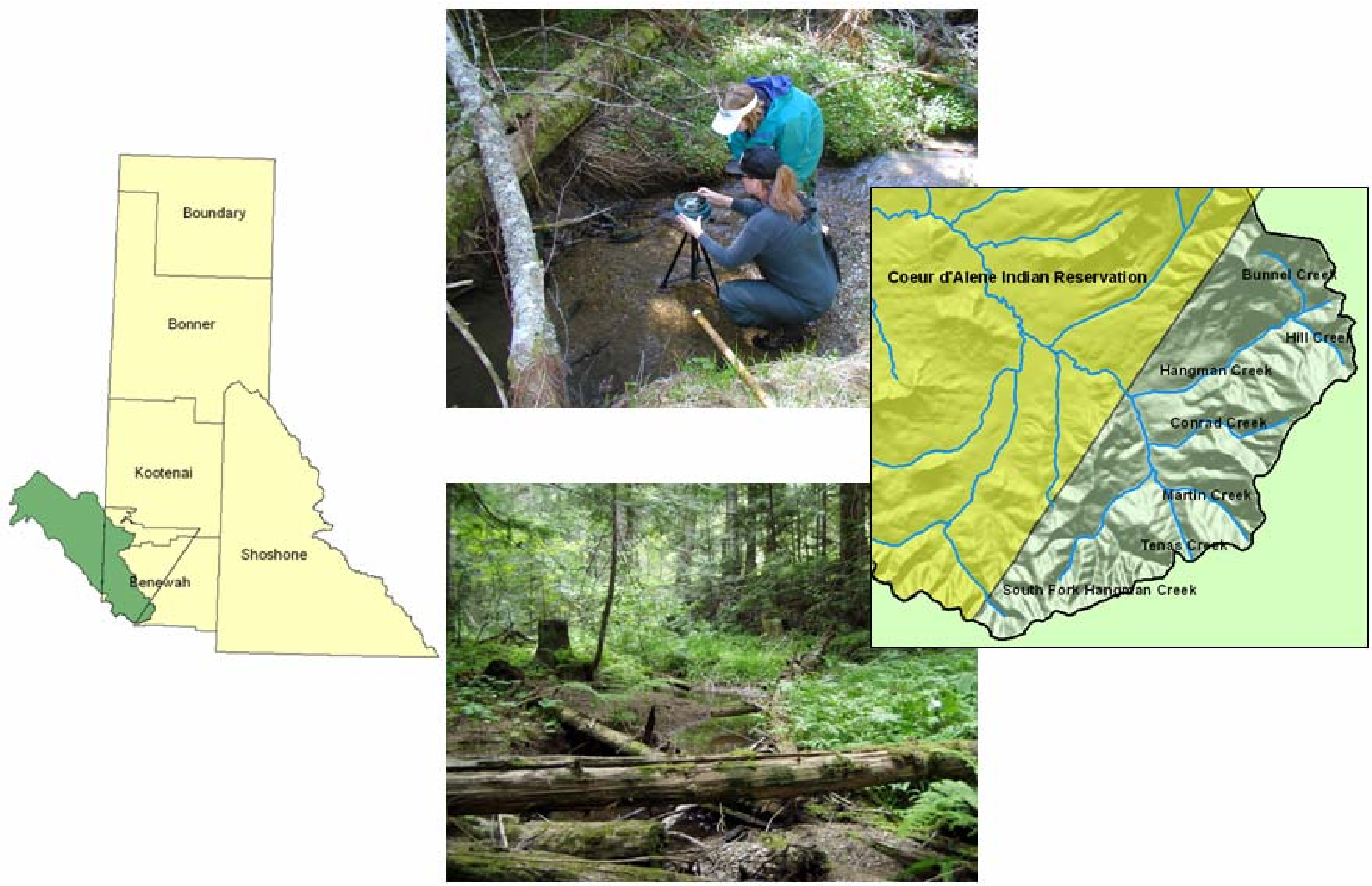
Upper Hangman Creek Subbasin Assessment and Total Maximum Daily Load



Final

The Idaho Department of Environmental Quality

May 2007

On the cover is a photograph of Dee Bailey, Coeur d’Alene Tribe, and Brenda Valverde, Idaho DEQ, collecting stream shade information, and a picture of the South Fork Hangman Creek taken in 2003 taken by an Idaho DEQ BURP crew member.

