev. at gage (ft)	Period of Record	Agency
1	12411000: NF Coeur d'Alene R Above Shoshone Ck Nr Prichard	335	2,485	10/1/1950 - Present	USGS
2	12411500: Coeur d'Alene River at Prichard (no longer active)	441	2,403	10/23/1911 - 9/30/1914	USGS
3	12411935: Prichard Ck at Mouth (no longer active)	53	2,400	10/1/1998 - 9/30/2002	USGS
4	12412000: Coeur d'Alene R near Prichard (no longer active)	583	2,360	8/28/1944 - 9/30/1953	USGS
5	12412500: Little NF Coeur d'Alene near Enaville (no longer active)	170	2,180	10/23/1911 - 12/31/1912	USGS
6	12413000: NF Coeur d'Alene R at Enaville	895	2,100	10/1/1939 - Present	USGS
A	Independence Creek	60	2,880	1982 to Present	FS
B	Big Elk Creek	11.6	3,100	1988 to Present	FS
C	Shoshone Creek (no longer active)	69	2,490	1982- 1997	FS
D	Little NF Coeur d'Alene River	44	2,870	2001 to Present	FS
E	Halsey Creek	4.8	3,080	1982 to Present	FS
F	Upper Wolf Lodge Creek (west of the subbasin)	7.2	2,300	1995 to Present	FS
G	Marie Creek (west of the subbasin)	17.7	??	1995 to Present	FS

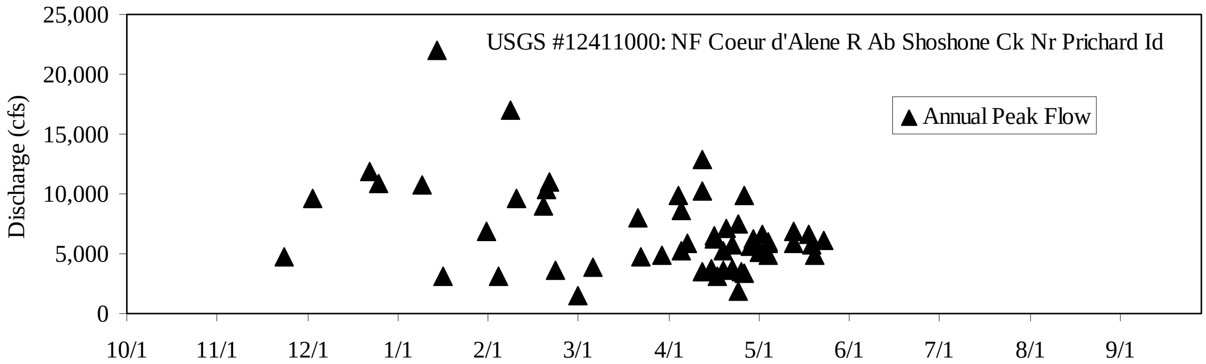
Note: The USFS also maintains 5 crest gages in addition to the continuous water level recorders noted above, however, the locations of these gages and period of record is unknown at this time.

4.2 Hydrologic Regime

As described in the climate section above, the North Fork subbasin is influenced by both moist maritime air masses moving east from the Pacific Ocean, and cold continental air masses moving south from Canada, with the majority of the subbasin being located within the rain-on-snow[5] (ROS) zone, which locally occurs in the 3,300-4,500 foot elevation range (IDEQ, 2001). Snow pack is transitory below the ROS zone, while in higher elevations snowpack is generally resistant to significant melting during winter storm events.

The mean daily flow record at the USGS gage site, North Fork Coeur d'Alene River above Shoshone Creek (Figure 9; bottom graph), illustrates overall hydrologic conditions within the North Fork subbasin. Mean daily flows fluctuate early in the winter in response to ROS events, however, the highest mean daily flows occur during the spring snowmelt season (April-June). Flows steadily decline with diminishing snowpack during the late spring and early summer, reaching their lowest levels prior to the beginning of fall rains. An examination of annual peak flows at the gage (Figure 9; top graph) indicates that approximately half of the annual peaks occur during the spring snowmelt season, and the remainder during the winter ROS season. The two largest events at the gage (1/15/1974 and 2/9/1996) were regionally significant ROS events. The pattern appears to be similar in the tributary streams (e.g., Independence Creek, Figure 10). Graphs of all gages found in and adjacent to the North Fork subbasin are given in Appendix 1.

[5] Rain-on-snow is the common term used to describe wintertime conditions when relatively warm wind and rain combine to produce rapid snow melt



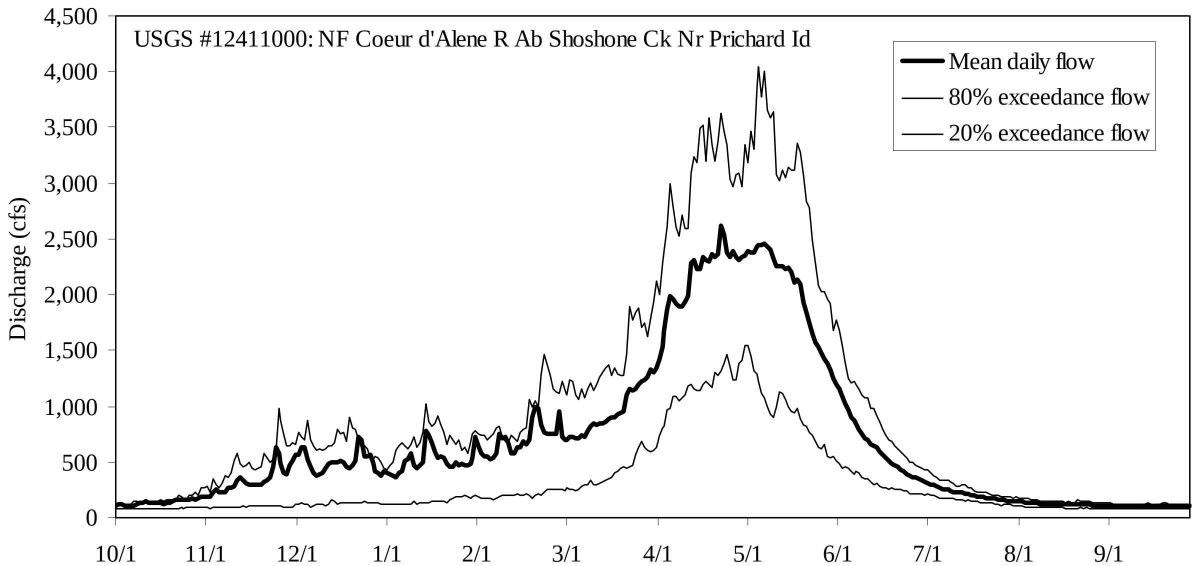


Figure 9. Mean daily flow (bottom) and annual peak flows (top) at USGS gage # 12411000, North Fork Coeur d'Alene River above Shoshone Creek near Prichard Idaho (mean daily flows are averaged over the period December 1950 to September 2006). 20% and 80% exceedance flow are mean daily flows that have been exceeded 20% and 80% of the time for the designated period.

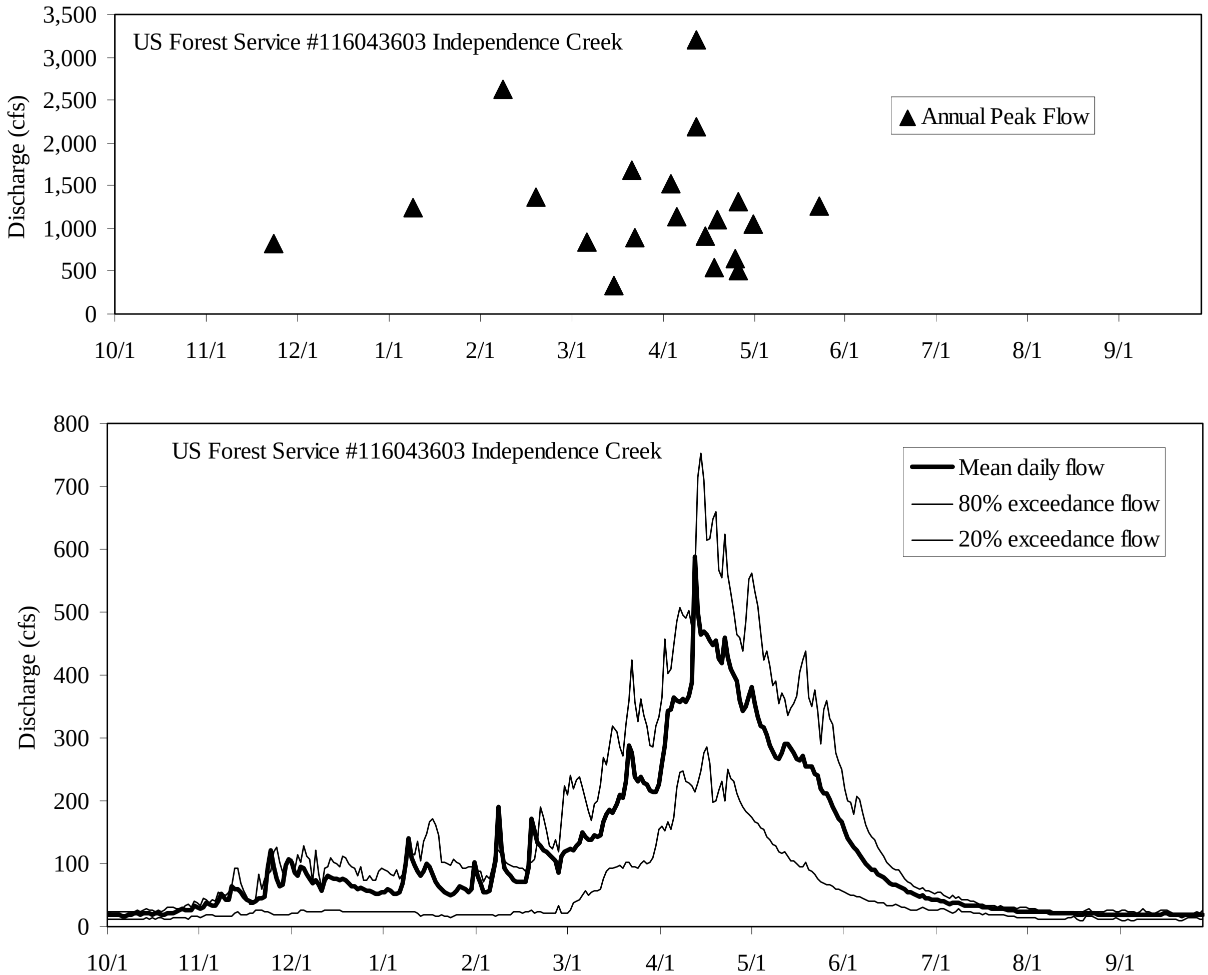


Figure 10. Mean daily flow (bottom) and annual peak flows[6] (top) at USFS Independence Creek gage (mean daily flows are averaged over the period 1982 to 2006). 20% and 80% exceedance flow are mean daily flows that have been exceeded 20% and 80% of the time for the designated period.

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[6] Annual peak flows at the USFS gages are mean daily flow values. Instantaneous peak flow values were not provided in time for this report.

4.3 FLOOD HISTORY

A time series of annual flood peaks was assembled for the two long-term USGS gages within the North Fork subbasin. The long-term annual peak flow history provides context to recent channel disturbances (or lack thereof) observed throughout the area. For purposes of comparison, the data are presented as a time series showing the recurrence interval of the annual flow event (Figure 11). This approach allows for a comparison of events from a wide variety of watershed sizes. Recurrence intervals were calculated for the period of record at each gage station using techniques described by the Interagency Advisory Committee on Water Data (1982). Peak flow magnitude was next plotted against probability (i.e., 1/recurrence interval) on log-probability paper. Recurrence interval was then interpolated for each event from the plotted values.

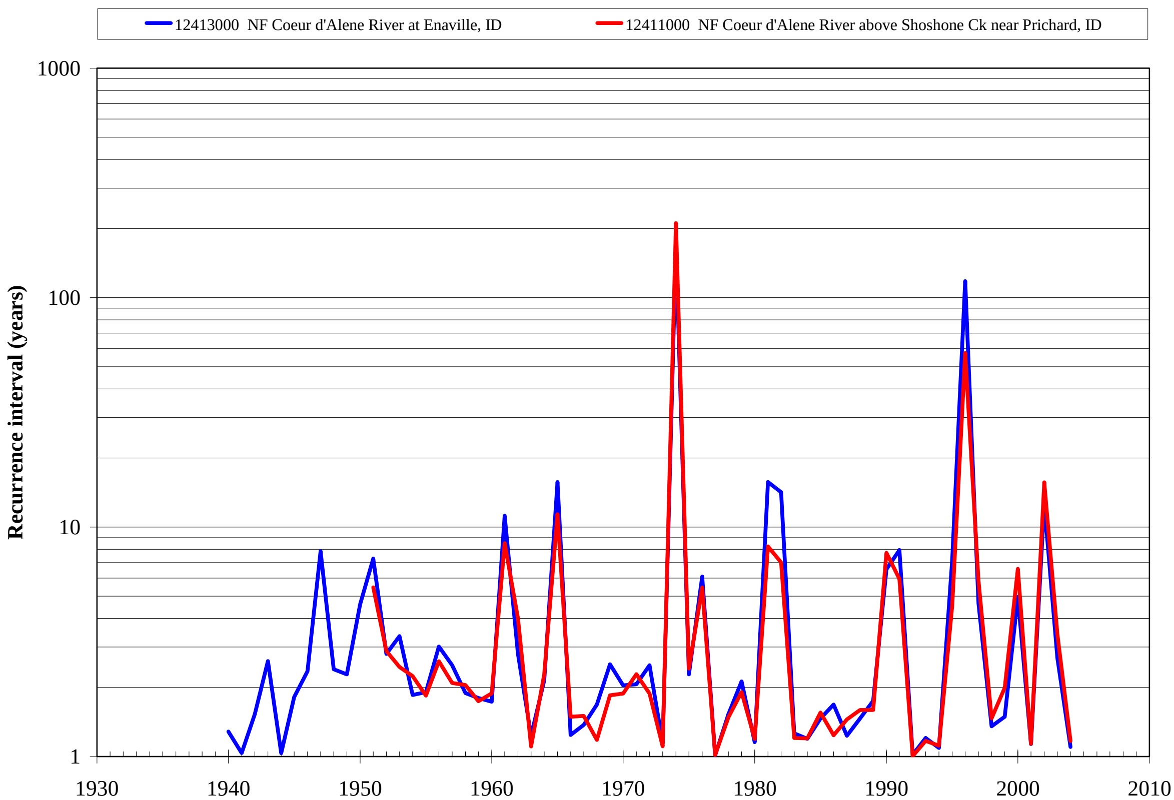

Figure 11. Recurrence interval associated with annual peak flow events at two stream gages in the North Fork Subbasin (USGS, 2005).

The two gages presented in Figure 11 both present a similar peak flow response. This is not surprising given that both are located on the mainstem of the North Fork River. Based on the record presented in Figure 11, it appears that the later half of the record (from the early 1970s to present) saw many larger peak flow events than the earlier half of the record. Note that this period of greater peak flow activity coincides with the cool/wet PDO cycle that began in the North Fork area in ~1973 and continues to present (Figure 4).

5.0 HYDROLOGIC ISSUES IDENTIFIED / REVIEW OF HYDROLOGIC STUDIES

Studies pertaining to hydrologic issues within the North Fork subbasin were reviewed and are summarized below.

5.1 NORTH FORK SUBBASIN ASSESSMENT AND TMDL (IDEQ, 2001)

The North Fork TMDL addressed water-quality limited stream segments within the subbasin for sediment and metals. Several streams segments were on the 1994/96 and 1998, Idaho §303(d) list as water quality limited due to "flow alteration", specifically, adverse changes in the magnitude of flood flows. These segments include the mainstem of the North Fork River from the mouth upstream to the confluence with Tepee Creek, the Little North Fork CdA River above Laverne Creek, and Steamboat Creek (Figure 12). IDEQ and EPA have made an agreement that "flow alteration" (and "habit alteration") are not specifically listed as a definition of "pollutant" in §502(6) of the Clean Water Act, and therefore TMDL calculations and allocations reported by IDEQ do not address flow alteration per se (IDEQ, 1998). Never-the-less, channel impairment and excess sediment load related to peak flow velocity and flood flows remain as an issue to be examined, and remediated where warranted. The issues of flow alteration were discussed in the narrative of the IDEQ TMDL (IDEQ, 2001).

Section 2.3.2.1.1 of the North Fork TMDL attempts to address the concerns of increased peak flow magnitudes in the subbasin by comparing the magnitude of the largest regionally significant peak flow on record, the peak flow of January 1974, with the second largest peak flow on record, the flood of February 1996. Because the 1996 flood was of a smaller magnitude then the 1974 event the authors conclude that peak flow events have not been significantly affected by land use practices in the North Fork subbasin. Given that peak flow magnitude is driven by climate conditions during and immediately preceding the storm event, and given the complete lack of any analysis as to what these conditions were, the analysis presented in no way supports this claim. These results are cited in subsequent sections of the document to support the claim of no management-related impacts on peak stream flow. This conclusion can not be made based on the analysis presented.

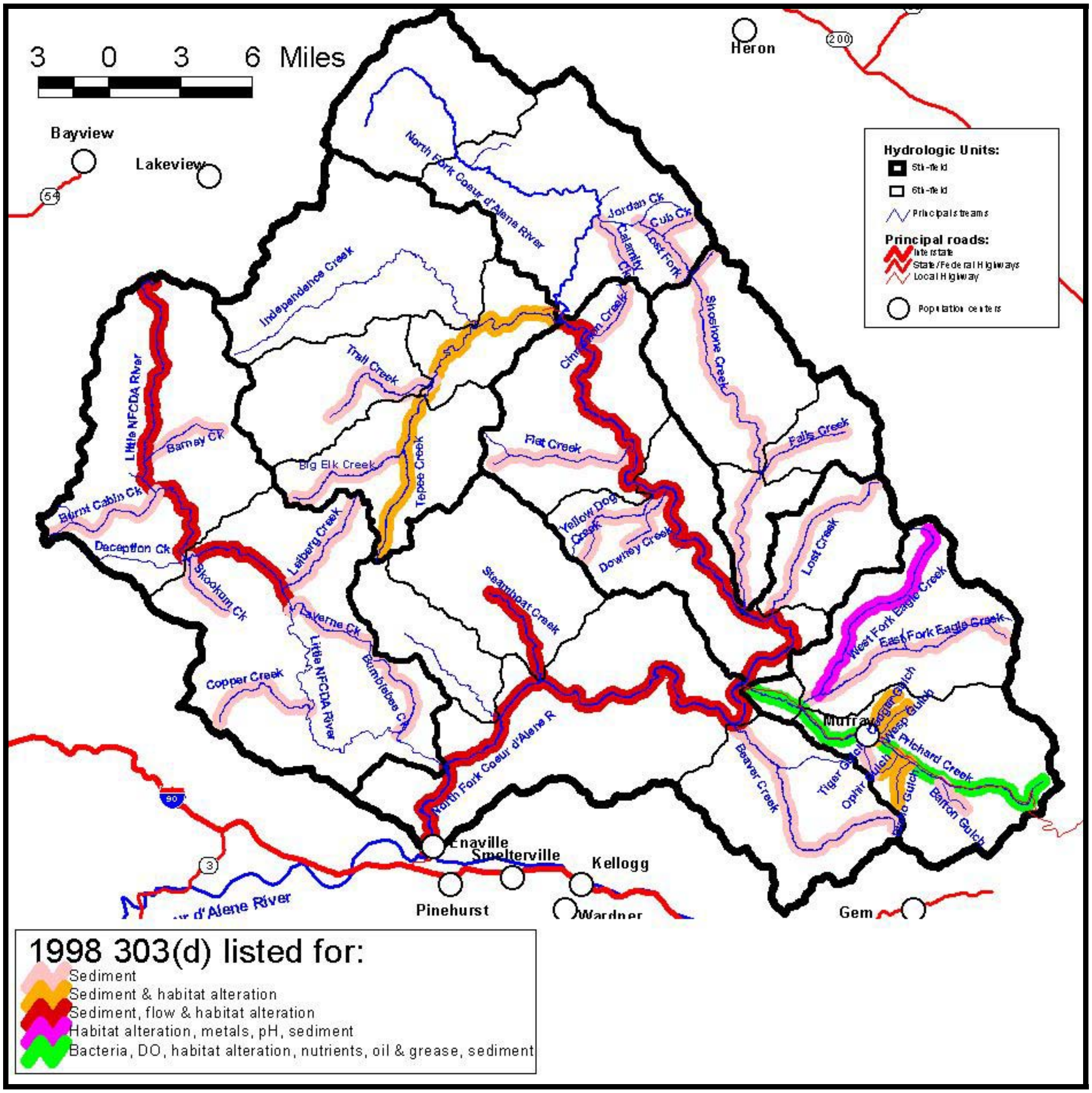

Figure 12. Water quality limited streams in the North Fork Subbasin.

Section 2.3.2.5.3 of the report describes potential mechanisms for sediment production and delivery in the North Fork subbasin. These potential mechanisms are driven in part by management-related changes in hydrology, which can result in more erosive force being applied to stream banks, and increased stream power leading to increased sediment transport. The mechanisms discussed are:

- Vegetation alterations. The authors discuss how vegetation removal can lead to decreased evapotranspiration, resulting in increased soil moisture levels, and the potential for increased base flows. Given that this process affects primarily summertime base flows the impact on peak flows (which occur during the winter or spring snowmelt periods) is probably negligible.