Upper Hangman Creek Subbasin Assessment and Total Maximum Daily Load

May 2007

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Foreword

This foreword was developed by the members of the Watershed Advisory Group (WAG) who participated in the review of this Upper Hangman Creek Total Maximum Daily Load (TMDL) plan. The purpose of the foreword is to express and capture some of the difficult issues that arose from our discussion and review of this document. The foreword is intended to help readers of this document as well as stimulate discussion about possible improvements to the TMDL process by agencies and groups involved in the development of future water quality restoration plans.

The success of any watershed restoration project requires the complete support of the local community. Ultimately meeting the objectives in the TMDL would require support of the local community and be at the expense of landowners in the drainage. The steps involved in any watershed improvement involve assessment of the health of the watershed, identification of problem areas, prioritizing restoration efforts and implementation of the restoration plan to attain a specific biological outcome.

Here starts the points of concern from the WAG:

The manner in which the information was presented and the document was written appeared confrontational. Information presented regarding water quality stated what was wrong with the watershed and nothing about what was good with the watershed. Part of the issue is the nature (narrow scope) of the TMDL plan and document which tends to focus on pollutant levels and water chemistry not overall biological health of the watershed. The TMDL approach starts with a list of impaired waters, referred to as the 303(d) list, identifies sources of the pollution then prepares a "pollutant budget" allocating pollutant levels to meet federal Clean Water Act (CWA). The emphasis on meeting legislated standards set in the TMDL does not always relate to the unique environmental conditions within the watershed or tell the story of the health of the biological communities living in the watershed.

The format of the TMDL document appears cumbersome for the reader and is difficult to follow. The document you are about to read represents an Idaho Department of Environmental Quality (DEQ) interpretation of the elements of a TMDL document as required by the Environmental Protection Agency (EPA). If the document was only used as a communication vehicle between the EPA and DEQ it would be fine but as the document meant to tell the public about the state's plan for water quality improvements to a particular watershed, every effort should be made to make it as clear as possible. Having a standardized template for state TMDL documents is a good idea but the cookie-cutter approach means the data is made to fit the template.

WAG members provided extensive edits to the original TMDL and Idaho DEQ staff made every effort to accommodate those changes but the inflexibility of altering the document template meant data was repeated in different sections and sections that did not apply were still included. A document that is difficult to read and understand undermines the success of convincing the public and local community to support the proposed plan.

Applications of state temperature water quality standards (both numeric water quality criteria, as well as the natural conditions provision) seem unrealistic for the waters in the Upper Hangman Creek watershed. WAG members expressed concern that TMDL criteria reflect standards used to fit legislated rules and do not include the biological or historical context necessary to set realistic and achievable criteria. WAG members repeatedly asked questions about how these standards translated into management practices on the ground and how to reconcile alternate targets outlined in the Idaho Forest Practices Act. Specifically members pointed out inconsistencies between the shade targets within the TMDL and those in the Idaho Forest Practices Act, which is Idaho's approved best management practices for forest activities. TMDL assessment units do not address class I and class II streams as delineated by the Idaho Forest Practices Act. These classes further differentiate between fish bearing and non-fish bearing streams which then determine the level of forest management activity allowed adjacent to them. The TMDL, however, applies its criteria to the entire reach of stream from where it starts at the top of the ridge to its outlet without recognition of levels of activity allowed. The WAG did not resolve the issue of the appropriateness of the voluntary standards set forth in the TMDL but felt strongly that private land will be managed according to Idaho Forest Practices Act regulations.

There is a critical need for a monitoring plan and allocation of funds to perform long-term evaluation of TMDLs. It was clear from the discussions and questions asked that WAG members struggled to understand the methodology used to list water bodies and set standards in TMDL. A healthy dose of skepticism questioned whether implementation of the TMDL plan would ultimately produce a functioning ecosystem. Rigorous assessment and monitoring are required to evaluate the investment of time and money into these plans. This could also clarify the methodology used to track progress and ultimately remove water bodies from the impaired water list.

The cumulative effect of these concerns is that the TMDL process at times appears to be a "top-down" agency exercise. The TMDL plan is an important mechanism for states to identify impaired waters and work towards watershed restoration. The narrow analytical nature of the TMDL, the rigid document format imposed by the Idaho DEQ, the water quality standards that appear to satisfy legal targets rather than actual environmental conditions and lack of successful TMDL programs gives the impression this is a "top-down" agency exercise. The WAG fully understands the pressures put on Idaho DEQ staff to comply with court ordered deadlines to complete this TMDL and gain EPA approval. However, to justify the time, effort and expense of these plans, each TMDL document should build on and add to the cumulative knowledge about Idaho watersheds. This means evolving a process to honestly evaluate the specific watershed, assign realistic targets, developing an implementation plan and securing funding to monitor watershed progress and validity of the plan.

Successful watershed restoration is important to all of us and requires strong community support. The WAG puts forth the above concerns for your consideration and discussion.

Upper Hangman Creek Watershed Advisory Group

Elaine Snouwaert, as a non-voting member of the WAG, a citizen of a neighboring state and a representative of the Washington Department of Ecology, abstained from inclusion in the Foreward's authorship. She feels the Foreward should belong to those residing and representing interests within the area covered by the TMDL.

The Coeur d'Alene Tribe is a voting member of the WAG and is in the process of developing a TMDL for those portions of Hangman Creek which lie within the exterior boundaries of the

Coeur d'Alene Reservation. The Tribe will remain a member of the WAG and appreciates the input and participation of the other WAG members in the development of this TMDL. Unfortunately, the Tribe does not concur with all of the statements made in this Foreword and requests that it also be abstained from inclusion in the Foreword's authorship.

Mike Mihelich, who did not attend the Upper Hangman Creek WAG meetings but participated with written comments to the DEQ concerning the TMDL, did not want his name associated with the Foreword because he did not agree with the language and statements in the Foreword.

Acknowledgments

Dee Bailey and Bruce Kinkead of the Coeur d'Alene Tribe provided water quality data, assistance with stream bank erosion surveys and coordinated private property access with landowners. Don Zaroban provided project oversight and the collection of field data in 2005. Brenda Valverde provided assistance with field collections in 2005. Mark Shumar composed the draft subbasin assessment and total maximum daily load calculations.

This document was completed and reviewed with the help of the Upper Hangman Creek Watershed Advisory Group.

Upper Hangman Creek Watershed Advisory Group Participants

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* Officially appointed Upper Hangman Creek Watershed Advisory Group members. Appointed group membership was reviewed and approved by the Panhandle Basin Advisory Group on September 12, 2006. The approved Basin Advisory Group list was then submitted and approved by the director of the Idaho Department of Environmental Quality on October 5, 2006.

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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
µ	micro, one-one thousandth
§	Section (usually a section of federal or state rules or statutes)
AU	assessment unit
BMP	best management practice
BOD	biochemical oxygen demand
BURP	Beneficial Use Reconnaissance Program
BSWCD	Benewah Soil and Water Conservation District
C	Celsius
CFR	Code of Federal Regulations (refers to citations in the federal administrative rules)
cfs	cubic feet per second
cfu	colony forming units
cm	centimeters
CRP	Conservation Reserve Program
CWA	Clean Water Act
CWAL	cold water aquatic life
CWE	cumulative watershed effects
DEQ	Department of Environmental Quality
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
F	Fahrenheit
FPA	Idaho Forest Practices Act
GIS	Geographical Information Systems
HUC	Hydrologic Unit Code
IDAPA	Refers to citations of Idaho administrative rules
IDFG	Idaho Department of Fish and Game
IDL	Idaho Department of Lands
km	kilometer
km^2	square kilometer
LA	load allocation
LC	load capacity
m	meter
m^3	cubic meter
mi	mile
mi^2	square miles
MBI	Macroinvertebrate Biotic Index

mg/L milligrams per liter

MOS margin of safety

MWMT maximum weekly maximum temperature

n.a. not applicable

NAIP National Agriculture Imagery Program

NB natural background

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NTU nephelometric turbidity unit

PCR primary contact recreation

PNV Potential Natural Vegetation

ppm part(s) per million

SBA subbasin assessment

SCCD Spokane County Conservation District

SCR secondary contact recreation

SCS Soil Conservation Service

SFI DEQ’s Stream Fish Index

SHI DEQ’s Stream Habitat Index

SMI DEQ’s Stream Macroinvertebrate Index

SS salmonid spawning

TMDL total maximum daily load

TP total phosphorus

TSS total suspended solids

U.S. United States

U.S.C. United States Code

USDA United States Department of Agriculture

USDI United States Department of the Interior

USFS United States Forest Service

USGS United States Geological Survey

WAG Watershed Advisory Group

WBAG *Water Body Assessment Guidance*

WBID water body identification number

WDOE Washington Department of Ecology

WLA wasteload allocation

WQLS water quality limited segment

Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. This document addresses the water bodies in the upper Hangman Creek portion of the Hangman Creek Subbasin that have been placed on Idaho's current impaired waters list. This subbasin assessment (SBA) and TMDL analysis have been developed to comply with Idaho's TMDL schedule. The assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the upper Hangman Creek portion of the Subbasin above the Coeur d'Alene Tribal Reservation, located in northern Idaho.