  The authors go on to discuss how removal of overstory vegetation can result in increased snow accumulation, and reduced wintertime melt due to higher radiational cooling rates when a canopy is absent. This increased snowpack is then susceptible to more rapid melt during rain on snow events due to the potential for higher surface wind speeds. The authors discuss how this has the potential to augment peak flow events (i.e., deeper snowpack available for melt, higher wind speeds at the snow surface), but dismiss this as a significant factor in the subbasin because the proportion of watershed area that is devoid of overstory vegetation is roughly comparable to natural fire openings that occurred prior to the practice of fire suppression. This may be a reasonable conclusion at the subbasin scale, however, more analysis seems warranted given that forest harvest appears to be more heavy in some 5th field HUCs and 6th field HUCs.

- Road drainage / channel extension: The authors discuss how interception of shallow groundwater by road cuts and drainage ditches has the potential to change flow pathways. If ditches are well-connected to the stream channel system this can result in increased drainage efficiency and potentially larger peak flows, assuming that flows become more and not less synchronized across the landscape. The authors conclude that this process may significantly increase flood peaks in small drainages, however, it is unlikely to be significant at the subbasin scale. Given the extremely dense network of roads in some portions of the North Fork subbasin, this question seems to warrant further investigation.

Additional mechanisms are discussed (or alluded to) that have the potential to change peak flow magnitudes in the subbasin. These include:

- Stream channelization and road dikes (which has occurred along the mainstem North Fork River) has cutoff many side channel areas, and disconnected the channel from its floodplain. In addition to eliminating sediment storage areas, this process may also be increasing runoff efficiency by shortening flow paths and reducing bank, side channel, and floodplain storage of floodwaters.

- Direct removal of instream Large Woody Debris (LWD), and loss of LWD inputs due to removal of forested riparian stands, has resulted in loss of channel complexity, which may further increase runoff efficiency during flood events.

- The legacy effects of splash dams and log drives may be an additional factor that has resulted in loss of channel complexity and increased runoff efficiency.

Again, IDEQ policy does not recognize flow alterations as quantifiable, and therefore, TMDLs were not developed for this parameter. Many of the improvement projects discussed elsewhere in this report, while primarily intended to address sediment inputs, have the secondary effect of improving flow conditions. For example, projects designed to obliterate forest roads for the purpose of decreasing sediment production will also result in disconnecting road drainage ditches from the stream channels, and will (over time) restore forest overstory.

Summary: Many of the public comments included in Section 4 of the North Fork TMDL report (Comments #55, 72, 73, 74, 77, 79, 81,85, 86, 104, 108, 110, 127, 129) question the impacts of land management on peak flow response, and in every case the response to the comment is to refer to the analysis included in section 2.3.2.1.1. This analysis of hydrologic change does not support the conclusion that peak flows have been unaffected by land management activities. The authors of the report have based their conclusion of no impact on an analysis of the three largest regional flood events, an analysis that has not considered weather conditions during or immediately preceding the events. Furthermore, no analysis is provided as to changes in the smaller, more frequent flood events, despite the fact that the majority of sediment in a river system may be moved by the dominant, or channel-forming discharge (i.e., events having a recurrence interval of 1-2 years; Knighton, 1984). The authors of the TMDL do acknowledge that hydrologic impacts may be present in smaller subwatershed areas, and discuss how these impacts may be lost at the subbasin scale due to desynchronization of flows, conclusions that are generally supported by the literature (see for example Moore and Wondzell, 2005). The authors also acknowledge that channel filling may lead to increased over-bank flooding, which may result in the perception that peak flow magnitudes have been increased due to land management.

5.2 COEUR D'ALENE RIVER COOPERATIVE RIVER BASIN STUDY (SCS, 1994)

This study was intended to determine sediment levels in the Coeur d'Alene River from various land uses, evaluate flooding, evaluate bedload movement, and to identify water quality solutions. It was geared toward the development of a Lake Management Plan for Lake Coeur d'Alene. The major conclusions with respect to hydrologic change are that clearcut logging and high road densities of forest roads has resulted in: 1) an increase in the frequency and magnitude of flooding during rain-on-snow events, 2) a change in the magnitude and timing of spring snowmelt and associated peak flows, and 3) a decrease in summer base flows.

Although the study contains some very useful information on bank erosion (based on an analysis of a time series of aerial photos), and a good peak flow history at the Basin and Subbasin scale, the conclusions on harvest and road-related changes in hydrology appear to be unfounded. These conclusions appear to be completely based on a visual comparison of hydrographs (normalized for drainage area) for two rain-on-snow events and for one-year's spring runoff period at the Halsey and Big Elk USFS stream gages (see Table 7 and Figure 8). Although the more heavily-harvested Big Elk Creek shows higher unit-area discharges, there is no analysis of pre- vs. post-treatment data. Given probable differences in basin characteristics (e.g., soils, physiography, aspect, etc) it is not possible to conclude any management-related impacts from the analysis presented.

5.3 HYDROLOGICAL AND GEOMORPHIC RESPONSES TO FOREST MANAGEMENT IN NORTH IDAHO (DANIELE *ET AL*., DRAFT).

This study takes a further and more detailed look at rain-on-snow related peak flow changes due to forest removal. This study also takes place in the Halsey and Big Elk tributaries within the Tepee Creek HUC, and uses data from the two USFS stream gages available (see Table 7 and Figure 8). This study is not a true paired watershed study in that there is no pre-treatment period during which the hydrologic response of the two watersheds can be established. However, the authors calibrate a hydrologic model (HEC1; HEC, 1981) and a snowmelt model (UEB; Tarboton and Luce, 1996) to local conditions, and show (through comparison to observed stream flows) that the modeled flows reasonably approximate observed flows. Results of the model show an increase in rain-on-snow peak flows of as much as 28% in a logged watershed as compared to an non-harvested condition.

This study may provide a reasonable approach to evaluating possible peak flow impacts at larger scales throughout the North Fork subbasin. Shortcomings of this approach are that it only evaluates peak flow changes due to forest removal; road drainage, impervious surface, and other impacts are not evaluated, nor are impacts to base flows. This document is currently in draft form; consequently the data quality is rated as only moderate – it is expected that the data quality will be high following peer review and publication

5.4 MICA CREEK WATERSHED STUDY

In 1990 Potlatch Corporation began a forest watershed study in the Mica Creek watershed, located approximately 25 miles south of Enaville on the Saint Joe River subbasin (Chen *et al*., 2005). The purpose of the study is to assess the effectiveness of the Idaho forest practice rules in protecting water quality. Detailed hydrological, meteorological, water quality, biological, and channel data have been developed for the study area. Several watershed models are being calibrated and validated for the area including:

- Watershed Analysis Risk Management Framework (WARMF; Chen *et al*., 2001)
- Hydrologic Simulation Program Fortran (HSPF; Bicknell *et al*., 1997)

These models were independently applied to the Mica Creek watershed. The authors concluded that the WARMF model was suitable for application to forested watersheds, and successfully predicted stream flows comparable to measured values. The authors concluded that, while the HSPF results were reasonable, the HSPF model was more difficult to apply. It is not clear if either model is sufficiently robust to account for possible road drainage effects. Future studies are planned to calibrate and evaluate the Distributed Hydrology, Soils and Vegetation Model (DHSVM; discussed below).

5.5 VARIOUS APPLICATIONS OF THE DISTRIBUTED HYDROLOGY, SOILS, VEGETATION MODEL (DHSVM)

The Distributed Hydrology, Soil Vegetation Model (DHSVM) is a distributed hydrologic model originally developed to evaluate the effects of topography and vegetation on water movement through a watershed (Wigmosta *et al*., 1994). Spatially distributed models such as DHSVM provide a dynamic representation of the spatial distribution of soil moisture, snow cover, evapotranspiration, and runoff production, at the scale of digital elevation model (DEM). DHSVM has been used to assess changes in flood peaks due to enhanced rain-on-snow and spring radiation melt response (e.g., Thyer *et al*., 2004), effects of forest roads and road drainage (e.g., Lamarche and Lettenmaier, 2001), and the prediction of sediment erosion and transport (Doten and Lettenmaier, 2004).

5.6 RECOMMENDED APPROACH TO ANALYZING HYDROLOGIC ISSUES

Given the legitimate concerns (summarized above) that hydrologic change issues were not adequately addressed in the North Fork TMDL (DEQ, 2001), it seems reasonable that the next phase of the analysis should include an assessment of hydrologic change. Simple lumped parameter models, such as the Washington State DNR hydrologic change model[7] are probably inadequate in that they do not account for multiple management effects (e.g., timber harvest, road drainage), and only evaluate rain-on-snow peak flows (i.e., no evaluation of spring snowmelt peaks). It is our opinion that the DHSVM model would provide the most robust analysis of potential forest-management related impacts, however, further investigation into to applicability of the WARMF model may be warranted.

Analysis should focus on those areas where continuous stream flow records are available (Table 7, Figure 8). The subwatersheds having gage records appear to encompass a wide range of road densities, harvest and fire history; and cover a wide range of drainage area, which will allow extrapolation of the results to other non-gauged portions of the analysis area.

6.0 GEOLOGY/SEDIMENT SOURCES

6.1 GEOLOGY AND SOILS

The North Fork subbasin is underlain by rocks of the Belt Supergroup (Figure 13, Lewis *et al*., 2002, Munts, 2000, Lewis and Derkey, 1999). The Belt Supergroup includes very old metamorphic rocks of the Libby, Striped Peak, Wallace, Revett, and Burke formations. These units were originally deposited as sediments during the Proterozoic period, approximately 1-1.5 billion years ago, and included silt, sand, and minor amounts of dolomite. The sedimentary rocks were buried, subjecting them to heat and pressure of metamorphosis, and changing them into argillite, siltite, and quartzite. Following metamorphosis, the rocks were uplifted and faulted to form the present Bitterroot and Coeur d'Alene mountain ranges. Rivers and streams have cut deep valleys into the mountain range, and deposited thick layers of cobble and gravel alluvium in the wider mainstem valleys.

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[7] See Section C of the WDNR watershed Analysis Manual, available on-line at http://www.dnr.wa.gov/forestpractices/watershedanalysis/manual/

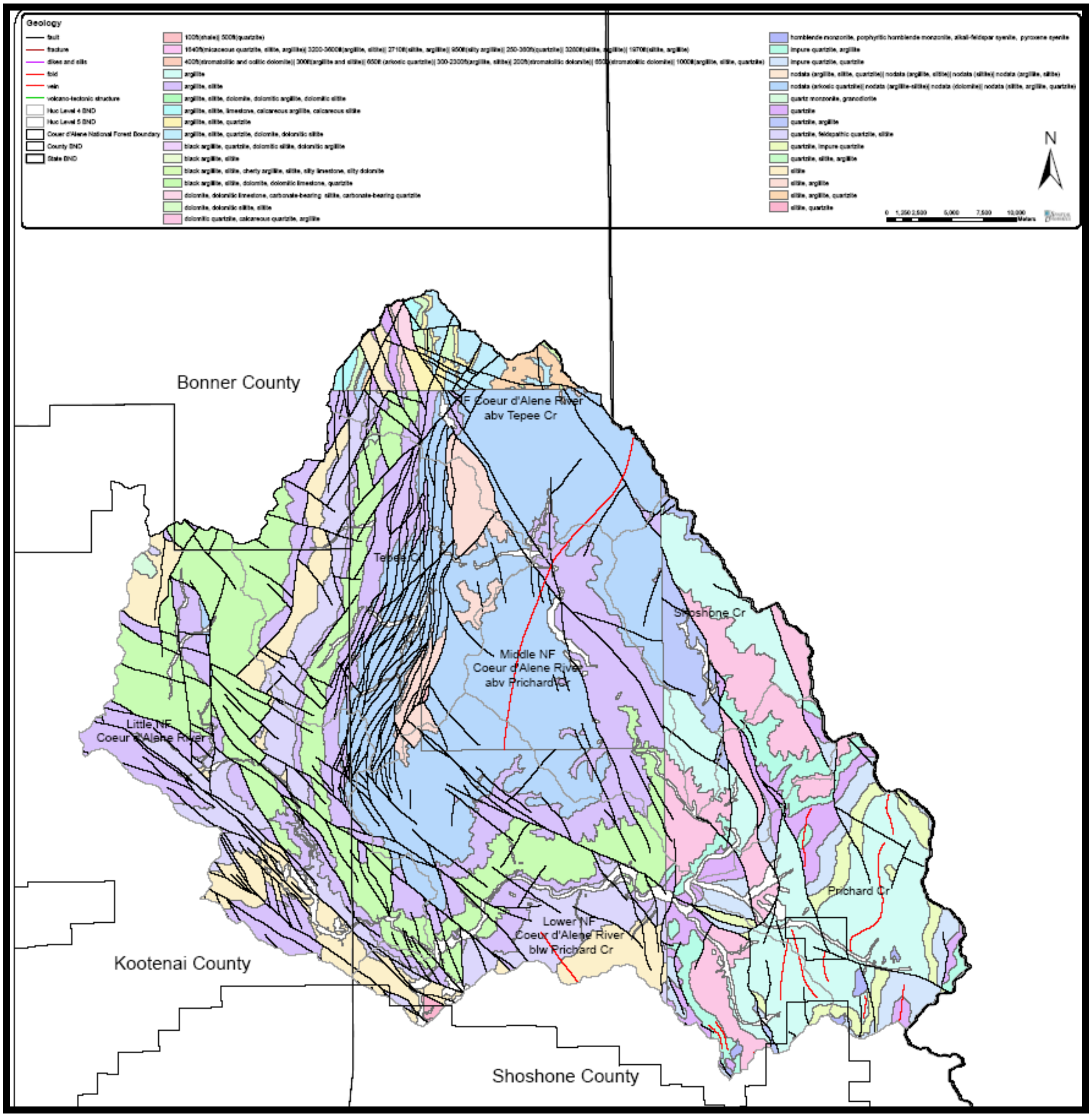


Figure 13. Geologic Map.

Soils developed on the metamorphic rocks are generally thin and silty with rock fragments. When these soils are eroded, they provide fine sediment and cobble/gravel material to streams. Soils in valley bottoms are thicker, and formed from colluvium (material that has moved down the hillsides and accumulated in the valleys) and alluvium (stream-worked material). These soils are generally silty to sandy, with occasional pockets of organic material in wetlands and old side channels

6.2 LANDFORMS

The USFS, the major landowner in the subbasin, has prepared a map of landforms. Landforms are a combination of topography (e.g., flat valley bottoms, steep hillsides), geology/soil type, aspect, and elevation. The majority of landforms in the watershed are associated with hillside landtypes: mountain slopes, headlands, and breaklands (deeply-incised V-shaped valleys). Valley bottom landforms occur along the broad stream valleys in the Lower North Fork HUC, and Teepee Creek. Landforms are used to rate the suitability of the landscape for forestry, agricultural, wildlife, and development. The USFS has also rated each landform based on the susceptibility to surface erosion and mass wasting, which provides an idea of how susceptible different parts of the landscape are to erosion following disturbance. These ratings have been used by the USFS to determine erosion potential.

6.3 SEDIMENT SOURCES

Several streams in the North Fork subbasin have been listed as §303(d) impaired streams due to high levels of sediment (Figure 12). The purpose of the TMDL implementation plan is to reduce sediment input to streams so that water quality and aquatic habitat can recover. In order to determine the best way to reduce sediment inputs, we need to understand the sources of sediment inputs in the subbasin. The TMDL process deals primarily with sediment coming from current management practices in the watershed. However, it is quite possible that past management practices such as timber harvest practices, splash damming, and mining may have provided large sediment inputs that the streams and rivers are still processing. For this reason, we will discuss significant, past sediment sources so we can understand the current condition of the subbasin and the potential rate of watershed recovery.

Sediment sources in the North Fork Subbasin include:

- Background or natural inputs (mass wasting, stream channel erosion, erosion resulting from the natural fire regime)
- Timber Harvest (mass wasting, surface erosion, skid trails)
- Roads (mass wasting, crossing failures, gullies below culverts, surface erosion)
- Mining (spoil piles, other mine wastes)
- Agricultural uses (dispersed grazing, pastures, fields)
- Management-related stream channel erosion (possible effects of changes in hydrology, riparian vegetation, or floodplain management resulting in headcutting or bank instability – this is discussed in Section 8, Channel Morphology)

The following sections summarize existing information we found on each of these sediment sources in the North Fork subbasin. Stream channel sources are discussed in Section 7.

6.4 Background Inputs

Sediment input to streams is a natural occurrence, and provides streams with coarse and fine substrate that create diverse aquatic habitat. Natural sediment input is often used to judge the relative amount of management-related sediment loading that a watershed can handle.

In the North Fork subbasin, natural sources of sediment include mass wasting and streambank erosion fed by soil creep, and erosion following natural fires. Since all areas of the Coeur d'Alene Basin have been disturbed in some manner, it is not possible to measure or directly determine an appropriate background sediment input. The North Fork TMDL estimated background sediment based on an average sediment yield of 14.6 tons/square mile/year for forested Belt series geology (IDEQ, 2001); this yielded 13,094 tons/year of background sediment.

The approach used by IDEQ provides a suitable estimate of background erosion. An alternate method of estimating background erosion would be to calculate soil creep based on the stream network. This could be done as part of the WPN assessment. Mass wasting is virtually non-existent in the subbasin, even in disturbed areas as a result of stable geology and slope conditions. Therefore, a mass wasting inventory based on a series of aerial photographs would not provide any additional information on background sediment volumes.

6.4.1 Timber Harvest and Fire

Some timber harvest practices can disturb soil and cause erosion. Current harvest practices, stream buffers, and the rapid re-growth of groundcover tend to minimize erosion from harvest. However, past harvest methods have caused wide-spread disturbance and associated erosion.

Harvest in the North Fork subbasin began in the lower elevation valleys in the late 1800's. Cutting and bucking trees within the harvest units themselves did not cause severe erosion, but methods of moving trees from the hillside to the mill included flumes, splash dams, and log drives down rivers that resulted in widespread erosion. Since running water was used for many of these transportation methods, the stream channel and surrounding riparian areas of many of the mainstem and smaller tributaries were severely impacted by these practices. No estimates of erosion associated with these early logging practices have been found. However, the erosion was likely quite severe based on photographs of logging practices of the era (Photo 1). The TMDL estimated erosion associated with recent harvests by multiplying the acres of forest in different conditions (fully stocked, recent clearcut, etc.) by a range of sediment yield coefficients of 12-17 tons/square mile/year from Belt group geologies based on stocking density (IDEQ, 2001).

Photo 1. Logs ready for log drive. Note lack of riparian buffer, and bare soil on hillside where logs were slid into river. ***University of Idaho.***

The natural fire regime of the North Fork Subbasin includes frequent low-intensity fires with infrequent stand replacing fires. The subbasin has a history of stand-replacing fires with a recurrence interval of approximately 200 years (see Section 3.3.1 of the *Watershed Overview* Report for a discussion of Fire History). Severe fires can cause increase erosion if all vegetation is burned, or if the fire is intense enough to cause hydrophobic soil conditions which decrease infiltration. The extent or magnitude of erosion associated with past severe fires in the subbasin is not known. The TMDL document estimated erosion from areas that were burned twice by wildfires by applying a slightly higher sediment yield coefficient (IDEQ, 2001). Fire suppression since the mid-1900's has created conditions that increase the likelihood of severe fire in the future, whether started by natural or human causes.

6.4.2 Roads

Roads can be a large source of ongoing erosion in forested watersheds. The majority of roads in the North Fork subbasin were constructed to access timber as harvest technology shifted from splash damming to railroad logging to truck transport. The advent of railroads and then roads to transport logs reduced direct impacts to streams that were associated with flumes and log drives, but many railroad and road systems were constructed within the flat floodplains or directly adjacent to streams. The railroads and roads often resulted in fill at stream crossings or parallel to streams that constricted channels. Roads constructed in the 1950's and 1960's were engineered to serve jammer operations which required a network of roads spaced 300 feet apart across a hillside. As a result, areas harvested during the mid-1900's have a legacy of closely-spaced "spaghetti" roads along the hillsides (Figure 14). These are particularly evident in the middle and western areas of the subbasin, where early harvest had not taken place. The low road density in the northern area of the subbasin reflects the large 1910 fire that burned that area; there were no trees to harvest, so few roads were constructed.

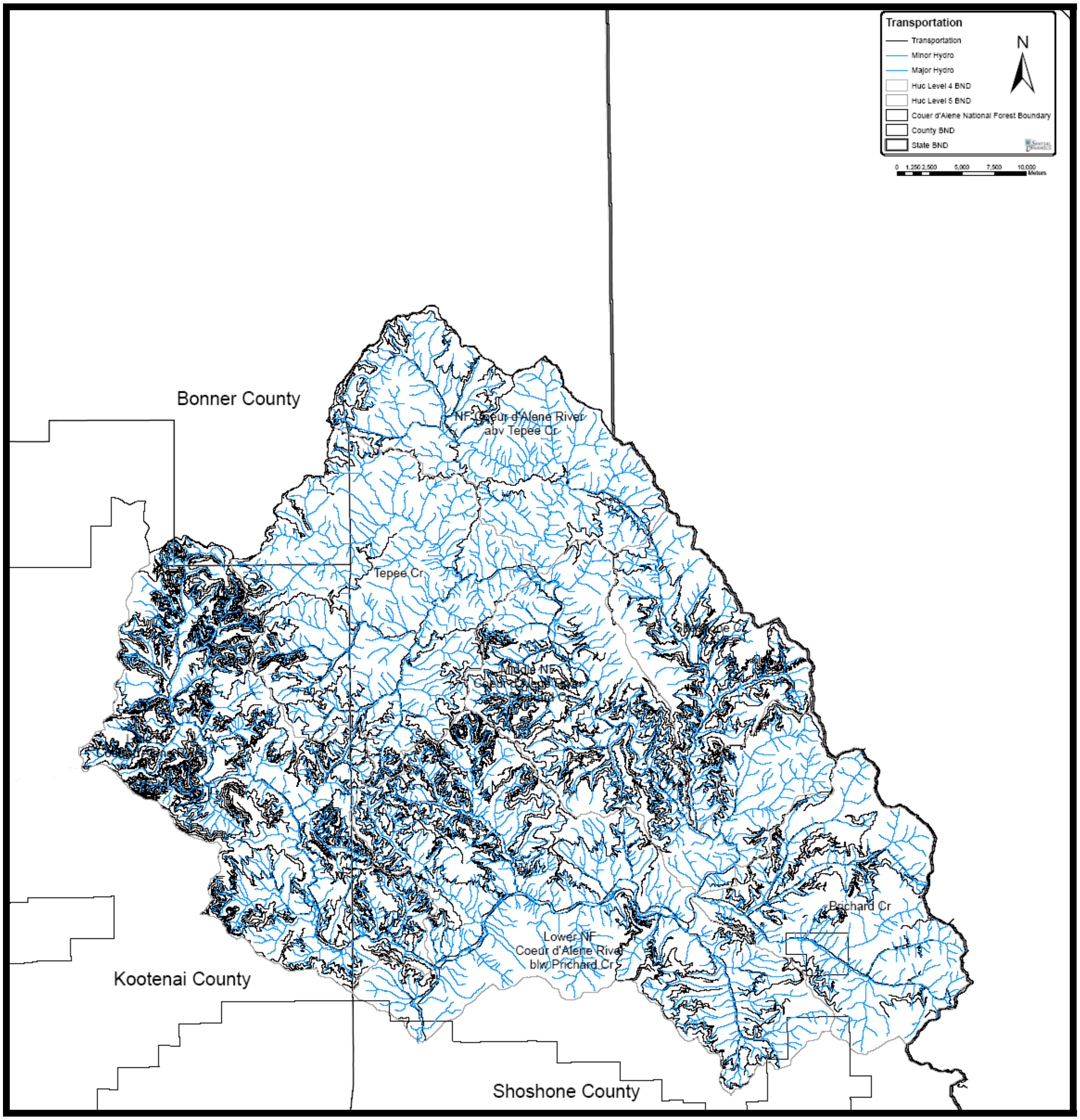


Figure 14. Roads in the North Fork Coeur d'Alene subbasin.