The first part of this document, the SBA, is an important step in leading to the TMDL. The starting point for this assessment was Idaho's 1998 §303(d) list of water quality limited water bodies (Table A). One segment within the Hangman Creek subbasin above the Coeur d'Alene Tribal Reservation boundary was listed on this list. The SBA examines the current status of listed water and defines the extent of impairment and causes of water quality limitation throughout the Idaho portion of the subbasin. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

During the development of the *Upper Hangman Creek SBA and TMDL* the state of Idaho adopted a new list of water quality limited water bodies. The new list was submitted to EPA in 2002 and was approved by EPA in 2005 (Table B). The new list, Section 5 of the 2002 Integrated Report, addresses the same assessment unit/pollutant combinations outside of the Coeur d'Alene Tribal Reservation as did the 1998 §303 (d) list. The 2002 Integrated Report includes assessments of surface waters of the state made up to and including 2002.

This document addresses two assessment units within the Hangman Creek subbasin. Both assessment units are located outside of the Coeur d'Alene Tribal Reservation and together occupy an area of approximately 10,000 acres. Throughout this document the mention of the upper Hangman Creek subbasin or watershed will be in reference to this portion outside of the tribal reservation unless otherwise noted. Sediment, bacteria, and temperature TMDLs were developed for seven named streams within these assessment units, Table C and Figure A. Streams for which TMDLs were developed include Hangman, South Fork Hangman, Tenas, Martin, Conrad, Hill, and Bunnel Creek. The pollutants originate solely from nonpoint sources.

The following are major, human-caused, nonpoint sources for each pollutant:

Sediment: roads, mass failures, and accelerated stream bank erosion.

Temperature: increased solar radiation due to reduction in shade provided to the stream from the adjacent plant community.

Bacteria: farm animals, natural, and humans (homes and recreation).

Table A. Idaho's 1998 §303(d) listing outside the Coeur d'Alene Tribal Reservation.

Stream	Stream segment boundaries	Pollutant
Hangman Creek	Headwaters to tribal reservation border	Bacteria, Habitat Alteration, Nutrients, Sediment

Table B. Idaho's 2002 Integrated Report Section 5 listing outside the Coeur d'Alene Tribal Reservation.

Stream	Assessment Unit	Stream segment boundaries	Pollutant
Hangman Creek	ID17010306PN001_03	Headwaters to tribal reservation border	Bacteria, Nutrients, Sediment
Hangman Creek, South Fork Hangman Creek, Bunnel Creek, Hill Creek, Conrad Creek, Martin Creek, Tenas Creek	ID17010306PN001_02	Streams outside Coeur d'Alene Tribal Reservation above the Hangman/South Fork Hangman Creek confluence	Temperature

Table C is a complete list of the pollutants and streams for which TMDLs were developed in the upper Hangman Creek watershed.

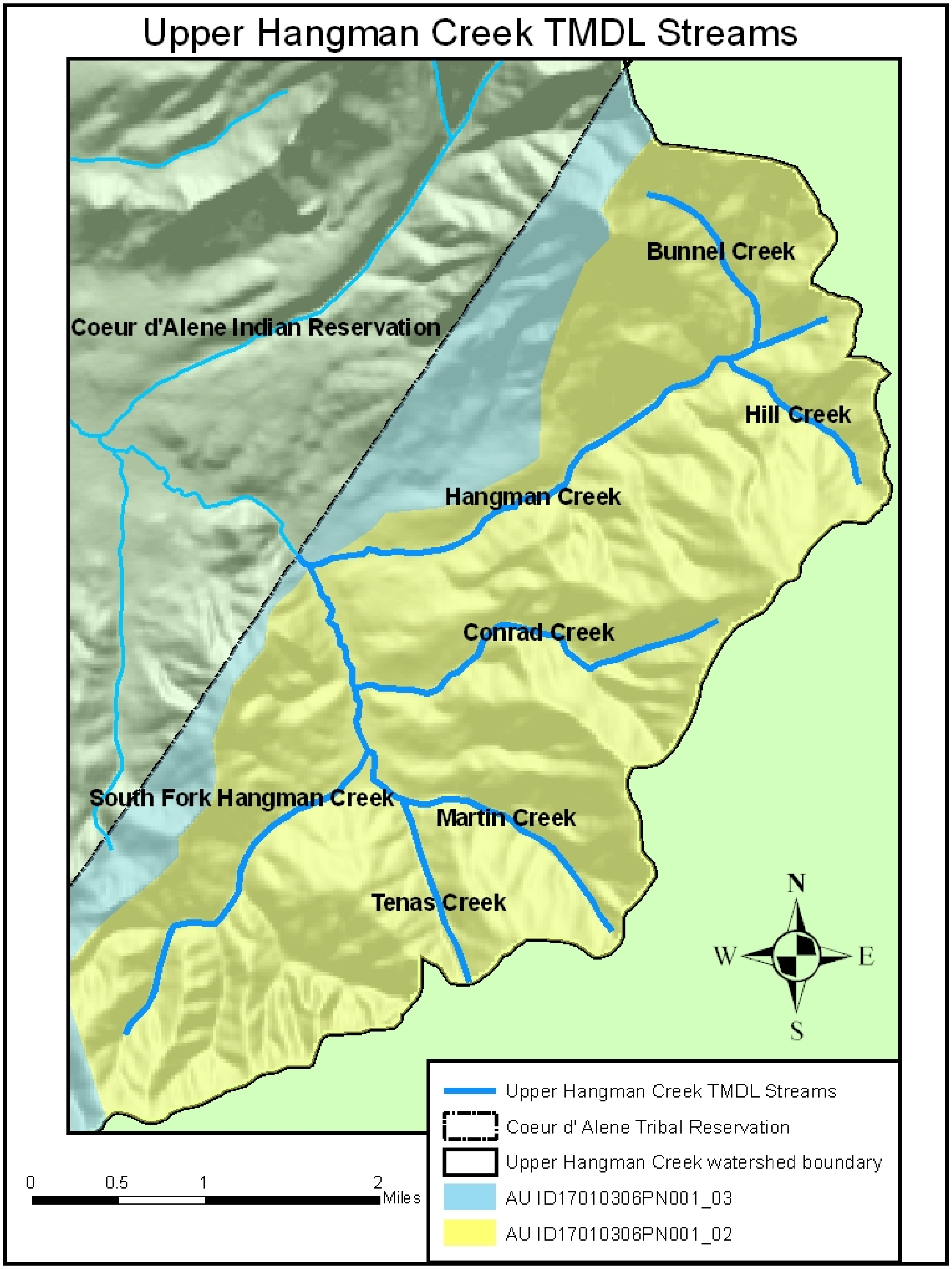
Table C. Streams and pollutants for which TMDLs were developed in this document.

Stream	Assessment Unit	Pollutant(s)
Hangman Creek (below confluence with South Fork Hangman Creek)	ID17010306PN001_03	Sediment, Temperature, Bacteria
Hangman Creek (above confluence with South Fork Hangman Creek), South Fork Hangman Creek, Tenas Creek, Martin Creek, Conrad Creek, Hill Creek, Bunnel Creek	ID17010306PN001_02	Sediment, Temperature, Bacteria

Table D. Streams and pollutants for which TMDLs were developed for impaired but unlisted waters.

Stream	Assessment Unit	Pollutant(s)
Hangman Creek (below confluence with South Fork Hangman Creek)	ID17010306PN001_03	Temperature
Hangman Creek (above confluence with South Fork Hangman Creek), South Fork Hangman Creek, Tenas Creek, Martin Creek, Conrad Creek, Hill Creek, Bunnel Creek	ID17010306PN001_02	Sediment, Bacteria

Figure A. Streams in upper Hangman Creek for which TMDLs were developed.