Table 8. Road attributes in the North Fork Subbasin (from USFS, IDEQ, and USFS data).

5th field watersheds (HUCs) as delineated by the USFS	Road density (miles/ square mile)	Stream crossing frequency (#/mile)	TMDL-estimated road sediment: surface erosion and failures (tons/yr)[a]	TMDL-estimated road sediment: bed & bank erosion from encroaching roads (tons/yr)[a]
Little North Fork	8.6	2.1	279	3,870
Lower North Fork Below Prichard	5.6	1.6	266	3,862
Middle North Fork Above Prichard	3.3	1.2	43	42
Upper North Fork Above Teepee	3.0	0.5	63	889
Prichard	6.6	1.2	90	69
Shoshone	8.4	2.2	96	1,224
Tepee	2.5	0.8	81	1,139
Watershed Total	**5.4**	**1.4**	**917**	**11,094**

For the IDEQ TMDL sediment delivery calculations from roads (last two columns), IDEQ boundaries for the 5th field HUCs must be used. The IDEQ boundaries differ from the USFS boundaries as follows:

1. Little North Fork HUC: IDEQ and USFS are the same.
2. Lower North Fork HUC: IDEQ reach for North Fork River is from mouth to Yellowdog Creek. IDEQ does not include Beaver Creek, USFS does.
3. Middle North Fork HUC: IDEQ boundary for North Fork River is Yellowdog Creek to Tepee Creek, and does not include Lost Creek where USFS does.
4. Upper North Fork HUC: IDEQ includes Independence Creek, USFS does not
5. Prichard Creek HUC: IDEQ includes Beaver Creek, USFS does not.
6. Shoshone Creek HUC: IDEQ includes Lost Creek, USFS does not
7. Tepee Creek HUC: IDEQ does not include Independence Creek, USFS does

Several different sources of current road information were reviewed, including USFS GIS databases, the TMDL sediment spreadsheets (IDEQ, 2001), and the summary database compiled by the USFS (1998b). Road miles and densities in each 5th field HUC varied slightly between the different sources, but were fairly consistent. Overall road densities are high within most 5th field HUCS (Table 8). However, a high road density does not necessarily mean that sediment yields to streams from roads are high, this depends on the location of roads with respect to streams. Roads constructed adjacent to streams and stream crossing culverts, are locations where sediment from roads can be delivered to streams. Both of these conditions exist in the subbasin. Stream crossings are frequent in all but the Tepee Creek HUC and Upper North Fork HUC.

IDEQ estimated road erosion from the following three sources for the TMDL:

- Road surface erosion. Based on road inventory scores from IDL Cumulative Watershed Effects (CWE) protocol, with a sediment delivery coefficient applied to road miles within 200 feet on each side of all stream crossings.

- Road failures at stream crossing culverts and fill failures from roads adjacent to streams. Based on a combination of unstable land types and estimated CWE road failure delivery rates (see Photo 2).

- IDEQ also estimated in-stream bed and bank erosion (which could include a road fill bank serving as a stream bank) due to roads encroaching on stream courses (roads within 50 feet, see Photo 2). The calculation assigned one-quarter inch erosion per lineal foot of bed and bank up to three feet in height along encroaching road segments. The calculation was annualized by dividing by 10 years (erosion only during large discharge events every 10 years).

The TMDL-estimated sediment associated with roads varies considerably by 5th field HUC depending upon specific characteristics of roads in each HUC (Table 8; note that the IDEQ sediment delivery calculations are based within somewhat different 5th field HUC boundaries than established by the USFS). Overall, roads were determined to be one of the largest sediment sources in most of the basins.

The in-stream bed and bank erosion estimates are, overall, much greater than sediment yield estimates from the road surface at stream crossings plus failures at crossings and adjacent roads. This calculation result reflects the view of the TMDL authors (which included a North Fork sediment Technical Advisory Team), that roads encroaching on the meander pattern and historical floodplain cause significant erosion during large discharge events by increased stream energy which erodes at the road fill, or erodes at the opposite bank and stream bed (IDEQ, 2001). In the North Fork subbasin, there is a significant mileage of encroaching roads. Increased stream energy through hydrologic modifications may also be an interacting factor in sediment delivery from road failures and bed and bank erosion.

Additional data on past culvert failures and road encroachment on streams is available from the USFS and will be compiled for the WPN North Fork assessment. During the field season of 2006, WPN will perform road inventories along representative portions of the road network to substantiate the TMDL assumptions and extrapolations used in the road erosion calculations since much of the TMDL implementation plan will likely address roads. This independent evaluation would reexamine the relative erosional contributions from in-streambed and bank versus failures and road surfaces.

Photo 2. Photos of culvert fill failures (left photo) and flood erosion of road fill encroaching on stream channel (right photo). Photos courtesy of USFS.

The USFS has been working on decommissioning and improving roads on Forest Service land since 1985 (Table 9). This work has included: decommissioning roads by recontouring the road prism to match the hillside and removing culverts; upgrading culverts so they can pass the 100-year flood; and converting roads to trails by re-contouring and narrowing the travelway. Over 744 miles of roads, or 15% of the entire forest road network, has been treated in the past 20 years (Table 9, Figure 15). A database of road and stream improvement projects has been developed and is available as an Appendix to the final Report. Areas with the highest road densities in the Little North Fork, Lower North Fork, and Middle North Fork HUCs received the majority of improvements. These improvements were not accounted for in the original TMDL calculations, but will be considered during the implementation planning process.

Table 9. Summary of Road Improvements 1985-2005 (miles of road improved)

5th field watersheds (HUCs)as delineated by USFS	Roads Re-contoured, culverts removed	Culverts upgraded to 100-year flood	Converted to trail	Total miles	Percent Upgraded
Little North Fork	156.4	6.8		163.2	11%
Lower North Fork Below Prichard	265.9	19.9	10.1	295.9	28%
Middle North Fork Above Prichard	92.3			92.3	23%
Upper North Fork Above Teepee	31.1	6.6	0.6	38.4	12%
Prichard	31.8	1.1		33.0	5%
Shoshone	34.6			34.6	6%
Tepee	86.8			86.8	24%
Watershed Total	699.0	34.4	10.8	744.2	15%

6.5 MINING

The headwaters of Prichard, Beaver, and Eagle Creeks are within the Coeur d'Alene Mining District, historically one of the largest producers of silver, lead and zinc ore in the nation. Mining in these three creeks began with the discovery of placer gold in Prichard Creek in the early 1890's (Box *et al.*, 2004). Placer mining, hydraulic mining, and underground mine works were developed and worked in the creeks and surrounding hillsides between 1880 and 1960. These mining operations have left a lasting legacy of major disturbance in Prichard, Beaver, and parts of Eagle Creeks.

Placer mining in the later 1800's and early 1900's took place in Prichard Creek, lower Eagle Creek, and Trail Creek (a tributary to Beaver Creek). A floating dredge worked these streams, pulling up bottom sediments, processing them, and leaving large, cobble dredge piles along and in many miles of these stream valleys that can still be seen today (Photo 3). Hydraulic mining of older gravels along the hillsides took place around 1900, where large jets of water were used to wash away the hillsides and find gold in the older gravels.

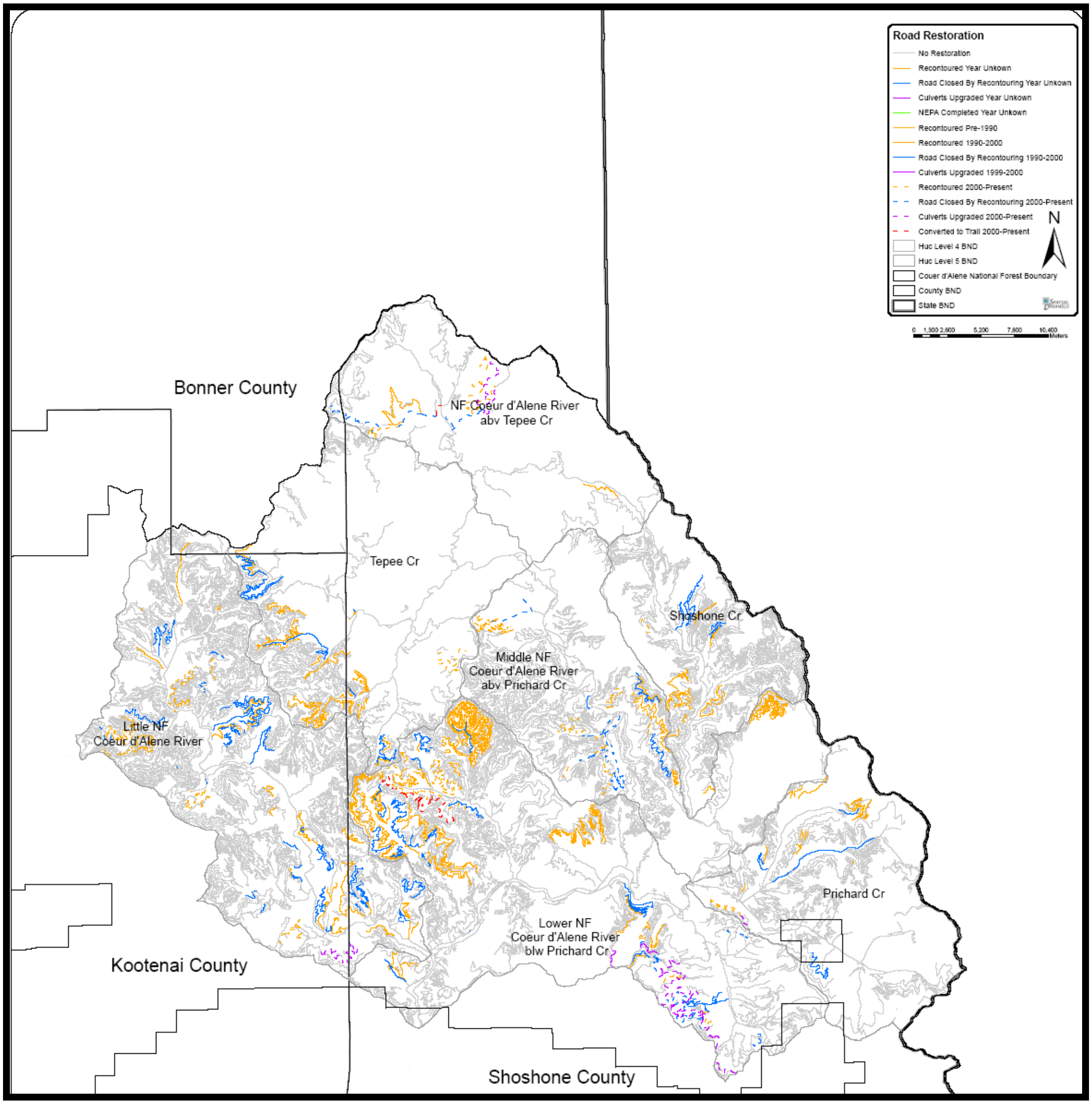


Figure 15. Road Improvements made since 1995.

Photo 3. Photo of Prichard Creek showing dredge pile spoils along creek.

Underground mining in the headwaters of the three creeks produced ore that was processed in the drainage, and produced over a million tons of tailings (Figure 16). These tailing piles were fine- to coarse-grained and enriched in metal, and either released into the streams or deposited in tailing ponds near streams. Past and current streamflow has eroded and transported some of these tailings downstream, resulting in sediment and metal concerns. The EPA has listed portions of Prichard and East Fork Eagle Creek for metals as well as sediment contamination (the metals TMDL is being handled in a separate document).

Legacy effects of past mining are a major part of the ongoing sediment concern in Prichard and Eagle creeks. The TMDL document did not calculate loading from mining spoils separately.

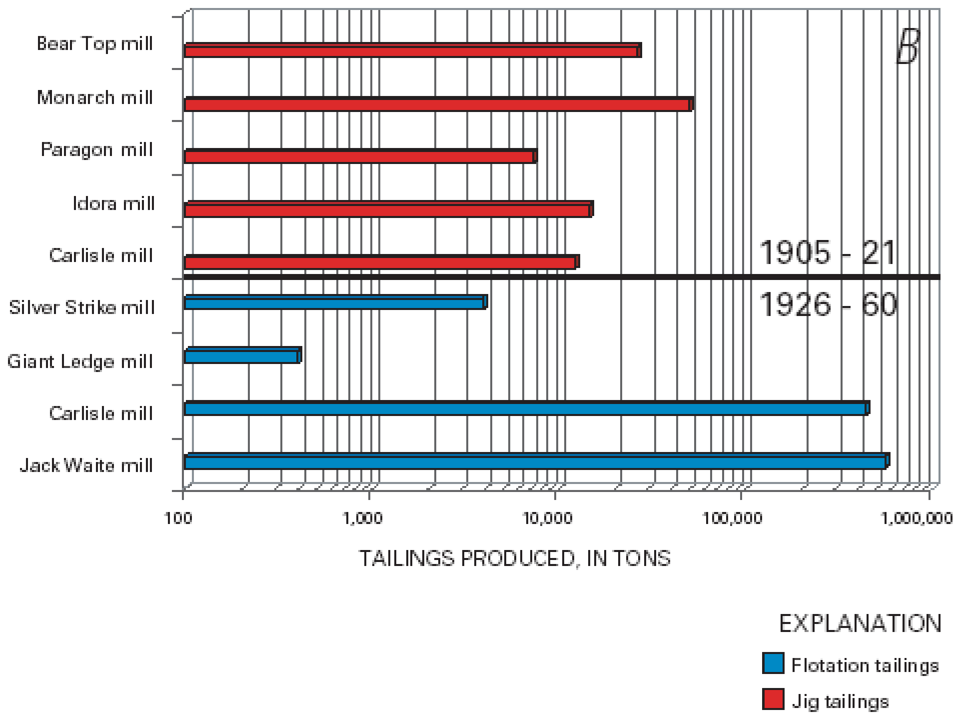


Figure 16. Total tailings output from mining in Prichard, Eagle, and Beaver Creeks (from Box *et al.* 2004).

6.6 Grazing and Agriculture

The North Fork subbasin has been used for livestock grazing and farming since settlers and miners moved into the area in the late 1800's. Developed agricultural uses are confined to the river bottoms where flat ground is most suitable for farming and pastures along the Lower North Fork and lower Little North Fork HUCs. These farms today are used primarily for pasture, and do not appear to be a major source of sediment. The North Fork TMDL (IDEQ, 2001) used the Revised Universal Soil Loss Equation to estimate that 3,591 acres of pasture land in the Lower North Fork HUC produced 108 tons of sediment/year, and 344 acres of pasture in the lower Little North Fork HUC produced 10 tons/year.

Dispersed grazing by livestock, primarily sheep, has been practiced throughout the subbasin in the past, particularly following large fires such as the 1910 fire in the Upper North Fork HUC when grasses sprouted quickly and provided good forage. Intensive grazing by livestock can increase erosion and lengthen the recovery time following an intense fire. This may have resulted in increased surface erosion of fine-grained sediment in the past.

Currently, there is a grazing allotment in the upper Little North Fork HUC, upstream of Deception Creek (Figure 17). While intensive grazing can increase surface erosion and bank erosion along streams, well-managed grazing can take place with only minor effects to streams. No information was found on the effects of the current grazing allotment on streams; this can be pursued during the WPN assessment if necessary.

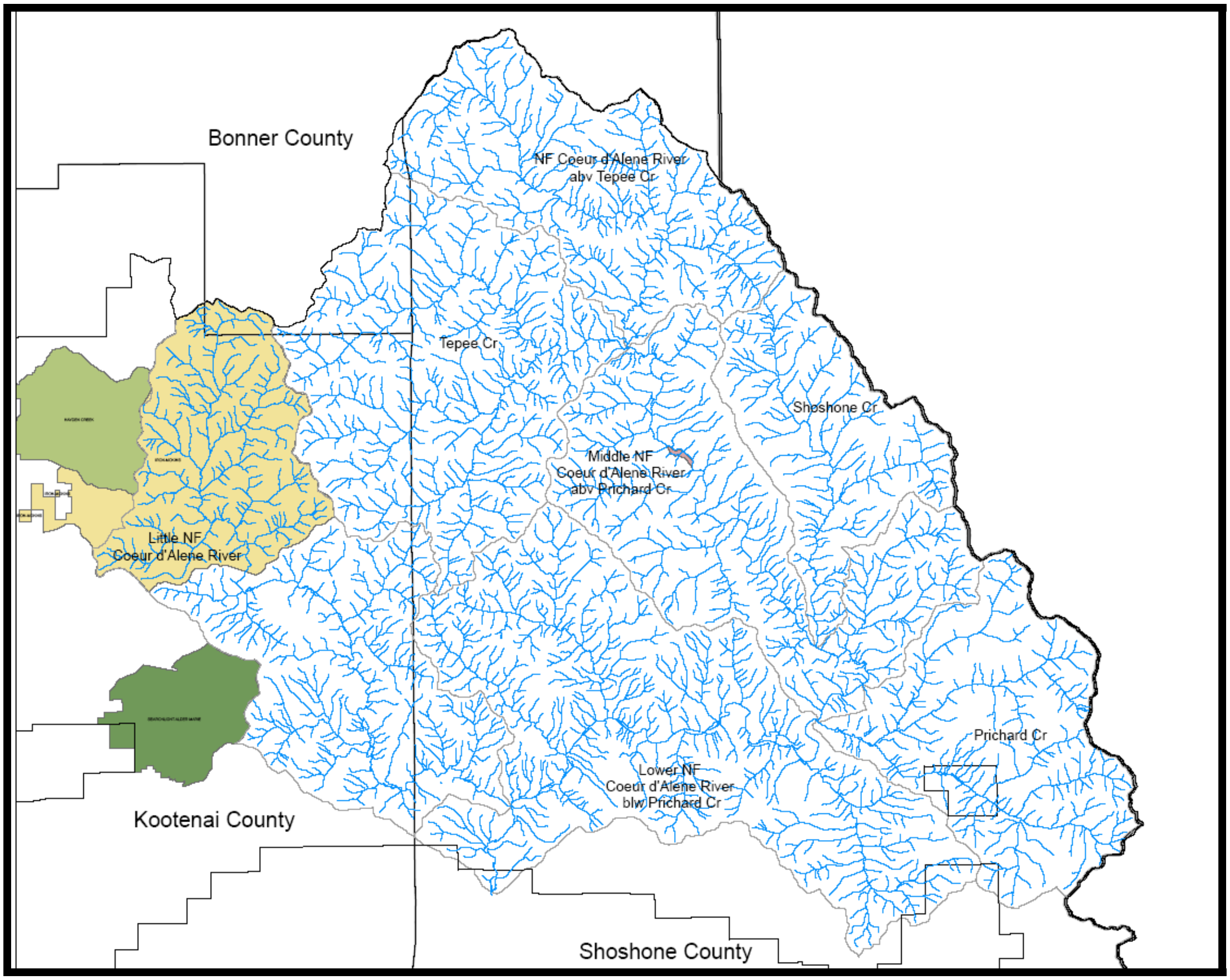


Figure 17. Grazing Allotments in the North Fork Coeur d'Alene subbasin (USFS Fernan District data).

7.0 CHANNEL MORPHOLOGY

Rivers respond to changes in sediment load and water discharge by adjusting their morphology. The current channel morphology provides many clues as to where and how sediment is being processed through the system. Comparing past and present morphology using historic maps, aerial photographs, and cross-section surveys will provide more direct evidence of sediment movement to the extent that historic data is available. This chapter describes existing knowledge about channel morphology based on the documents and other data sources reviewed in the Applicable Reports table that is included as an appendix to the final Watershed Overview document.

7.1 River Channel Pattern, Confinement and Migration

From the South Fork confluence to Prichard Creek, the North Fork River flows through an unconfined valley (Figure 1, Lower North Fork HUC). Narrow, 600 to 800-foot wide valley segments alternate with wider segments that have maximum valley widths of 1,300 to 2,500 feet. In most places, the valley is narrower than the amplitude of the meander bends. Although the river is sinuous to meandering, nearly all the bends are locked in place by the valley walls or by roads along both sides of the floodplain. The river pattern in the early 1900s was similar to today in most of the Lower North Fork HUC, based upon comparison of recent USGS topographic maps with the original Government Land Office (GLO) survey (Table 10). Some mapable changes in channel position have occurred in wide reaches near the Little North Fork River confluence, and between Grizzly and Beaver Creeks. There are also some sloughs and side channels in the downstream one-third of the lower North Fork River. Some of these have been disconnected from the river by roads.

The river valley is much narrower upstream from Prichard Creek (Middle North Fork HUC), although the river is still technically unconfined. Reaches with valley bottoms less than 200 or 300 feet wide alternate with wider reaches up to 700 through 1,000 feet wide. Channel migration is generally constrained by bedrock valley walls that lock the river bends in place. The river is straight to sinuous, and some of the bends occur due to bends in the valley. The channel pattern in the early 1900s was very similar to today in most of the Middle North Fork HUC, based upon comparison of recent USGS topographic maps with the original GLO survey (Table 10). Nevertheless, there are some side channels present in some reaches. The upstream part of the Middle North Fork segment (T52N R3E) contains a broader valley (900 to 2,200 ft wide) where channel migration likely occurs, but the GLO map was too inaccurate to verify this. There are 1 or 2 roads along the edge of the river valley throughout this reach, as well as bridge crossings.

The river valley is even narrower upstream from the Tepee Creek confluence zone (Upper North Fork HUC). The river is moderately to tightly confined in many places. Valley widths range from 200 to 500 feet downstream of Alder Creek, then become narrower still upstream. Meander wavelength and bend amplitudes are smaller due to the upper North Fork's smaller discharge. The meandering pattern of the bedrock valley is superimposed on the river channel. No side channels are evident at the scale of the topographic maps. A road goes up the narrow valley, with some bridge crossings.

Aerial photographs from the 1930s, and 2004, were obtained but not analyzed. These will provide more detailed information on side channels, braiding, and gravel deposits, as well as how their locations have changed over time.

Roads and bridges constrain the river's location and reduce floodplain width. Roads are typically located at the edges of the valley, but in some locations (primarily in the Lower North Fork HUC), they cut off larger portions of the floodplain including meander bends and former side channels. There is also a gas pipeline that constricts the river downstream from the Little North Fork.

In addition, bank protection projects unrelated to roads constrain river movement. Most such projects were built by NRCS together with local landowners to protect private land in the Lower North Fork HUC. The total length is relatively small, about 6,800 feet (Table 11), but these projects tend to constrain the river in the few locations where channel migration is most likely to occur, thus precluding formation of new side channels. More than half of the NRCS projects were built in 1997 following the large 1996 flood. Others were built in the 1970s following the larger 1974 flood. The list of NRCS projects since 1974 in Table 11 may be incomplete (Kim Erk, NRCS, personal communication). More detailed information has been tabulated in *NRCS projects.xls*. Frequently-flooded houses near Enaville were bought out by FEMA following the 1996 flood, removing the impetus for future bank protection projects in that area.

7.2 CHANNEL GEOMETRY

7.2.1 Data Sources

Numerous measurements of channel geometry, large woody debris, and surface sediment size have been made within the North Fork subbasin. Table 12 shows the number and type of surveys in each of the seven, 5th field HUCs. Note that the HUCs in this table are as defined by the Forest Service and differ somewhat from the seven “sub-watershed divisions” used by IDEQ in their TMDL document (see footnote 1 of Table 12). Most or all of the USFS data listed in this table were collected with standard protocols and confidence in data quality is high (Lider, USFS, personal communication). The IDEQ Beneficial Use Reconnaissance Program (BURP) data was also collected with standard protocols and data quality is rated high.

7.2.1.1 USFS Monitoring Data

The main section of Table 12 lists monitoring data collected by the Fernan and Wallace USFS District offices since 1985. WPN compiled this table from multiple worksheets provided by USFS in the file *cda_monitoring_spreadsheet.xls*. Each entry indicates the number of times a particular type of survey was made in each 5th field HUC. An individual survey consists of data collected in a particular stream reach on a single date, and might consist of multiple measurements in that reach. Multiple surveys could indicate one of two things. Either the same locations were resurveyed on multiple dates (true for about half of the repeatable survey types such as cross-sections, due to repeated monitoring of specific restoration projects), or several different locations were surveyed once (true for the non-repeatable types such as basin-wide LWD counts, and about half the repeatable types).

Table 10. Government Land Office surveys of the North Fork Subbasin: dates, coverage, and comparison of river patterns

Township & Range	Map Order from River Mouth	Date of Original GLO Surveys	Followup Surveys w/ new river course	Water Features Shown	N Fork CDA Subbasin	N Fk CDA River Detail and Accuracy[1]	Comparison with USGS topo maps[1] Remarks
T51NR4E	7	1908		N Fk CDA	MNF, Shoshone	Good	River pattern unchanged. Valley wall control.
T51NR3E	8	1903-1909		N Fk CDA	Middle N Fk	Good	River pattern unchanged. Valley wall control.
T52NR2E		1904		Tepee Cr.	Tepee	N/A	
T52NR3E W1/3	9	1904		N Fk CDA	Middle N Fk	Poor	Simplified river channel, inaccurate location.
T52NR3E E2/3		1939			Shoshone, MNF	N/A	Shows road to Pond Peak
T49NR1W SE1/4		1891		4th of July Cr.		N/A	
T49NR1W rest		1903		4th of July Cr.		N/A	
T49NR1E	1	1885		N Fk CDA	Lower N Fk Little N Fk	Poor	Good detail of mainstem CDA River; poor detail of 1st 0.3 miles of N Fk.
T49NR2E not 30-31	3	1904	1972 Sec 18-19	N Fk CDA	Lower N Fk, RM 3 u/s	Good	Channel migration evident Sec 4,17-19. Sec 8 wider in GLO w/more side channels.
T49NR2E Sec 30-31	2	1891		N Fk CDA	Lo NFk RM 0-3	Poor	Simplified river channel not surveyed, just drawn in.
T50NR1W		1905		Wolf Lodge Cr.		N/A	
T50NR1E		1905		Little N Fk	Little N Fk	N/A	Shows trail to Cataldo, mainstem CDA River.
T50NR2E	4	1903-1905		N Fk CDA, Cougar, Steamboat	Lower N Fk	Good	River pattern unchanged. Valley wall control. Sec 24 wider in GLO map.
T50NR3E	5	1904-1905	1983 Sec 28&25	N Fk CDA	Lower N Fk	N/A	Most of reach has valley wall control except wider w/channel migration Sec 22,25,36. Long side channel in Sec 25 is gone on topo map.
T50NR4E	6	1905-1908	1981 Sec 10	N Fk CDA, Prichard etc.	Middle N Fk, Prichard, Little N Fk	Good	River pattern similar. Mostly valley wall control. GLO does not show Sec 10 channel shown on later topo map. Shows numerous mining claims Prichard Cr and 1st N Fk meander bend d/s of Prichard -- placer mined?

1. Accuracy, detail, and river pattern were compared with USGS 7.5-minute topographic maps, scale 1:24000, based on 1965-1986 air photos (Forest Service B maps).

2. GLO maps for Townships north of 52N were not obtained due to the small size of the North Fork CDA River.

Table 11. Bank stabilization projects on private land. Information provided by NRCS Coeur D'Alene office December 2005.

LENGTH (ft)	NAME	YEAR	PROJECT TYPE	PROJECT GOALS
1000	Lightener Draw	1997	LWD debris removal	remove flow obstruct
800	North Fork CDA River	1974	rock, bank stabilization	bridg protect
175	North Fork CDA River	1975	log revetments+ riprap	bank stabilization
300	North Fork CDA River	1975	rock riprap	bank stabilization
350	North Fork CDA River	1978	gabions	bank stab
250	North Fork CDA River	1985	log revetments+ riprap	bank stab
400	North Fork CDA River	1997	bank stabl, riprap	bridg protect
700	North Fork CDA River	1997	cleanup	debris removal
200	North Fork CDA River	1997	riprap bank stabilization	road protect
300	North Fork CDA River	1997	barbs, riprap, debris removal	protect homes
200	North Fork CDA River	1997	riprap bank stabilization	protect homes
2000	North Fork CDA River	1997	5 barbs	bank stab
75	North Fork CDA River	1997	1 barb	bank stab
800	North Fork CDA River	2003	stream barbs, veg, grading	bank stab
250	North Fork CDA River	2006	bank stab, veg	wildl hab
55	Pritchard Creek	1997	culvert repair, riprap	culvert repair, bank stab
300	Thomas Creek	1997	4 log drop struct, grade control, culvert	reestablish gradient, pool,
2640	Tributary Creek	1981	capping	mine tailing stabil
50	West Fork Eagle Creek	1997	debris removal	remove log jam
75	Yellow Dog Creek	1985	gabions, debris removal	bank stab

Much of the monitoring data in the USFS District offices has not been tabulated or analyzed. Retrieving, analyzing and summarizing all these data is beyond the scope of this report. For this existing knowledge report, only a limited amount of data were retrieved for a few specific locations. The data are not distributed uniformly throughout the subbasin. All the data in the Tepee Creek HUC are from Jordan Creek in the Upper North Fork. The Lower North Fork, Little North Fork, and Shoshone Creek HUCs have the most monitoring surveys, and there is little data from the other HUCs or the North Fork River itself. Table 12 does not list USFS channel surveys prior to 1985 or monitoring data collected by the Panhandle National Forest Supervisor's Office.

7.2.1.2 PIBO Data

Pacific Fisheries Biological Opinion (PIBO) surveys were conducted in 2002 and 2003 by the USFS across the upper Columbia River basin. There were 14 PIBO sites in the North Fork Subbasin. Multiple channel attributes were measured. There were no North Fork mainstem sites, and the largest number of sites were concentrated in the Tepee Creek and Little North Fork HUCs. The file *channeldata.xls* contains the PIBO data and a map showing site locations.

7.2.1.3 BURP Data

Beneficial Use Reconnaissance Program (BURP) surveys that included channel geometry were conducted by IDEQ in 1996 through 2003. The Upper North Fork, Little North Fork, and Prichard Creek HUCs were most heavily sampled. There were 3 sites on the North Fork mainstem (one middle and two upper reaches), and 5 to 8 sites in each of the remaining HUCs. Substrate and channel geometry parameters were tabulated by WPN from the data collection forms. The file *channeldata.xls* contains data tables and maps showing the sample sites.

7.2.1.4 Beneficial Use Attainability Data

Additional channel data from 42 sites were collected by IDEQ in 1992 for the Beneficial Use Attainability study (Hartz, 1993). For most variables, only the mean value from several sample sites was reported. Data quality is rated high. The data tables are reproduced in *beneficial use tables(2).pdf* and selected data are included in *channeldata.xls*. In addition, some channel data were utilized from IDEQ's 2001 TMDL report. Some of the data were from the sources listed above, and some from yet other sources. Channel data tables from the TMDL report are also tabulated in *channeldata.xls*. Data are identified by stream, but the reports do not contain maps that show the survey locations.

Table 12. Types of Existing Channel Survey Data in the North Fork Subbasin

		Number and Type of USFS Fernan and Wallace Districts Monitoring Surveys from 1985 to 2003, by 5th-field HUC											Number of PIBO surveys by USFS, 2002 or 2003	No. of BURP surveys by IDEQ, 1996-1998 or 2003
5th-field HUC[1], 5th field HUC Name (may differ from TMDL subbasins[1])	**Drainage Area (sq mi)**	**Total Repeatable All Types[2]**	**Total Non-Repeatable All Types[2]**	**Cross Section**	**Long. Profile**	**Pebble Count, long. profile**	**Pebble Count, Basin wide**	**Bank Stability, long. Profile**	**Bank Stability, Basin wide**	**Photos**	**LWD, long. Profile**	**LWD, Basin Wide**	**Multiple Parameters Measured**	**Multiple Parameters Measured**
17010301 North Fork Coeur d'Alene River mainstem (3 HUCs)	896	5	7	1	1	0	0	0	0	0	0	2	0	2 (3?)
1701030101 Upper NF Coeur d'Alene River above Tepee Cr.	102	54	7	10	1	11	1	0	0	0	11	3	1	12
1701030102 Tepee Creek	144	115	112	20	19	8	21	4	0	6	5	38	4	8
1701030103 Middle NF Coeur d'Alene River above Prichard Cr	123	7	17	3	3	0	3	0	0	1	0	6	2	7
1701030104 Shoshone Cr	69	13	49	4	2	0	7	0	0	2	0	15	1	5
1701030105 Prichard Cr	98	8	14	0	0	0	1	0	0	2	0	4	1	15
1701030106 Lower NF Coeur d'Alene River below Prichard Cr	189	29	110	5	1	2	20	2	0	9	0	33	1	8
1701030107 Little NF Coeur d'Alene River	170	30	44	8	5	3	10	0	0	3	0	9	4	15
HUC unknown 6 creeks		24	34	6	4	0	8	0	0	6	0	11		

1. The USFS 5th-field HUCs used in this table differ from IDEQ's TMDL subbasins as follows:
-- Independence Creek is in the Tepee Creek HUC instead of Upper North Fork
-- Lost Creek is in the Middle North Fork HUC instead of Shoshone
-- Middle North Fork HUC extends from Prichard Creek; in IDEQ TMDL it begins at Yellowdog Creek
-- Beaver Creek is in the Lower North Fork HUC instead of Prichard
-- Lower North Fork HUC ends at Prichard Creek; in IDEQ TMDL it extends to Yellowdog Creek
2. "All Types" includes additional types of monitoring surveys, such as snorkel surveys, not broken out in this table.
Repeatable surveys are shaded light, non-repeatable surveys are shaded dark.

7.2.2 Channel Geometry Findings

7.2.2.1 Regional Channel Geometry

Regional channel geometry has been determined by the USFS using the Rosgen Field Book methodology (Lider, 1999, unpublished notebook). It was based upon 5 stream gages in the Upper North Fork and Tepee Creek HUCs, as well as neighboring Hayden Creek (Figure 18). The gages are all Type C streams, except the small Halsey Creek which is slightly steeper and presumably a B type channel (Table 13).

These creeks were chosen because they were gaged, and located within the drainage area of the North Fork River above the Shoshone Creek gage. They are not pristine creeks and management may have affected discharge and/or bankfull geometry. Due to the 1910 fire, Independence Creek is mostly unharvested and has few roads, though it was reportedly salvage logged, and the creek was used for a log drive after the fire (Russell, 1984). However, it has had nearly a century to recover from that disturbance. Most of the Independence Creek watershed was rated as "best existing condition (most ecologically intact)". Halsey, Hayden, and Big Elk Creeks were not burned in the 1910 fire and hence were subject to more road-building and timber harvest. They were rated "most rehabilitation needed". The North Fork River drainage area above the Shoshone Creek gage site contains a mixture of disturbed and more pristine areas.

Table 13. Channel characteristics at gages used for regional channel geometry

Gage	Years of Record	Drainage Area (sq. mi.)	Rosgen Type	Field-Measured Bankfull Return Interval (yr)
Halsey Cr.	15	4.97	B? based on 2.5% slope	1.34
Big Elk Cr.	10	11.5	C4	1.15
Hayden Cr.	52	22	C4	1.6
Independence Cr.	?	60.4	C4	1.25
N. Fk. CDA River nr. Shoshone	45	335	C4	1.3

Figure 19 shows the plot of bankfull discharge vs. drainage area. The curve is steeper than the regional curves for other areas in the interior western US (Figure 20). These curves plot bankfull width, depth, and cross-sectional area as a function of drainage area. The North Fork curves are somewhat steeper than those for other regions.

A sixth gaged stream, Tepee Creek with a drainage area of 36 sq. mi., was also analyzed in the USFS workbook. It plots well on the discharge vs. drainage area curve (Figure 19) but was omitted from the final regional curves - presumably because its bankfull width of 61 feet exceeded the predicted 40 ft. using the regional curve derived from the other 5 gages.

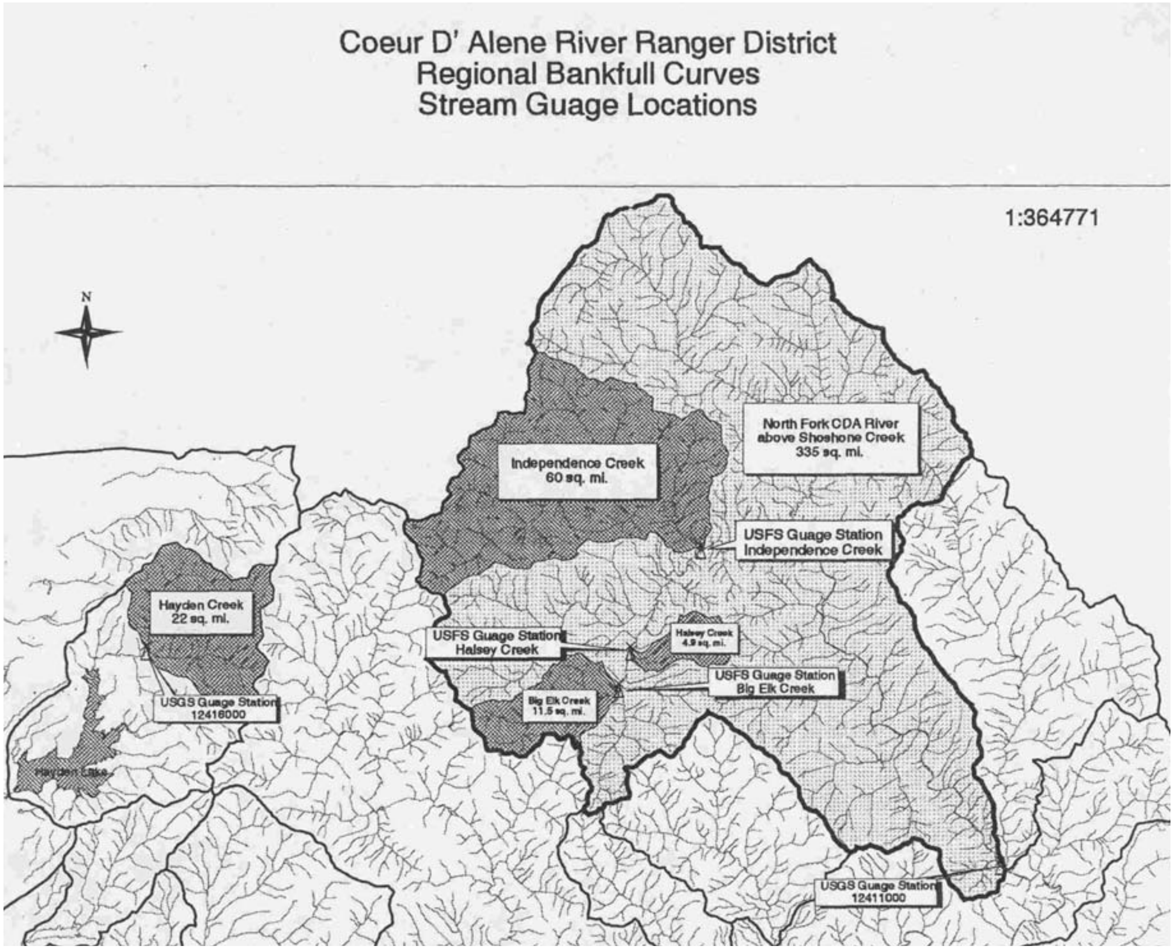


Figure 18. Map showing gage locations for regional hydraulic geometry

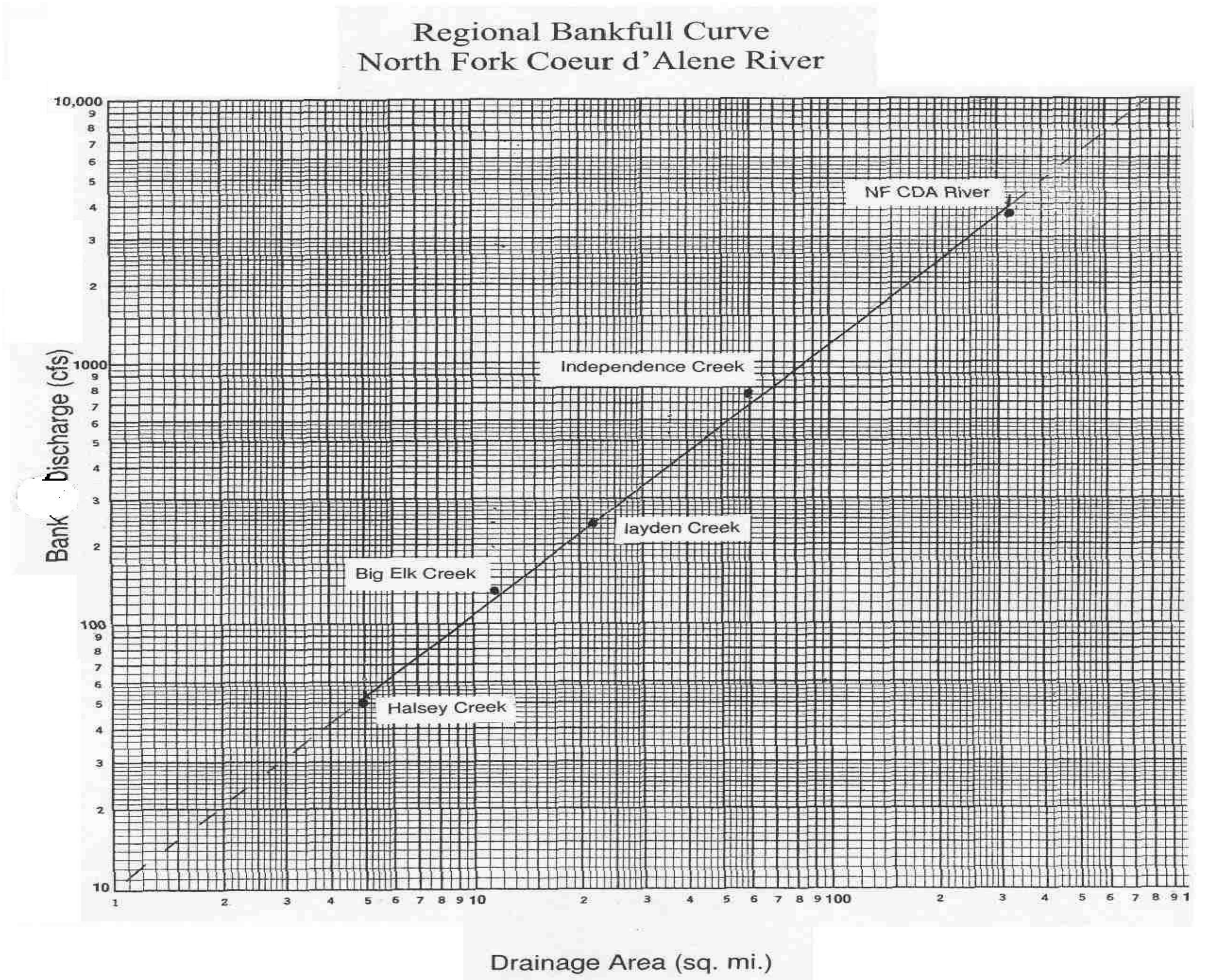


Figure 19. Plot of bankfull discharge vs. drainage area for the North Fork CDA River

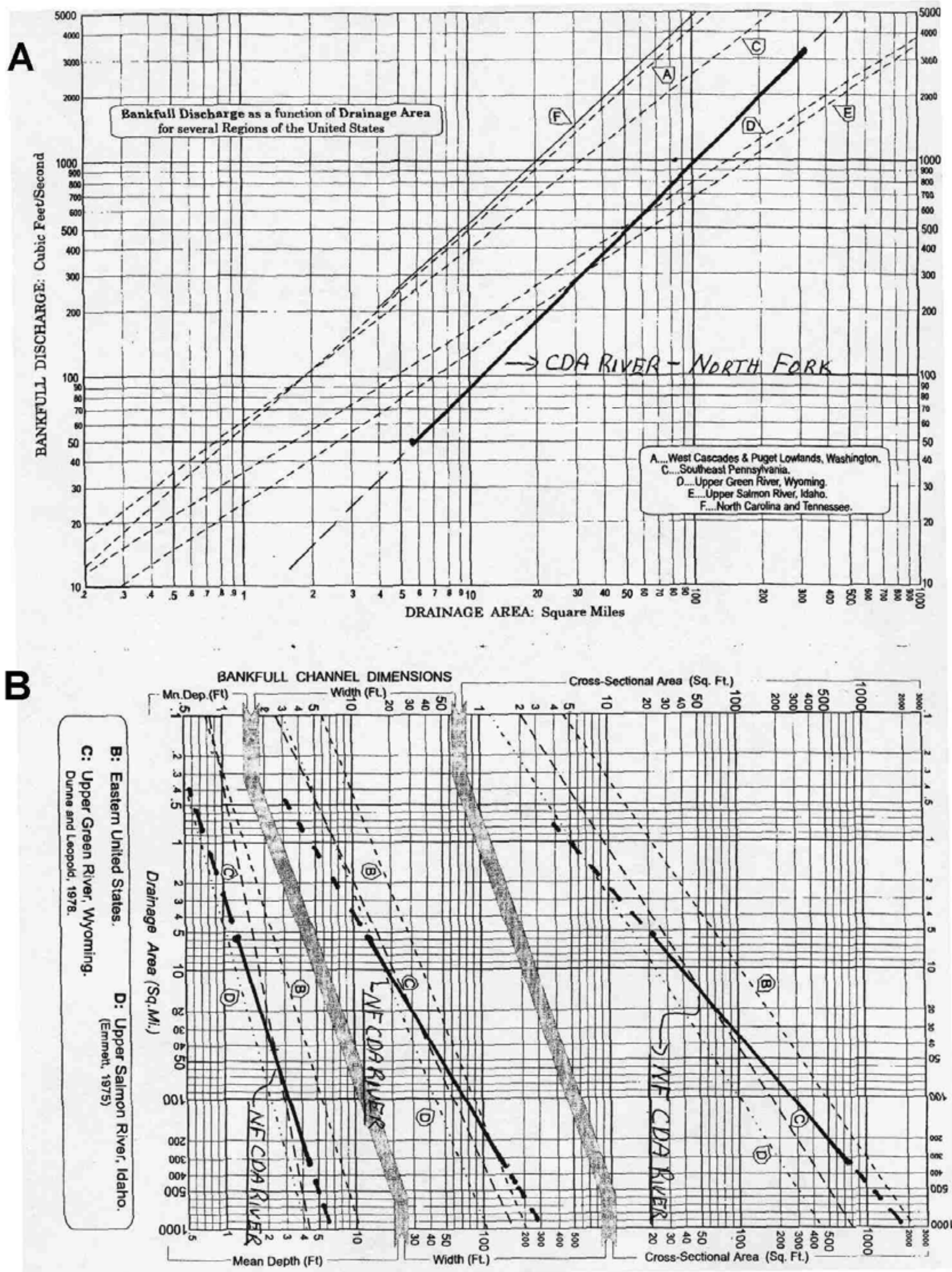


Figure 20. North Fork CDA River hydraulic geometry curves compared to other regions in the US

a) **Bankfull discharge as a function of drainage area**
b) **Bankfull area, width and depth as functions of drainage area**

7.2.2.2 Pool Abundance and Size

Deposition of sediment in lower-gradient streams (Rosgen C and B channels) reduces pool area and volume in some cases, but not always (Lisle, 1982 referenced in Kappesser, 2002). Large woody debris increases pool area and volume (Montgomery *et al*., 1995 and many others). Analysis of the pool data and estimation of sediment loading in later phases of this study will allow these effects to be better understood. USFS pool data from a 1991-1992 forest-wide survey are in the file *channeldata.xls* along with pool data from the sources described above. The paragraphs below only presents data analysis that has been done previously.

Cross and Everest (1995) compared a large number of sites on managed and relatively unmanaged reference streams in the greater Coeur d'Alene (CDA) River (including the North Fork), and St Joe River (next 4th field subbasin to the south). Their paper does not present data for the North Fork River separately. The reference streams had been entered for timber salvage after large fires in the early 20th century, but had not been affected by management since then. Compared to reference St. Joe tributaries, the mean residual volume of pools in type B channels was 51% less in managed St. Joe tributaries, and 67 percent less in managed CDA tributaries. Mean residual pool depth was less in managed streams by 17 and 30 percent, respectively, still a significant difference. In type A channels, managed watersheds had 26 and 27 percent lower residual pool volumes and depths, respectively.

The North Fork TMDL report stratified residual pool volume in the North Fork subbasin by bankfull width to account for the fact that pool volume tends to increase with channel width. Figure 21 plots the IDEQ Table 13 data along with a trend line for the relationship between bankfull width and residual pool volume. The four square symbols are from reference streams, whereas the other data points are for the water quality limited stream segments. Only one of the four reference sites plots significantly above the trend line. Bankfull width explains only 40 percent of the variation in pool volumes for the managed streams, indicating that a combination of other factors such as LWD, gradient, bank roughness and sediment load also affect pool volume.

7.2.2.3 Large Woody Debris

Large woody debris (LWD) provides a variety of channel functions: forming new pools, deepening existing pools, forming stable steps in the profile that dissipates energy and prevents downcutting, and promoting sediment deposition. In low-gradient C channels, LWD also forms logjams that cause side channels to develop. With sufficient wood loading, forced pool-riffle channels occur between gradients of 0.5-2%, and these channels have been found to have higher numbers of pools than plane-bed or pool-riffle channels without wood (Montgomery and others, 1995).

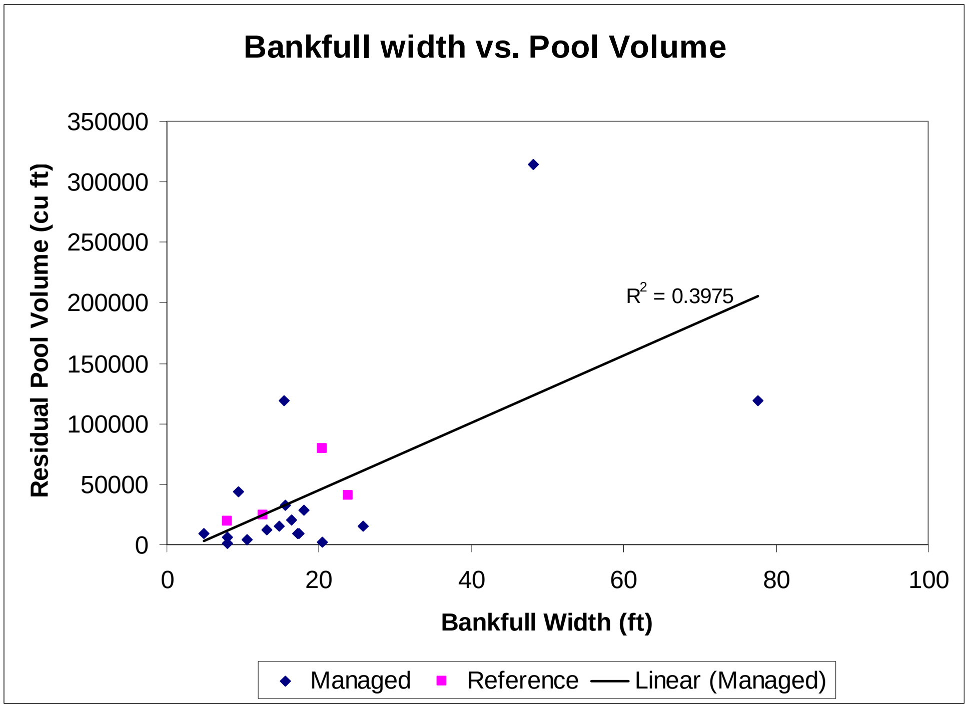


Figure 21. Residual pool volume as a function of bankfull width. Data from Table 13 of IDEQ (2001). Source data from both USFS and IDEQ.

The amount of LWD in the North Fork subbasin is generally low due to riparian timber harvest, the use of streams for log drives, stream-side road building, and large stand-replacing fires in the Upper North Fork HUC, especially the fire of 1910.

Table 14 summarizes LWD counts from the IDEQ BURP surveys. The surveys counted pieces of LWD with a minimum diameter of 10cm and length of 1m. LWD outside the bankfull channel is not counted. LWD was more abundant in the smaller, first and second order channels than in larger streams. This is a common pattern in all forested watersheds, reflecting the greater mobility of wood in wider streams. Average wood counts in each of the 5th field HUCs ranged from 14 to 48 pieces per 100m length of channel, with most streams having between 5 and 30 pieces per 100m. The Tepee Creek HUC had the highest average count, largely due to high numbers in mainstem Tepee Creek and Big Elk Creek.

Table 14. LWD data from IDEQ BURP surveys.

Stream Order	# of samples	Mean LWD (#/100m)
1	9	27
2	30	30
3	28	15
4	5	6
5	1	1

5th-field HUC	# of samples	Mean LWD (#/100m)
Little N Fk	15	20
Lower N Fk	8	21
Middle N Fk	8	14
Prichard	9	19
Shoshone	5	28
Tepee	8	48
Upper N Fk	19	17

LWD count is number of wood pieces longer than 1m and greater than 10cm diameter, per 100m stream channel length. Count is LWD found within bankfull channel, and any wood piece in the adjacent floodplain that breaks the plane of bankfull height into the channel.

Table 15 lists LWD counts from the 14 streams with PIBO surveys. Wood numbers were generally lower than for the BURP surveys. This result could simply be due to the small number of streams sampled, or it may also reflect differing survey protocols. The results shown in Table 15 do not count wood that is outside the bankfull channel, and for the second column, a minimum length of 3m was used. On average, the managed channels had higher wood numbers than the reference channels. USFS restoration projects have been adding wood to streams such as Jordan Creek in the Upper North Fork HUC.

Table 15. LWD data from PIBO surveys. Category 1 wood is below bankfull elevation, whereas category 2 is within bankfull width but above the channel. Piece counts per 100 m of stream channel length.

Stream	Mgmt Code	Rosgen Channel Type	LWD Category 1 & 2 All Lengths (#/100m)	LWD Category 1 >=3m long (#/100m)
W.F. Steamboat	Managed	B3c	3	3
Rampike	Managed	B4c	35	15
W.F. Eagle	Managed	C4	14	9
Copper	Managed	F3	7	5
Independence	Managed	F4	61	31
Leiberg	Managed	F4	6	5
Laverne	Managed	F4	8	4
Bumblebee	Managed	F4	4	2
Jordan	Reference	B4	8	2
Brett	Reference	B4	5	1
E.F.Lost	Reference	C4	18	13
Emerson	Reference	C4	14	7
Trail	Reference	F4	4	2
North	Reference	F4	11	4

7.2.2.4 Entrenchment and Width-Depth Ratio

Entrenchment occurs when the stream bed degrades to the point where floods can no longer access the floodplain regularly. Causes of entrenchment include increased flood discharge, removal of channel LWD for harvest or to facilitate log drives, and road encroachment of the floodplain that significantly deepens flows. The very large 1974 flood reportedly caused widespread entrenchment of second and third order channels (USFS, 1974). Widening and deepening of the channel cross-section by entrenchment can be a significant source of course sediment, though its importance within the North Fork subbasin has not been quantified.

Entrenchment is defined as floodplain width divided by bankfull width. Floodplain width is defined as the distance between elevation points twice the maximum bankfull depth, which commonly corresponds to the 50-year flood (Rosgen, 1996). Streams with ratios below 1.4 are entrenched (typical for Type F channels), between 1.4 and 2.2 moderately entrenched (typical for Type B channels), and above 2.2 slightly entrenched (typical for Type C channels).

Table 16 shows entrenchment ratios from the PIBO data. In this small data set, it appears that entrenchment ratios are within the typical ranges for their channel types. However, it is possible that erosion or deposition caused some of the managed segments to switch channel types. This would need to be investigated further. Comparing within channel types, there appears to be no particular trend toward more entrenchment in the managed F channels than reference F channels, or less entrenchment due to deposition in the managed C or B channels. More entrenchment data may become available if USFS cross-section monitoring data can be located.

Width:depth ratios are typically above 12 for all three channel types measured in the PIBO data (Table 16). High sediment loading would be associated with wide, shallower channels (higher ratios), whereas scour from increased discharge and less channel structure would tend to produce narrow, deep channels (lower ratios) that might also be entrenched. Mean width:depth ratios were very similar for the managed and reference streams. These data need to be interpreted in context of their position in the watershed, sediment load, gradient and other factors. IDEQ's BURP data set includes width:depth ratios for considerably more sites, and this data could also be analyzed. Yet more data on width:depth ratio may become available if USFS cross-section monitoring data can be located.

Surveyors' notes from the original Government Land Office surveys were obtained but have not yet been analyzed. They will likely provide at least some information on early channel conditions such as width, bank height, gravel bars, braiding or side channels, and riparian forest condition. However, timber harvest and log transport had already affected some areas of the river by 1905-1909 when these early surveys were done.

Table 16. Entrenchment and Width to Depth Ratio from PIBO data.

Stream	Mgmt Code	Rosgen Channel Type	Entrenchment Ratio	Avg Bankfull Width:Depth Ratio
W.F. Steamboat	Managed	B3c	1.8	26.24
Rampike	Managed	B4c	2.2	21.27
W.F. Eagle	Managed	C4	2.6	22.03
Copper	Managed	F3	1.3	29.6
Independence	Managed	F4	1.4	29.41
Leiberg	Managed	F4	1.2	36.46
Laverne	Managed	F4	1.4	31.68
Bumblebee	Managed	F4	1.2	22.81
Jordan	Reference	B4	1.8	26.37
Brett	Reference	B4	1.6	22.1
E.F.Lost	Reference	C4	3.0	23.89
Emerson	Reference	C4	2.2	19.94
Trail	Reference	F4	1.3	39.48
North	Reference	F4	1.4	18.39

7.3 CHANNEL SEDIMENT

Sediment eroded from roads, failed culverts at road crossings, and stream channel erosion is transported downstream, to be deposited farther downstream where gradients drop and flows spread out on the floodplains. Morphological signs of excess bedload sediment deposit include the following, as described in an unpublished USFS report (USFS, 1997): "There are observations and reports of excessively mobile bed forms, even during relatively frequent runoff events; rapid changes in bed form and shifting bed composition (i.e. the loss of pools and other channel structure, shift to overall finer bed elements); stream reaches of rapid channel migration; and a general widening and aggrading of the active channel."

There is relatively little data on sediment itself, except for pebble counts of the surface sediment on riffles. Pebble counts were done in many of the surveys described in above, but in most instances they have not been repeated at the same location over a long time period.

7.3.1 Changes in Sediment Size

Only one measurement of long-term change in sediment size has been obtained. The USGS gage 12412000 "CDA River near Prichard" was located on the North Fork River near Beaver Creek and below Prichard Creek, and operated from 1944 to 1953. In 1991, the USFS resurveyed the former cross-section and conducted a new pebble count in the same location. The cross-section surveys could not be obtained, but the river had aggraded significantly since the original survey which was either 1967 or 1948 (G. Kappesser, personal communication, 12/12/05). Changes in particle size distribution since 1967 were reported in the *1992 Forest Plan Monitoring and Evaluation Report*, which says "Long time residents remember a river whose bottom was made up of 'large plates of rock'...Barnes (1967) reports the d50 [median diameter] as 103 mm, and the d84 as 650 mm. Channel surveys conducted by the U.S. Forest Service in 1991 at the same location show the d50 to be 32 mm and the d84 as 64 mm. Riffle Stability Index (RSI) number in 1991 was 98, and is projected to have been 60 in 1967. The shift in the RSI number expressed the aggradation that has taken place as the large bed elements were buried by cobble and gravel."

A USFS monitoring project summary sheet dated 1989 also provides sediment size for pebble counts reportedly done in 1948 at two other gages on the North Fork River: below Lost Creek, and above Flat Creek. It is not clear which gages these refer to (perhaps the 2 gages that were briefly operated in the 1910s), but both would be in the Middle North Fork HUC. The d50 was 89 mm (large cobble) at both gage sites, and the d84 was boulder sized (191 mm at the Lost site, and 217 mm at the Flat site).

Pebble counts and cross-sections will be resurveyed at some of the old gage locations in a subsequent phase of this project, and gage rating curves will also be used to obtain a history of changes in river bed elevation.

7.3.2 Riffle Stability Index

The Riffle Stability Index (RSI) was developed and applied in the Coeur d'Alene Basin by USFS hydrologist Gary Kappesser (1993 and 2002). A RSI value is thought to provide an index of textural fining in response to sediment supply from the upstream watershed (Kappesser, 2002).

As described in the North Fork TMDL report (IDEQ, 2001), the RSI "consists of a 200-particle count and size measurements on a transect across a stream riffle using the methods of Wolman (1954). With this information, a particle size distribution curve is developed for the riffle. A RSI involves an additional measurement of the 30 largest particles found deposited on the point deposition bar located immediately downstream of the riffle. The RSI value is the percentage of particles in the distribution curve smaller than the mean size of the largest particles deposited on the point bar. Since the largest particles on the point bar represent the largest streambed particles moved by the stream during the most recent channel altering event, the RSI provides an assessment of the percentage of the streambed materials mobilized during the event."

RSI was measured in 1991 and 1992 in 21 reference watersheds and 36 managed watersheds in the CDA Basin and nearby St. Joe subbasin, for a total of 160 samples (Kappesser, 2002). The index was measured on Rosgen B type channels with gradients of 2 to 4 percent and in most cases cobble-dominated beds. "The reference watersheds had a median RSI value of 58, whereas the managed watersheds had a median value of 80. The 75th percentile of the reference watershed RSI values was 72, which was close to the 25th percentile value of 68 for the managed watersheds" (Kappesser, 2002). RSI values above 85 were considered "indicative of riffles that are loading increasingly with excess sediment". RSI values between 70 and 85 "suggest that the riffle is somewhat loaded with sediment". RSI values below 40 represent riffles with "either a high bedrock component or riffles that have scoured". Scores between 40 and 70 presumably indicate conditions in dynamic equilibrium, where sediment is transported through the reach without deposition or scour.

A spreadsheet of RSI data for individual streams was provided by Mr. Kappesser. There were a total of 53 samples on 12 streams in the Little North Fork and Tepee Creek HUCs for streams that had been entered, meaning road building and timber harvest had taken place (Table 17, left section). There were a total of 22 samples on 4 streams in the Tepee Creek and Upper North Fork HUCs that had not been entered, meaning that no management activity had occurred other than possible salvage logging following the 1910 fire. Figure 22 shows the distribution of scores. The entered streams had a median score of 89 compared to 76 on the unentered streams. A single factor analysis of variance test (ANOVA) showed the two groups are significantly different at the 0.01 percent level.

Since inspection of the data revealed that C type channels tended to have higher scores, the statistics were calculated again for the smaller number of Rosgen B type samples (Table 17, right section). Results were similar and there was still a significant difference between entered and unentered streams at the 0.01 percent level.

Table 17. Riffle Stability Index results for Entered streams (roads and timber harvest) and Unentered streams (no entry following 1910 timber salvage) in the North Fork Subbasin

All Rosgen Types	**Riffle Stability Index**	
	Entered	**Unentered**
Number of samples	53	22
Mean	88	75
Median	89	76
Minimum	70	52
Maximum	99	95

Rosgen B Channels Only	**Riffle Stability Index**	
	Entered	**Unentered**
Number of samples	27	14
Mean	88	73
Median	88	74
Minimum	76	52
Maximum	96	87

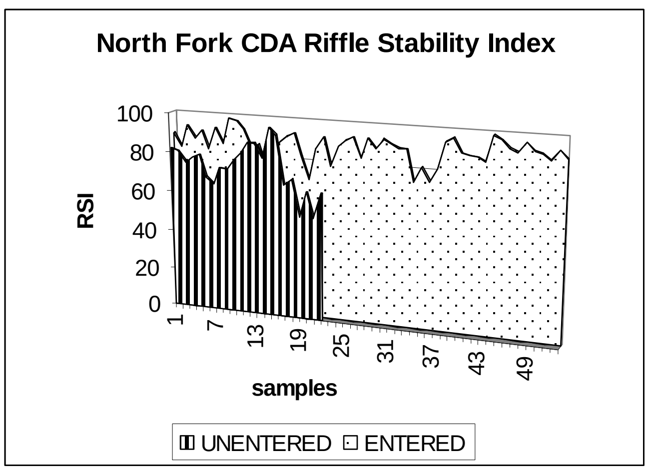


Figure 22. Riffle Stability Index results for Entered Streams (roads and timber harvest) and Unentered Streams (no entry following 1910 timber salvage) in the North Fork Subbasin

RSI scores measured in §303(d) listed stream segments (water quality impaired) in the North Fork subbasin were generally in the 80s and 90s with the exception of Tepee, Calamity and Yellowdog Creeks (Table 18, reported in IDEQ, 2001). These sites had a similar mean RSI score as the larger entered-stream data set presented above. RSI scores from non-impaired stream segments ("Low Development" sites in the final row of Table 18) had higher average RSI scores than the impaired segments, but this reported result appears unrepresentative of the larger data set presented above.

The North Fork subbasin RSI scores for both the entered and unentered streams are higher than for the regional study on the Idaho Panhandle National Forest described above. In addition to sedimentation issues, the high RSI scores could potentially reflect high bed mobility due to a system-wide lack of LWD and channel structure.

Table 18. Riffle Stability Indices (RSI) for the North Fork Subbasin, as reported in Tables 11 and 12 of the TMDL report (IDEQ, 2001). Scores were provided to IDEQ by Ed Lider, USFS.

Stream	HUC #	RSI Low	RSI Mean	RSI High
North Fork CDA River	3482	74	86	94
Tepee Creek	3508	53	56	61
Big Elk Creek	3511	86	87	89
Calamity Creek	5034	67	76	85
Yellowdog Creek	3506	68	72	72
Prichard Creek	3500	85	92	96
E. Fk. Eagle Creek	5617	80	85	85
North Fork CDA River	3481	90	93	94
Little North Fork CDA R.	3485	92	94	96
Copper Creek	3487	93	95	97
Burnt Cabin Creek	5032	97	97	98
Mean of the Listed Water Quality segments above:		**80**	**85**	**88**
Mean of North Fork CDA River, Low Development Segments	**various**	**85**	**89**	**94**

7.3.3 USGS Suspended Sediment Sampling

The USGS has collected water quality samples at a number of stream gages in the subbasin. Some of the samples at the North Fork Coeur d'Alene River at Enaville gage (USGS 12413000) included instantaneous measurements of total suspended sediment (TSS) concentration. Approximately 120 TSS measurements were taken between 1980 and 2004 at sporadic intervals, sometimes monthly, and often, less frequently. Suspended sediment concentration was low the majority of the time with values less than 15 mg/l TSS (Figure 23). Concentrations were highest at high streamflows, with the highest concentration of 220 mg/l TSS measured at a flow of 18,200 cfs. This pattern of low TSS concentrations rising to higher levels during peak flows is normal in gravel-bedded rivers.

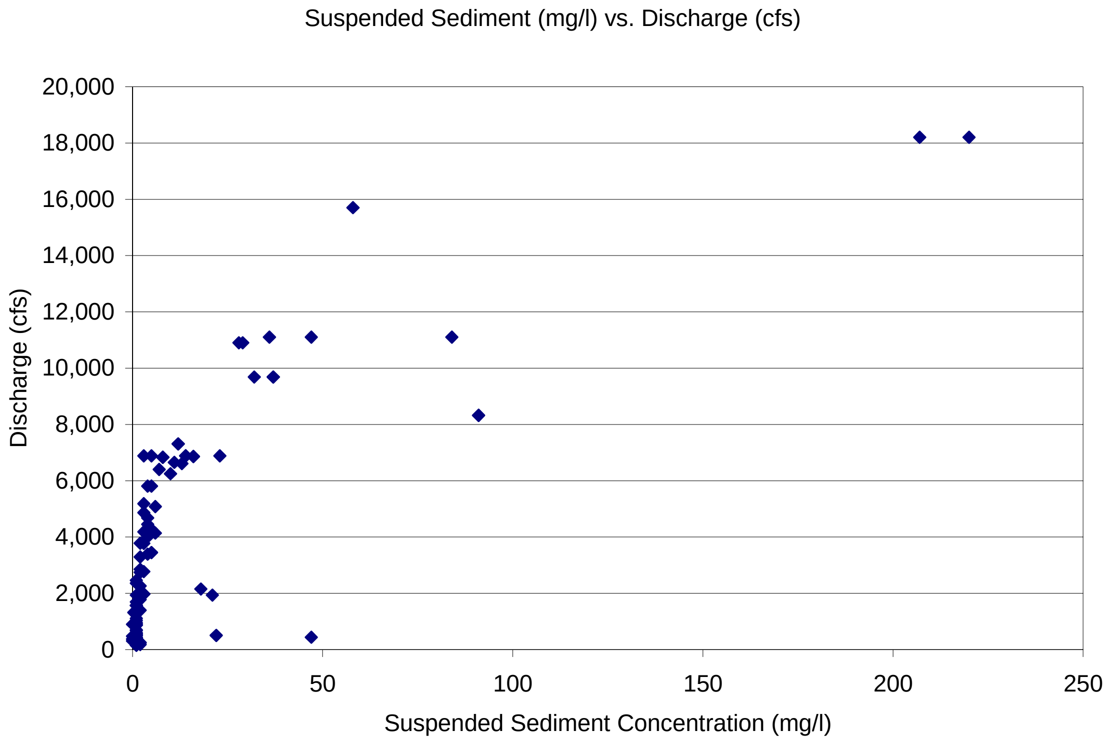


Figure 23. Suspended Sediment Measurements at the Enaville Gage (USGS 12413000).

8.0 AQUATIC RESOURCES & HABITAT

The Coeur d'Alene Basin is famous for its cutthroat trout fishing. With the extensive network of roads in the subbasin there is easy access to the river for fishing, and this coupled with the fabulous scenery, has created a popular fishing destination. The available information on fish populations and migration, and habitat conditions were compiled and reviewed. There have been several Master's and PhD thesis research projects and focused Forest Service studies. A large number of fisheries studies and research projects have been ongoing in the North Fork subbasin. Many of these studies had differing goals and addressed questions at differing scales, thus, not all data is comparable. In addition, over time Idaho Fish and Game (IDFG) has altered Fishing Harvest regulations making it difficult to determine trends over time in the entire North Fork subbasin. Table 19 provides an overview of reports reviewed for this project with summaries of their contents.

Table 19: Summary of applicable Fisheries Reports

Citation	Topic
Abbot, A. 2000. Land Management And Flood Effects On The Distribution And Abundance Of Cutthroat Trout In The Coeur d'Alene River Basin, Idaho. MS Thesis. University of Idaho.	1996 sampled 62 2nd & 3rd order tribs electrofishing. ✓ CT densities higher in NF Cda Tribs than Little NF ✓ Cutthroat present @ all sites ✓ Densities lower than 1995 sampling ~ due to flood. ✓ Compares densities to habitat variables – thesis does not provide variable values.
Bennett, D.H. and J. L. Dunnigan 1997. The Spatial Distribution of Westslope Cutthroat Trout in the Coeur d'Alene River System, Idaho. Completion Report Project Number INT 93 844 RJVA Department of Fish and Wild life Resources University of Idaho, Moscow.	1994 & 1995 sampled 73 2nd & 3rd order tribs electrofishing. ✓ CT densities higher in NF Cda Tribs (~2x) than Little NF ✓ Decrease 1994 to 1995 in NF tribs, no decrease in LNF ✓ Age 0 CT in tribs w/ area <60km^2 (headwater streams) ✓ Tested relationship to habitat based on visual estimates of complexity & FS data (no data summary in thesis)
Bowler, B. 1974. Coeur d'Alene River Study. Idaho Department of Fish and Game, Federal Aid in fish Restoration, F-53-R-9, 1974 Job Performance Report	Cited in Dupont 2005 – may be useful
Cross, D. and L. Everest 1995. Fish Habitat Attributes of Reference and Managed Watersheds with Special Reference to the location of Bull Charr Spawning sites in the Upper Spokane River Ecosystem, Northern Idaho.	Notes habitat in Little NF is less diverse than in 'reference' watersheds. Summary graphs of habitat parameters for entire drainage provide little site specific information.
DuPont, J, E, Lider, M. Davis, N. Horner. 2006 (In Press). Movement, Mortality And Habitat Use Of Coeur d'Alene River Cutthroat Trout IDFG Draft Report (In Press).	***** Excellent summary of radio telemetry study – provides key information for this report.

Citation	Topic
DuPont, Joe, N. Horner 2005. 2003 Annual Performance Report; Cutthroat Trout Trend Assessment. Idaho Fish and Game	Excellent Summary of Snorkel Survey Results 38 transects 1973 to 2003. ✓ 6 transects changed locations due to channel changes ✓ Counts of fish < age 1+ unreliable ✓ 43 transects snorkeled 8/2003 ✓ Highest densities in upstream reaches ✓ North fork slough (a side channel to main river) had highest density & temps 2^{o} cooler than main river. ✓ 1997 densities ~2x 1927 to 1981 densities – fishing regulations change ✓ 2003 densities of lg CT (>300mm) highest recorded ✓ Little NF densities declined 1973 to 1995 then increased in 2003 densities ~ same as 1973 ✓ Telemetry work (pending) in Teepee & LNF in winter fish move to floodplain reaches (refugia @ high flows ?) & larger CT group in cooler water ✓ Rainbow not stocked in 2003 fish observed were left over or naturally spawned. ✓ RB reproduction in NF downstream of Shoshone & in LNF downstream of Laverne ✓ Reaches with lowest CT density had highest rainbow density.
Harper, D.D., A.M. Farag. Biology data for the Pritchard Creek Watershed Idaho, 2000-2001. USGS open-file report 2004-xxxx – DRAFT DO NOT CITE	Focuses on trace metal concentrations and survival in stream biota. Fish abundance estimates may be useful.
Hartz, Mike. 1993. Beneficial Use Attainability Assessments of Streams in the Lake Coeur d'Alene Basin, Idaho. Idaho Department of Health and Welfare, Division of Environmental Quality, Boise, ID. 76 pgs.	Contains stream assessment results for 31 North Fork streams including summary of attainable uses and use support status with habitat scores for each segment surveyed. *Encompasses the North Fork Coeur d'Alene Watershed Basin*
Hunt, J.P. and T.C. Bjornn 1995. An evaluation of the status of fish populations and habitat in the North Fork of the Coeur d'Alene drainage. Project F-73-R-14, Subproject VI, Study 1, Job 1. University of Idaho, Moscow, Idaho.	Cited in Dupont 2005. Greater % of pools & runs upstream of Yellow dog than down stream.
Idaho Fish and Game: Fish Stocking Records Available at: http://fishandgame.idaho.gov/apps/stocking/year.cfm?region=1	Counts of fish stocked.
Lider and Davis. 2004. Coeur d'Alene River Ranger District Monitoring Report Preliminary Analysis of Water Temp and Fish Habitat Data.	Summary of Temperature & Habitat Data for entire CDA basin. Below are key points for NF ✓ 2003 temperatures cooler in side channels than main channels ✓ Prichard Creek below subsurface reach had notable cooler temperatures than main NF or Shoshone (upstream trib) ✓ Summary of Jordan Creek (trib above TP) restoration habitat monitoring shows improvement in pools, LWD & 45% increase in fish density
McGrath, K. 2003. Size variation and fitness consequences in age 0 Westslope cutthroat trout. Phd. Dissertation, University of Idaho, Moscow, ID.	Study of size variation in Age 0CT Focused on CT growth patterns at small scale – not very relevant to this project.
Meclay, David J. 1940. Tentative Fish Management Plan, Coeur d'Alene National Forest. USDA Forest Service, US Government Printing Office. Washington, DC. 23 pgs.	✓ Notes fish populations in SF eliminated ✓ Log drives disturbed habitat ✓ Headwaters & sm tribs closed (<25% of basin open to fishing) ✓ Bull Trout sampled between mouth & Yellow Dog Creek
USDA Forest Service, Idaho Panhandle National Forest. 2001. Iron Honey Final Environmental Impact Statement. USDA Forest Service, Idaho Panhandle National Forest, Coeur d'Alene Ranger District. Coeur d'Alene , ID. 447 pgs.	Good information summary for small portion of the watershed.

This portion of the report largely draws on findings from two key IDFG sampling efforts. In order to understand the population trends in the North Fork subbasin, IDFG set up snorkel survey transects in 1973 that have been snorkeled on a regular basis ever since (Bowler 1974; DuPont *et al*., 2003). In addition, IDFG conducted a radio tagging study on large cutthroat trout from May 2003 to June 2004 to evaluate the movement, mortality and habitat use of westslope cutthroat trout *Oncorhynchus clarki lewisi* in the Coeur d'Alene River basin.

This portion of the analysis report summarizes existing fish population and habitat information. The review of existing information focused on addressing the following questions:

1. What are the factors impacting cutthroat in the subbasin? How are they functioning?
2. Summary of fishing regulations and their influence on cutthroat populations.
3. Discussion on torrent and shorthhead sculpin as impairment indicator species.

8.1 WESTSLOPE CUTTHROAT TROUT FACTORS IMPACTING POPULATIONS

8.1.1 Fishing Mortality

Illegal harvest appears to be a major factor that has lead to the suppression of cutthroat trout ≥ 300 mm in length in the stream reaches where a limited harvest is allowed (Table 20). In these stream reaches, 75% (9 out of 12) of the radio tagged fish that were killed by fishermen were too small to keep. This illegal harvest contributed to a very high annual fishing mortality estimate (69%) for fish ≥ 300 mm in length in the lower North Fork HUC (DuPont *et al*., 2006).

Dupont *et al*. (2006) recommended concerted effort should be made in those reaches where non-compliance is significantly increasing fishing mortality. These areas include the lower North Fork HUC, lower 4 miles of Shoshone Creek, and the Little North Fork subwatersheds downstream of Laverne Creek. These efforts should include increasing the public's awareness of what the regulations are and the impacts non-compliance appears to be having on the fishery (post more signs and talk more with the public) as well as increasing enforcement activities. Michaelson (1983) found that where illegal harvest was suppressing a fishery in a lake, it took only a year after enforcement was significantly increased to see substantial improvements in the fishery.

8.1.2 Adult Summer Rearing Habitat and Cold Water Refugia

Adult westslope cutthroat trout in the North Fork River system used pool or run habitat in the summer where water depths exceeded 1 m, although depths > 2 m tended to be selected more highly (Dupont *et al*., 2006). The radio tagged fish were associated with some form of cover approximately 80% of the time. Where fish weren't found associated with cover it was often in areas where water depth exceeded 2 m, which would make it a form of cover in itself (Bjornn and Reiser, 1991). The radio tagged cutthroat trout showed the highest preference for large wood. Lider (document in preparation) found that within the upper Little North Fork (catch and release areas), in pools and runs, abundance of larger cutthroat (> 225 mm) were positively correlated with total cover with the highest densities being associated with woody debris and over hanging vegetation.

The results above suggest that deeper pool and run habitat with cover are not limited within the lower North Fork HUC, and lower Little North Fork (downstream of Laverne Creek). In the Shoshone Creek subwatershed, upper North Fork, and upper Little North Fork, both the abundance of pools and runs as well as their depths are limited. Within the middle North Fork HUC, Tepee Creek HUC, and Prichard Creek HUC, pools and runs are more abundant but they are shallow. None of the watersheds studied appeared to have considerable cover, especially large wood which the radio tagged cutthroat trout showed the greatest preference for. Adult cutthroat trout abundance in Prichard Creek may also be limited due to subsurface flows and elevated concentrations of heavy metals.

During 2003, water temperatures in the North Fork downstream of Tepee Creek exceeded 22° C. Dupont *et al*. (2006) found that radio tagged fish utilized four different strategies to cope with this high water temperature. This included: 1) moving short distances (< 5 km) to areas where cold water refugia occurred (4-9°C cooler than what occurred in the main river channel), 2) moving to the mouths of tributaries, 3) moving into tributaries and, 4) moving into side channels with cold water upwellings. Approximately half the radio tagged fish used one of these strategies while the other half appeared to move into shaded areas under cover such as undercut banks, large woody debris or boulders. Side channels appear to be the most important form of cold water refugia in the lower North Fork HUC as 50% of all radio tagged fish that utilized this area during late July/early August were located in side channels. Unfortunately, side channel habitats are limited in number.

Based on stream temperature work by Dupont *et al*., water temperature appeared to increase as it flowed through confined reaches (little floodplain exists), and decreased when it flowed through unconfined areas with wide floodplains. For example the highest water temperatures (27° C) were observed in the main North Fork River near Shoshone and Prichard Creeks which is mostly confined in nature. Approximately 8 km downstream of Prichard Creek the river entered a wide floodplain and temperatures continually declined to the point where they never reached 22° C in much of the free flowing reach of the river. This same cooling pattern was also observed in the Little North Fork as temperatures decreased in the lower watershed where a wide floodplain occurs. This cooling process can be explained by the large volume of water that flows subsurface through floodplains (hyporheic zone). Where this cooler subsurface flow mixes with surface water it causes cooling of the river. Reducing the hyporheic zone through road building, diking, or other means can greatly reduce the amount of subsurface flow that occurs and its ability to cool the river (Brunke and Gonser, 1997). Without this cooling effect that was observed in the North Fork system, the researchers believe that much of the lower river would frequently reach water temperatures that would not support salmonids. For this reason, Dupont *et al*. recommend that future activities that may occur within floodplains, need to be carefully planed to insure that floodplains maintain their fully functioning benefits.

8.1.3 Over-Winter Habitat

An abundance of research has shown that smaller cutthroat trout utilize different habitat than larger fish during winter. Cutthroat trout <200 mm are typically found utilizing the voids in a stream's or river's substrate (Heifetz *et al*. 1986, Bjornn and Reiser 1991, Griffith and Smith 1993, Bonneau 1994, Power *et al*. 1999). As cutthroat trout get larger they may not be able to use the voids in the substrate and would be forced to utilize different habitat (Bjornn and Reiser, 1991). Cutthroat trout > 200-300 mm have been found to utilize slow deep pools in larger river systems in the winter (Thurow 1976, Lewynsky 1986, Bjornn and Reiser 1991, Hunt 1992, Schmelterling 2001). Loss of critical pool habitat could theoretically have a large impact on a cutthroat trout fishery, especially in those systems where fish appear to congregate in only a few pools.

The habitat use data (Dupont *et al*., 2006) showed that radio tagged cutthroat trout tended to move to areas with wider floodplains during winter. In fact, all the radio tagged fish that utilized river reaches where confined valley types occurred (upper North Fork HUC) migrated from these areas at the onset of winter (November) to where the river valley spread out and wide floodplains occurred. It appears the presence of a floodplain can be a key factor in winter habitat selection for many cutthroat trout populations in larger river systems. The presence of floodplains may provide several benefits. Winter rain-on-snow events which are common in northern Idaho can cause increases in energy expenditure by fish during a critical period of survival. With adjacent floodplains, cutthroat trout can move out of the main flow where they can conserve energy.

Another benefit floodplains may play in providing important over-winter habitat is they usually maintain hyporheic flows. Where these subsurface flows mix with surface water, warmer temperatures often occur in the winter (Cunjack 1996, Brunke and Gonser 1997, Power *et al*. 1999). Two radio tagged fish were documented using off channel areas during late winter that were 2-3° C warmer than the main river.

Dupont *et al*. (2006) found that the radio tagged fish congregated in only one area during winter, and that was in the lower 3.5 km of Tepee Creek and in the North Fork River within 4 km of Tepee Creek. Approximately 2.3 km (66%) of where the radio tagged fish over-wintered in Tepee Creek is privately owned. Many of the property owners along this reach of stream have cleared the trees and brush away from the floodplain and now maintain them in lawn like conditions. Many of these stream reaches are now experiencing severe bank erosion, and appear to be losing their cover, depth and pool habitat. Continued degradation in this area could lead to reductions of this important over-winter habitat and could be detrimental to the Tepee Creek fishery as it appears that all the adult cutthroat trout in Tepee Creek over-winter in this area. Efforts need to be made to educate these land owners on the importance of this reach of stream to the fishery as well as working with them in improving this critical habitat.

8.1.4 Spawning migrations

Dupont *et al*. (2006) found that radio tagged cutthroat trout made fast migrations. They quickly spawned and returned back to the main river which prevented the researchers from locating their exact spawning location. Often the fish disappeared for two or more weeks and then reappeared where they spent the previous summer. The radio tagged cutthroat trout appeared to spread out and spawn in different tributaries, however, 9 out of 22 of the radio tagged cutthroat trout that were believed to have spawned, spawned in the Tepee Creek HUC. Fish utilizing the lower North Fork, upper North Fork, Shoshone Creek, and Tepee Creek HUCs during the spring, summer, and fall, all spawned in the Tepee Creek HUC. These findings suggest that the Tepee Creek HUC is important to spawning to the entire Coeur d'Alene River basin cutthroat fishery.

Efforts to protect or improve spawning habitat in this watershed could be important in maintaining and improving this cutthroat trout fishery.

The radio tagged cutthroat trout that utilize the lower North Fork HUC demonstrated the longest migrations and spawned in the most widespread areas. These movements suggest that fish from many areas contribute to the population in the lower North Fork HUC which may be helping to maintain this fishery at a low level. However, the high fishing mortality that was documented in this area may also be selecting against fish that have long spawning migrations. This could be important as these longer migrating fish utilized over-winter habitat that may be less susceptible to flood events and extreme cold weather events. During extreme cold winters and winter flood events, fish utilizing the river in the lower watershed could have significantly higher survival than upstream reaches. This assumption is supported by comparing the snorkel trend data in the North Fork River between lower and upper elevation transects. In the upper elevation transects, the two lowest densities of cutthroat trout ever observed occurred after extremely cold winters whereas this was not observed in both years in the lower elevation transects (DuPont *et al*., 2003). If cold winters have less of an effect on cutthroat trout overwintering in lower elevation reaches, such as the lower North Fork HUC, these fish could be instrumental in helping to repopulate the fishery if significant declines related to extreme winter events occurred.

8.2 FISHING REGULATIONS

With a better understanding of the movement patterns of cutthroat trout in the North Fork subbasin, DuPont *et al*. (2006) recommend improvements to the fishing regulations that would increase opportunities for anglers as well as protect areas that appear important to survival of cutthroat trout (see Table 20 for history of fishing regulations). Currently, harvest is allowed in areas where the largest congregations of fish were observed during the open fishing season, such as in some side channels in the lower North Fork HUC, at the mouth of Prichard Creek, and in lower Shoshone Creek. These fish moved into these congregations during stressful times (warm water temperatures) which makes them more vulnerable to anglers at a time when they need the most protection. The areas that appear to receive the least amount of fishing pressure (upper North Fork HUC, and Little North Fork upstream of Lavern Creek) are listed as catch-and-release. In the Little North Fork HUC, it appears that after spawning, most large fish migrate downstream into the area of allowable harvest. This is not surprising as this stretch of river has the most pools, deepest waters, and wide floodplain. As a result, the catch-and-release area in this HUC does not provide much protection to this cutthroat trout fishery.

Dupont *et al*. (2006) do not believe that the current fishing regulations allow cutthroat to reach their potential in the North Fork subbasin with the non-compliance of fishing regulations that was observed. Changing the lower reaches of river to catch-and-release would provide an area with easy access where people would have a better chance of catching larger, long lived cutthroat trout.

Table 20. History of fishing regulations for cutthroat trout in the Coeur d'Alene River, Idaho.

Year	CdA Lake to Yellow Dog Creek	Yellow Dog Creek to headwaters	Laverne Creek to headwaters (LNFCdA)
1941-1945	15 lbs plus 1 fish - not to exceed 25 fish		
1946-1950	10 lbs plus 1 fish - not to exceed 20 fish		
1951-1954	7 lbs plus 1 fish - not to exceed 20 fish		
1955-1971	7 lbs plus 1 fish - not to exceed 15 fish		
1972-1974	7 lbs plus 1 fish - not to exceed 10 fish		
1975	7 lbs plus 1 fish - not to exceed 10 fish	3 fish, none < 13 inches	
1976	10 fish, only 5 > 12 inches & 2 > 18 inches	3 fish, none < 13 inches	
1977-1985	6 fish, only 2 > 16 inches	3 fish, none < 13 inches	
1986-1987	6 fish, only 2 > 16 inches	Catch-and-release	3 fish, none < 13 inches
1988-1999	1 fish, none < 14 inches	Catch-and-release	
2000-2004	2 fish, none between 8"-16"	Catch-and-release	

8.3 TORRENT AND SHORTHHEAD SCULPIN AS IMPAIRMENT INDICATOR SPECIES

Several recent studies have suggested the utility of using sculpins as impairment indicator species (Maret and MacCoy 2002, MeBane 2001). Sculpins are apparently less mobile than salmonids, they are not stocked and are seldom harvested (MeBane, 2001) which are all confounding factors in relating the abundance of salmon or trout to the ambient habitat conditions. Because sculpins live on and near the stream bottom and feed predominantly on benthic invertebrates they are more likely to come in contact with contaminated bed sediment than the more mobile salmonids (Maret and MacCoy, 2002). Maret and MacCoy (2002) found that streams located downstream from areas of intensive hard rock mining in the Coeur d'Alene River basin did not support sculpins, suggesting they are more severely affected by elevated metals than salmonids. However, while these studies suggest sculpin presence or absence may be indicative of habitat contamination of fine sediment levels, the studies do not provide any specific metrics. Following is a brief discussion of the life history and habitat requirements of the sculpin species occurring in the North Fork subbasin.

Torrent sculpin, *Cottus rhotheus*, has been found within the mainstem North Fork River and larger tributary streams. Their preferred habitat is riffle habitat in medium to wide streams and rivers (Markle *et al*., 1996). Large adults (>150 mm) are found in pools. Spawning usually occurs in May and June and occurs in riffles with moderate to swift flows. The range of torrent sculpin, a cold water species, overlaps with both westslope cutthroat and historic bull trout. Torrent sculpins are one of the longer-lived cottid species, and can live up to seven years and reach a maximum size of about 155 mm. Torrent sculpins eat a large variety of prey; larger organisms can be consumed because torrent sculpins have large mouths (Scott and Crossman 1973, Wydoski and Whitney 1979, Lee *et al*. 1980).

The shorthead sculpin, *Cottus confuses,* is very difficult to identify and it generally resembles the mottled sculpin *(Cottus bairdi)* and the slimy sculpin *(Cottus cognatus).* Home range size, dispersal, and mating system are undocumented, although Gasser *et al*. (1981) provide some evidence that adults in Idaho are relatively sedentary. Spawning occurs in April in Idaho (Gasser *et al*., 1981). Eggs are laid in burrows on the undersides of rocks (Lee *et al*. 1980, Roberts 1988). Males guard nests once eggs are laid, and hatching probably occurs in two or three weeks (Roberts, 1988). Adults live at least four or more years (Wydoski and Whitney 1979, Gasser *et al*. 1981).

9.0 REFERENCES

Bicknell, B.R., Imhoff, J.C., Kittle, J.L., Jr., Donigian, A.S., Jr., and Johanson, R.C. 1997. Hydrological Simulation Program--Fortran, User's manual for version 11. U.S. Environmental Protection Agency, National Exposure Research Laboratory, Athens, Ga., EPA/600/R-97/080, 755 p.

Box, S.E., J.C. Wallis, P.H. Briggs, and Z.A. Brown, 2005. Stream-Sediment Geochemistry in Mining-Impacted Streams: Prichard, Eagle, and Beaver Creeks, Northern Coeur d'Alene Mining District, Northern Idaho. USGS Scientific Investigations Report 2004-5284. http://pubs/usgs/gov/sir/2004/5284

Chen, C.W., J. W. Herr and L.H.Z. Weintraub. 2001. Watershed Analysis Risk Management Framework: Update One: A Decision Support System for Watershed Analysis and Total Maximum Daily Load Calculation, Allocation and Implementation, EPRI, Palo Alto, CA Available on line at: http://www.epa.gov/athens/wwqtsc/html/warmf.html

Chen, C.W., J. W. Herr, R. A. Goldstein, G. Ice and T. Cundy. 2005. Retrospective Comparison of Watershed Analysis Risk Management Framework and Hydrologic Simulation Program Fortran Applications to Mica Creek Watershed. Journal of Environmental Engineering., Volume 131, Issue 9, pp. 1277-1284

Cross, D. and L. Everest, 1995. Fish habitat attributes of reference and managed watersheds with special reference to the location of bull charr (Salvelinus confluentus) spawning sites in the upper Spokane River ecosystem, northern Idaho. Fish Habitat Relationships Technical Bulletin #17, USDA-US Forest Service. 6p.

Daly, C., R.P. Neilson, and D.L. Phillips. 1994. A Statistical-Topographic Model for Mapping Climatological Precipitation over Mountainous Terrain. Journal of Applied Meteorology 33:140-158.

Daniele. T., C. Luce, J. Buffington, S. Ali', J. Barry, S. Clayton, B. Rieman, P.Goodwin and C. Berenbrock. DRAFT. Hydrological and Geomorphic Responses to Forest Management in North Idaho. Rocky Mountain Research Station, 322 E Front St., Suite 401, Boise, ID

Doten, C.O. and D.P. Lettenmaier. 2004. Prediction of Sediment Erosion and Transport with the Distributed Hydrology-Soil-Vegetation Model, Water Resources Series, Technical Report 178, University of Washington, Seattle.

DuPont, J, E, Lider, M. Davis, N. Horner. 2006 (In Press). Movement, Mortality And Habitat Use Of Coeur D'alene River Cutthroat Trout IDFG Draft Report (In Press).

DuPont, J. and N. Horner. 2003. Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Fish Restoration, F-71-R-28, Job c-2, 2003 Job Performance Report, Boise, Idaho

Gasser, K. W., D. A. Cannamela, and D. W. Johnson. 1981. Contributions to the life history of the shorthead sculpin, Cottus confusus, in the Big Lost River, Idaho: age, growth, and fecundity. Northwest. Sci. 55:174-181.

Grafe, C. S. (editor). 2002. Idaho stream ecological assessment framework: an integrated approach. Idaho Department of Environmental Quality: Boise, ID. 276pp.

Grafe, C. S., C. A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, and D. T. Mosier. 2002. The Idaho Department of Environmental Quality waterbody assessment guidance, second edition-final. Idaho Department of Environmental Quality: Boise, ID.

Hartz, M., 1993. Beneficial use attainability assessment of streams of the Lake Coeur d'Alene Basin, Idaho. Idaho Dept. Health and Welfare, Division of Environmental Quality, Coeur d'Alene, Idaho. 76 p.

HEC (Hydrologic Engineering Center). 1981. HEC-1 Flood Hydrograph Package – Users Manual. US Army Corps of Engineers, Davis, CA. Available on-line at: http://www.hec.usace.army.mil/software/legacysoftware/hec1/hec1-documentation.htm

IDEQ. 2001. Subbasin Assessment and Total Maximum Daily Loads of the North Fork Coeur d'Alene River (17010301). 116p.

Interagency Advisory Committee on Water Data. 1982. Guidelines for determining flood-flow frequency: Bulletin 17B of the Hydrology Subcommittee, Office of Water Data Coordination, U.S. Geological Survey, Reston, Va., 183 p.

Kappesser, G., 1993. Riffle stability index. Idaho Panhandle National Forest, USDA-U.S. Forest Service, Coeur d'Alene Idaho. 10 pp.

Kappesser, G., 2002. A riffle stability index to evaluate sediment loading to streams. J. American Wat. Res. Assn., v. 38, no. 4, p.1069-1081.

Knighton, D. 1984. Fluvial forms and processes. Edward Arnold, Baltimore, MD. 218 pages.

Lamarche, J., and D.P. Lettenmaier. 2001. Effects of Forest Roads on Flood Flows in the Deschutes River Basin, Washington, Earth Surf. Process. Landforms, 26, 115-134.

Lewis, R.S. and P.D. Drkey, 1999. Digital geologic map of part of the Thompson Falls 1:100,000 quadrangle, Idaho. USGS Open-File Report 99-438. By Reed S. Lewis and Pamela D. Derkey. Prepared in cooperation with the Idaho Geological Survey. 1999.

Lewis, R.S., R. F. Burmester, R. M. Breckenridge, M. D. McFaddan, and J. D. Kauffman, 2002. Geologic Map of the Coeur d'Alene 30 x 60 Minute Quadrangle, Idaho. Idaho Geological Survey Map GM-33.

Lisle, T. E., 1982. Effects of aggradation and degradation on riffle-pool morphology in natural gravel channels, northwestern California. Water Resources Res. v. 90, no. 6, p. 1643-1651.

Mantua, N. 2001. The Pacific Decadal Oscillation. In: Encyclopedia of Global Environmental Change, Volume 1 The Earth System: Physical and Chemical Dimensions of Global Environmental Change. John Wiley & Sons.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific decadal climate oscillation with impacts on salmon. Bulletin of the American Meteorological Society 78:1069-1079.

Maret, T.R and D.E. MacCoy 2002. Fish Assemblages and Environmental Variables Associated with Hard Rock Mining in the Coeur d"Alene river basin, Idaho. Trans. Am Fish soc. 131: 865-884.

Markle, D.F., D.L. Hill, and C.E. Bond. 1996. Sculpin identification workshop working guide to freshwater Sculpins of Oregon and adjacent areas. Oregon State

MeBane , C.A.2001. Testing Bioassessment Metrics: Macroinvertebrates, Sculpin And Salmonid Responses To Stream Habitat Sediment and Metals. Environmental Monitoring and Assessment 67:293-322.

Minobe, S. 1997. A 50-70 year climatic oscillation over the North Pacific and North America. Geophysical Research Letters 24:683-686.

Montgomery, D.R. and J.M. Buffington, 1997. Channel reach morphology in mountain drainage basins: Geological Society of America Bulletin, v. 109, p. 596-611.

Montgomery, D.R., Buffington, J.M., Smith, R.D., Schmidt, K.M., and G. Pess, 1995. Pool spacing in forest channels: Water Resources Research, v. 31, p. 1097-1105.

Moore, R.D. and S.M. Wondzell. 2005. Physical hydrology and the effects of forest harvesting in the Pacific northwest: a review. Journal of the American Water Resources Association 41(4):763-784.

Mote, P., M. Holmberg, and N. Mantua. 1999. Impacts of climate variability and change - Pacific Northwest. A report of the Pacific Northwest Regional Assessment Group for the US Global Change Research Program. Prepared by the JIASO/SMA Climate Impacts Group, University of Washington. JISAO Contribution #715

Munts, S.R. 2000. Digital Geologic Map of the Coeur d'Alene 1:100,000 Quadrangle, Idaho and Montana. Open-File Report 00-135. Digital Compilation by Steven R. Munts. Originally compiled by A.B. Griggs in the 1:250,000 Spokane Quadrangle. 2000.

NRCS (Natural Resources Conservation Service). 2005. Climate data for several SNOTEL stations and snow course sites in and around the NFCDA Subbasin. Available on-line at http://www.wcc.nrcs.usda.gov/snow/

OCS (Oregon Climate Service). 1998. Average monthly and annual precipitation, 1961-1990 for the Western United States. Oregon Climate Service, Oregon State University, Strand Hall Corvallis, OR 97331. Digital maps available at http://www.ocs.orst.edu/prism/

Roberts, W. 1988. The sculpins of Alberta. Alberta Nat. 18:121-127, 153.

Rosgen, D., 199?. Reference reach field book. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D., 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO.

Ruebke, John. 2003. Steamboat Aquatic Restoration Area. USDA Forest Service, Coeur d'Alene River Ranger District. Coeur d'Alene, ID

SCS (Soil Conservation Service). 1994. Coeur d'Alene River cooperative river basin study. U.S. Department of Agriculture-Soil Conservation Service, 3244 Elder, Boise ID 83709. 68p.

Tarboton, D.G. and H.C. Luce. 1996. Utah energy balance snow accumulation and melt model (UEB), computer model technical description and users guide. Utah Water Research Laboratory and USDA Forest Service Intermountain Research Station.

Thyer, M., J. Beckers, D. Spittlehouse, Y. Alila, and R. Winkler. 2004. Diagnosing a distributed hydrologic model for two high-elevation forested catchments based on detailed stand- and basin-scale data, Water Resources Research 40, W01103, doi:10.1029/2003WR002414.

US Forest Service, 1974. Flood damage report, Panhandle National Forest, Fernan District. Typed manuscript, 15 pp.

US Forest Service, 1997. Terrestrial characterization, Step 1 of Ecosystem analysis, Coeur d'Alene geographic area assessment. Unpublished manuscript dated 1/16/97, 22 pp.

US Forest Service, Idaho Panhandle National Forest. 1998. Toward an Ecosystem Approach: An Assessment of the Coeurd'Alene River Basin, Ecosystem paper #4.

US Forest Service, Idaho Panhandle National Forest. 1998. Watershed conditions spread sheet in support of Toward an Ecosystem Approach: An Assessment of the Coeurd'Alene River Basin, Ecosystem paper #4.

US Forest Service, 1998. Watershed characterization: Coeur d'Alene River Basin. Unpublished manuscript, 29 pp.

USGS (US Geological Survey). 2005. Peak flow data for stream gages within the NFCDA Subbasin. Available on-line at http://nwis.waterdata.usgs.gov/id/nwis/sw

USGS (US Geological Survey). 1999. National Land Cover Data Set, Edition: 1. 1 arc second (approximately 30 meter) raster digital data set. U.S. Geological Survey, Sioux Falls, SD. Available on-line at http://seamless.usgs.gov/

Wigmosta, M.S., L. Vail, and D. P. Lettenmaier, 1994. A distributed hydrology-vegetation model for complex terrain, Wat. Resour. Res., 30, 1665-1679.

Wolman, M.G., 1954. A method of sampling coarse riverbed materials. Transactions American Geophysical Union 35(6):951-956.

WRCC (Western Regional Climate Center). 2005. Climate data for several stations in and around the NFCDA Subbasin. Western Regional Climate Center, 2215 Raggio Parkway, Reno, NV Available on-line at: http://www.wrcc.dri.edu/

APPENDIX 1 – HYDROGRAPHS FOR ALL STREAM GAGES

Note: Annual peak flows at USFS stations are peak mean daily flow values; instantaneous values were not provided in time to be included in this report. Refer to Figure 8 in the report for gage locations, characteristics, and period of record.

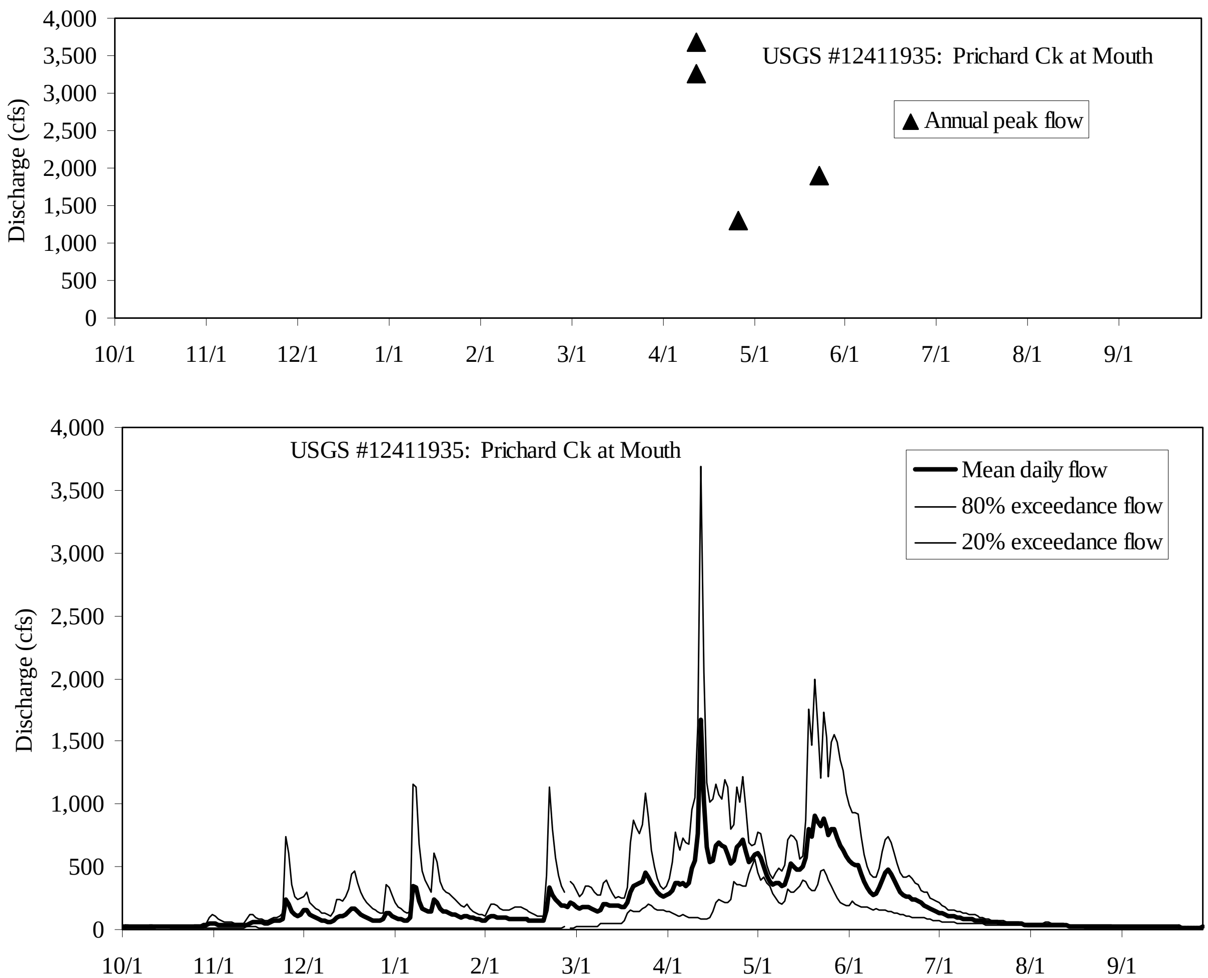


Figure 24. Mean daily flow (bottom) and annual peak flows (top) at USGS gage #12411935, Prichard Creek at mouth at Prichard, Idaho.

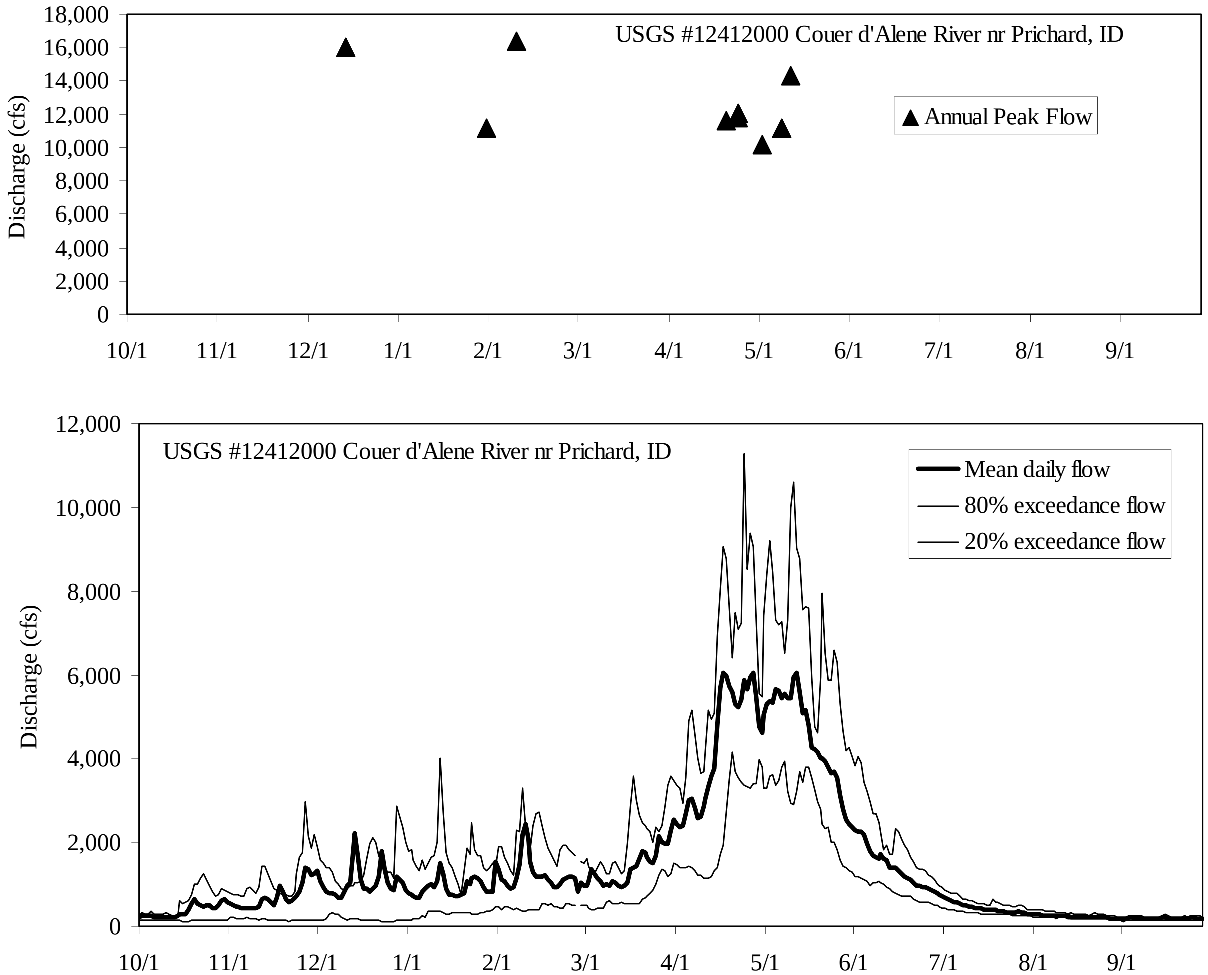
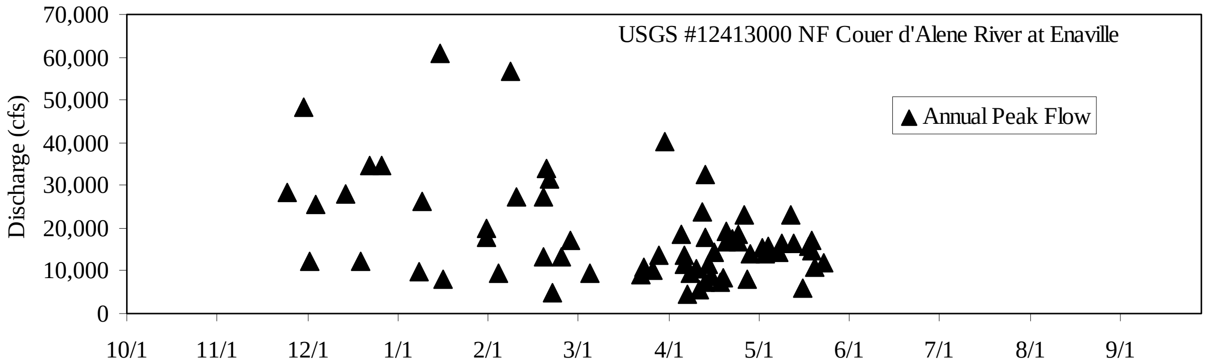


Figure 25. Mean daily flow (bottom) and annual peak flows (top) at USGS gage #12412000, Coeur d'Alene River near Prichard, Idaho.



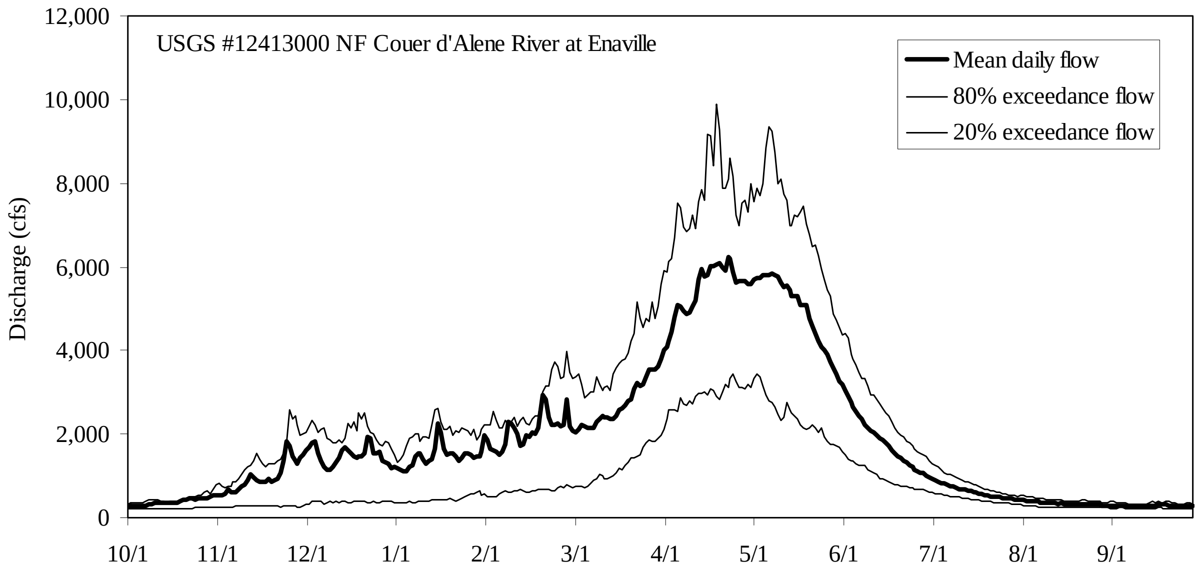


Figure 26. Mean daily flow (bottom) and annual peak flows (top) at USGS gage #12413000, North Fork Coeur d'Alene River at Enaville, Idaho.

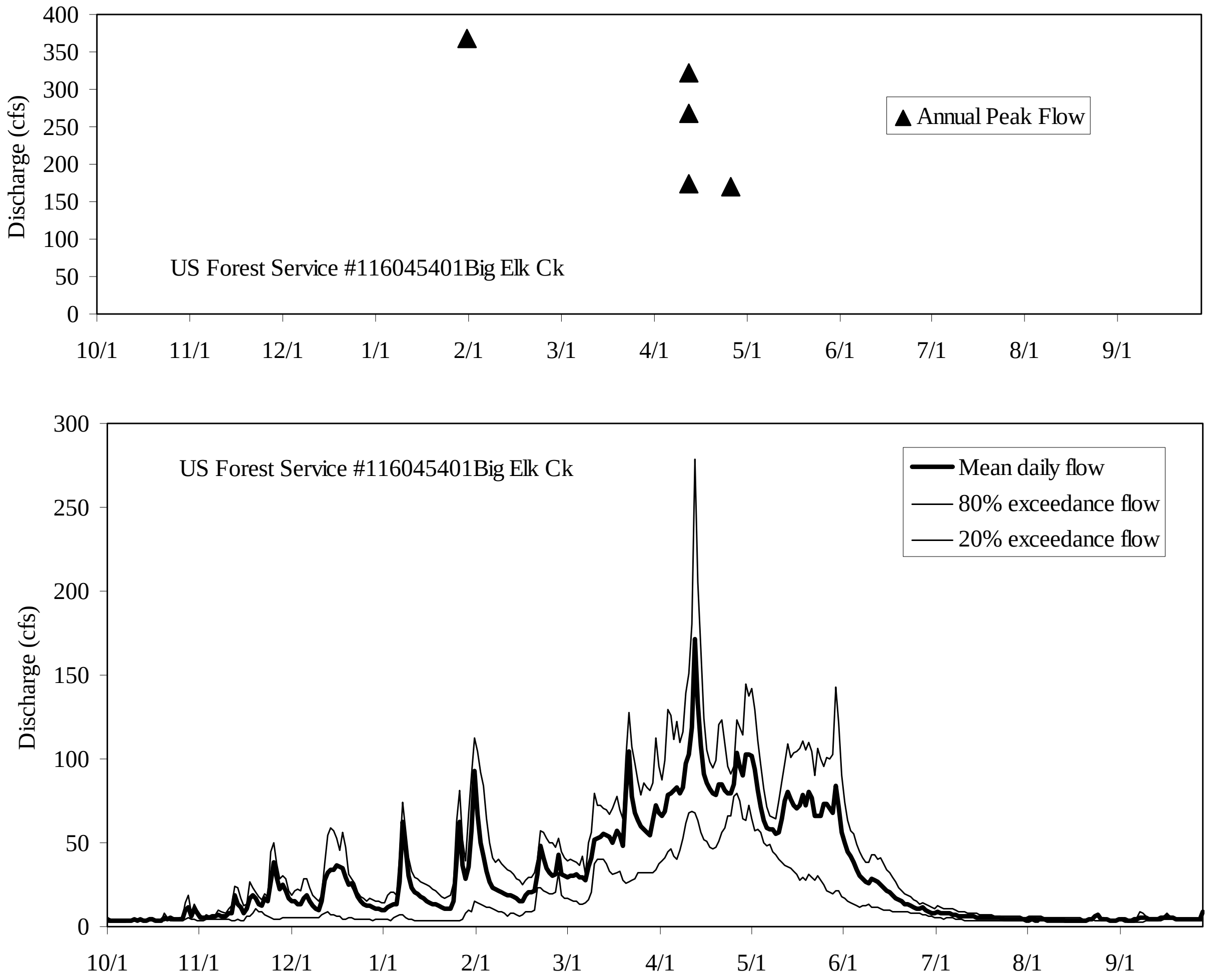


Figure 27. US Forest Service Big Elk Creek. NOTE: Only shows data from 2000-2004

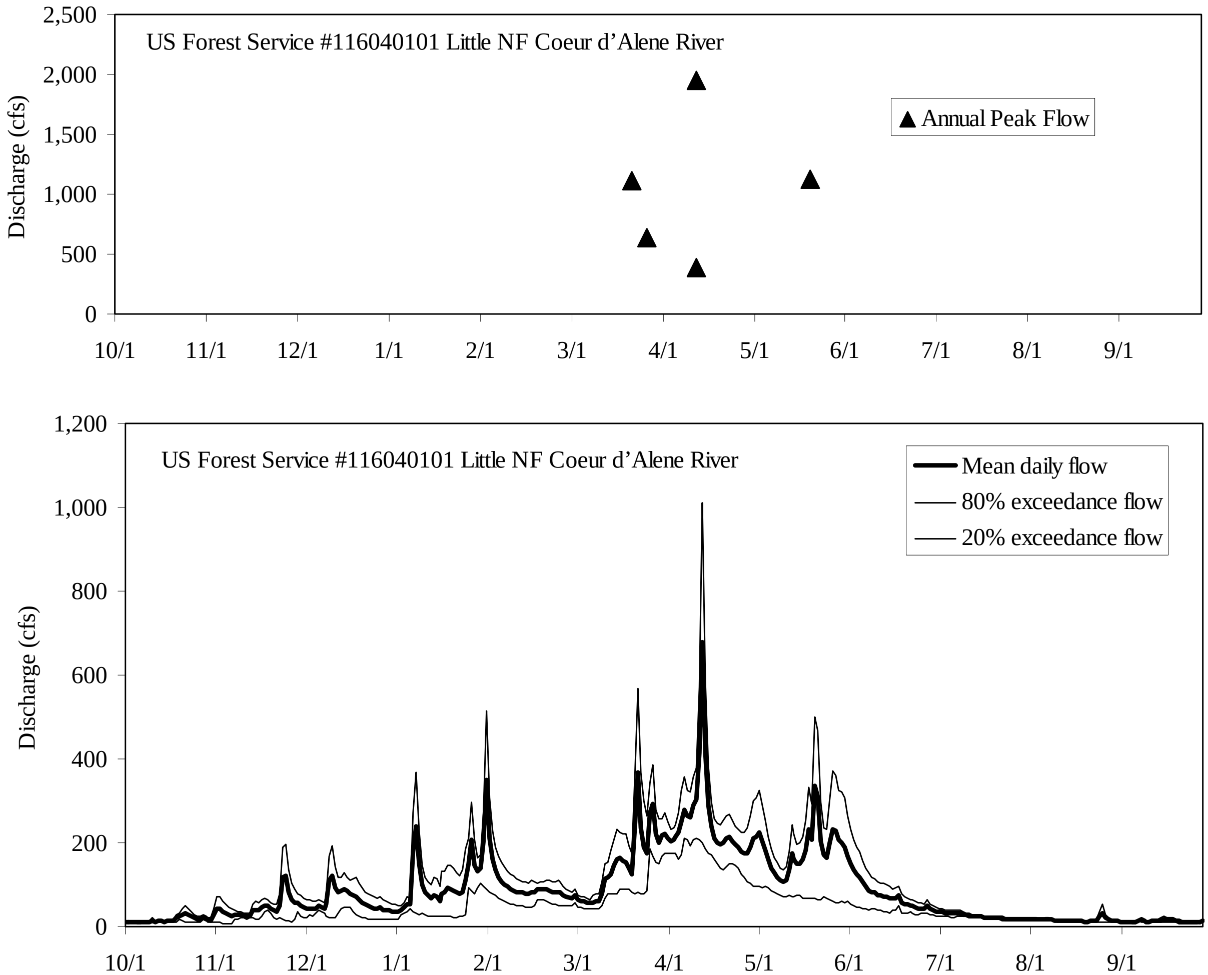
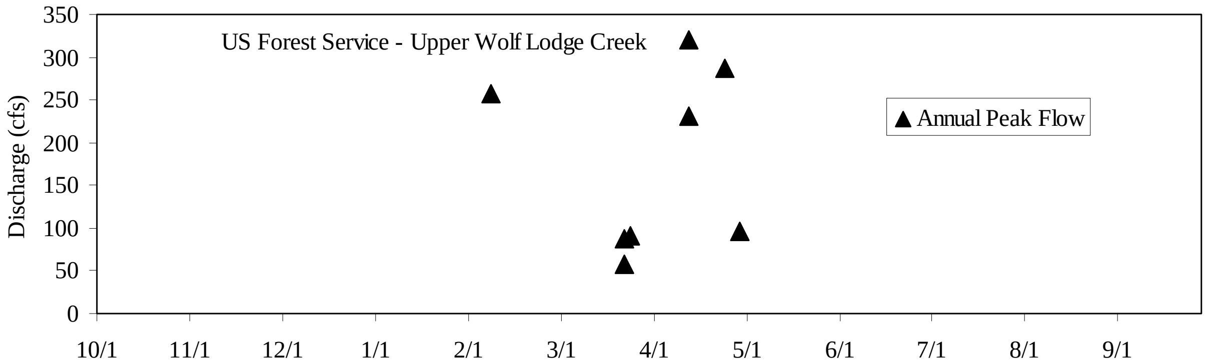


Figure 28. US Forest Service LNFCDA gage



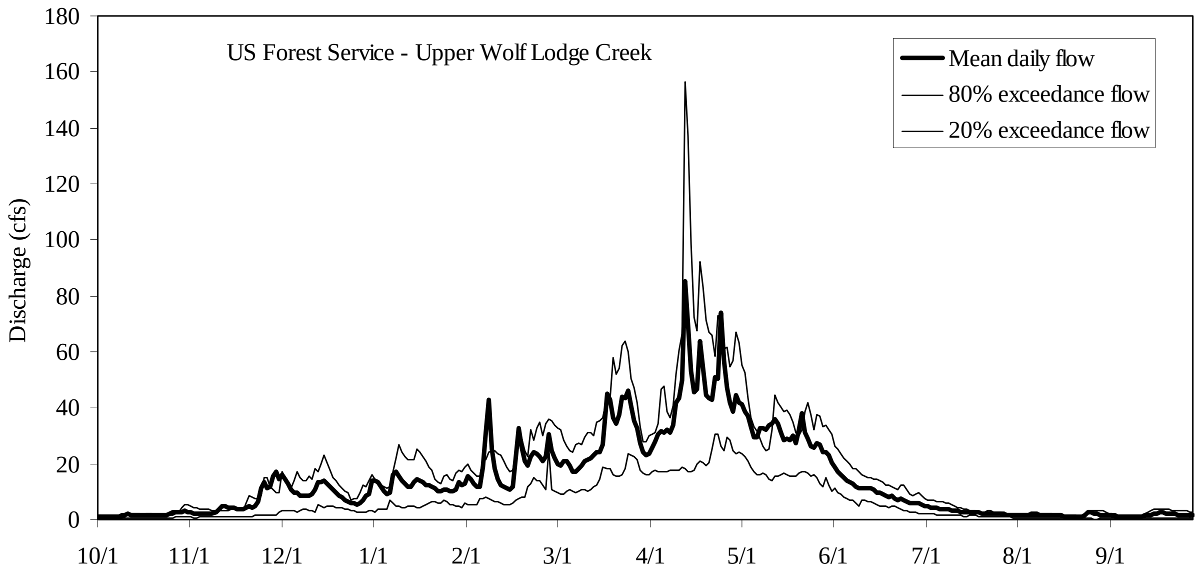


Figure 29. Upper Wolf Lodge Creek gage

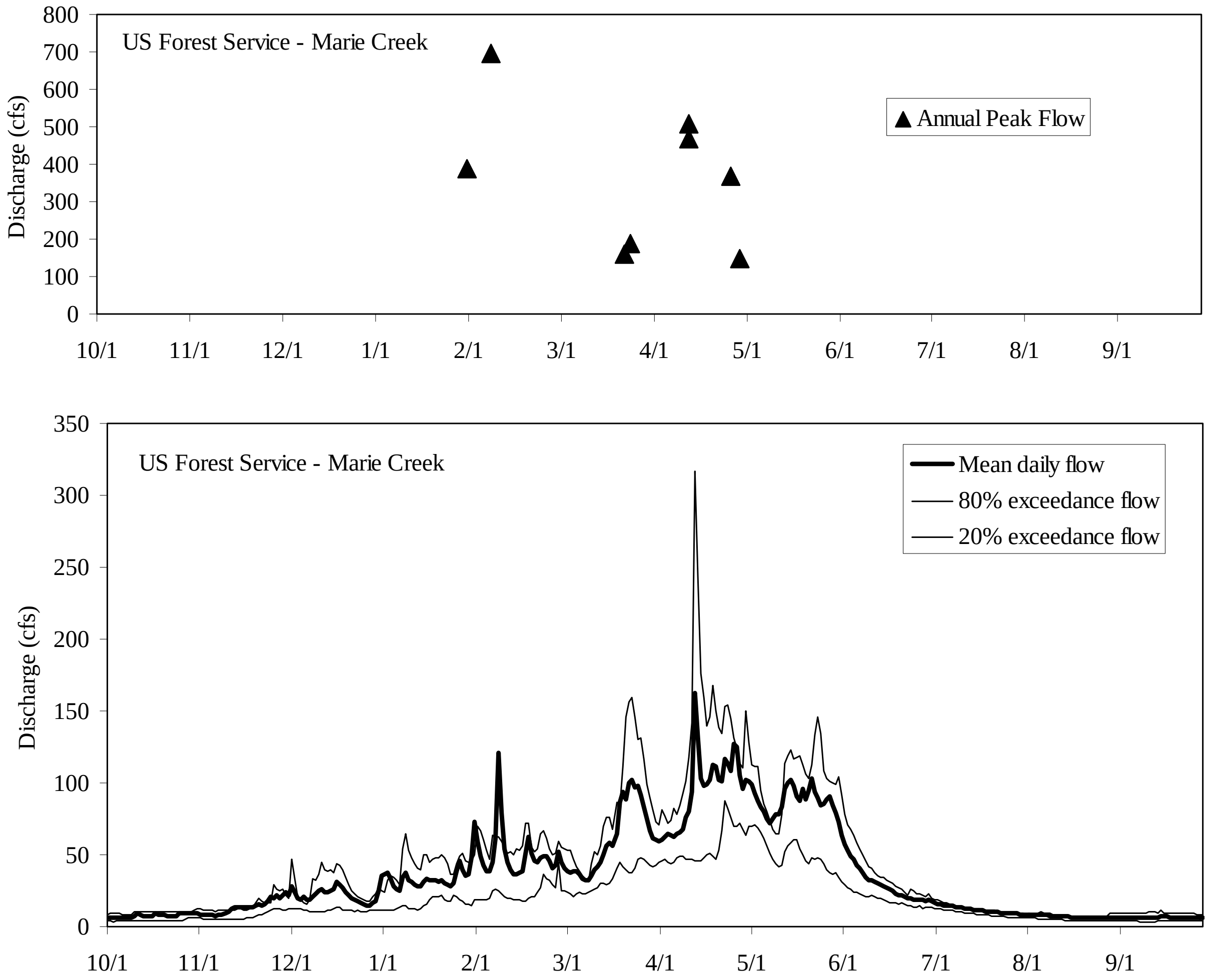


Figure 30. Marie Creek gage