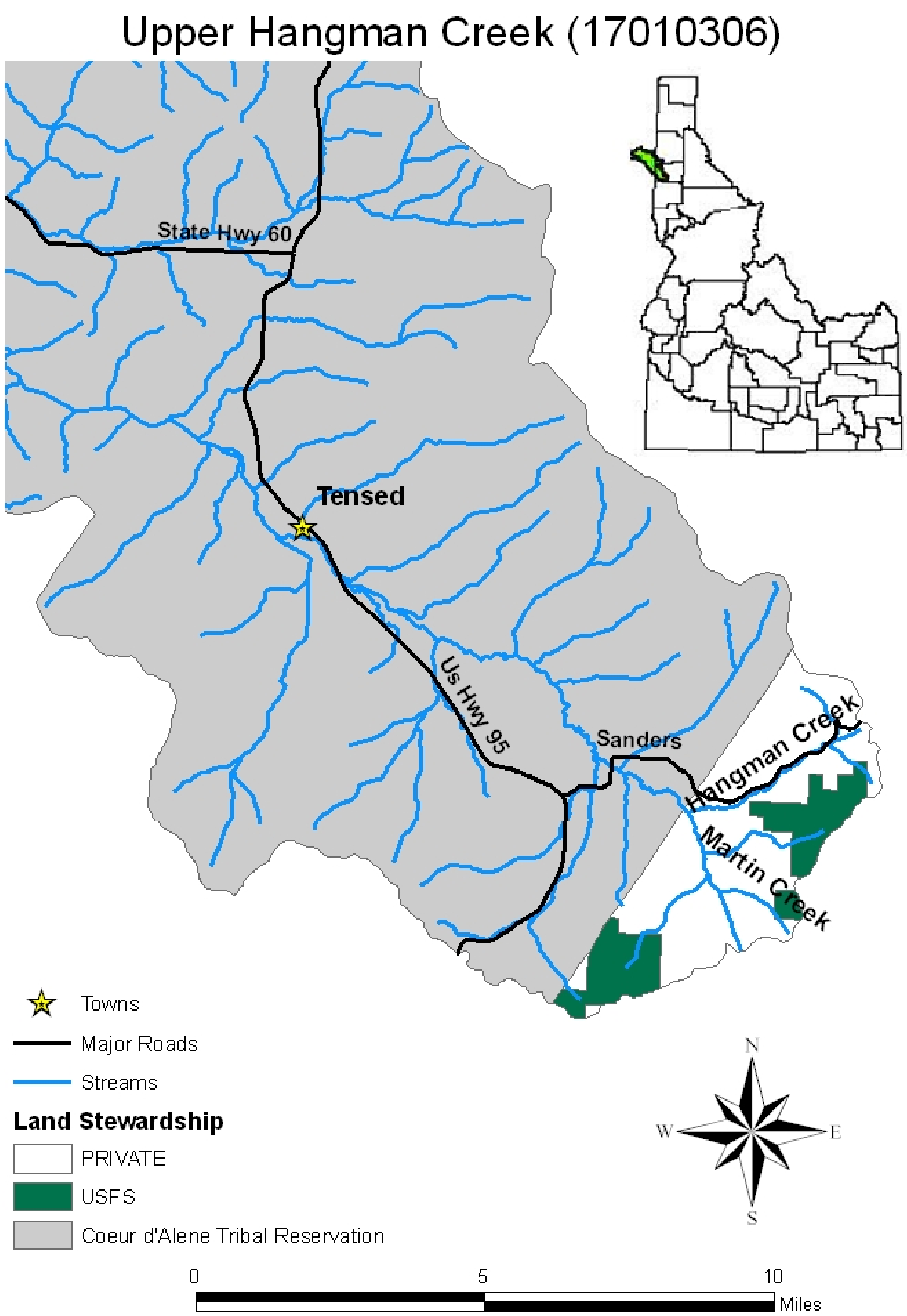
Subbasin at a Glance

The upper Hangman Creek watershed is located where the rolling hills of the Hangman Creek valley meet steep mountain sides. This portion of the watershed is primarily forested, although there have been some openings created for other land use activities. The land is primarily privately owned with only a small amount of national forest lands. The primary land use is timber management with some residential development along major roads and some livestock grazing activity at lower elevations.

Table E. Land use activities and land management/ownership in the Upper Hangman Creek watershed.

	Land manager/owner	
Land use type	**United States Forest Service**	**Private**
Forest-Forest Harvest	2,253	6,549
Agriculture-Grazing	0	680
Total	2,253	7,229

Figure B. Upper Hangman Creek in Idaho 17010306.



Upper Hangman Creek water quality listing history

Environmental monitoring of the ecosystem began as early as 1963 and possibly sooner. Data evaluated in this report includes baseline monitoring conducted by the Idaho Department of Health and Welfare, Division of Environment, now known as the Idaho Department of Environmental Quality (DEQ), and fish sampling efforts conducted in 1963 by the Coeur d'Alene Tribe. Below is a summary of the listing history of Hangman Creek in the state of Idaho's pursuit to meet the goals of the Clean Water Act.

1992

- In 1992 the upper Hangman Creek watershed from the headwaters to the Coeur d'Alene Tribal Reservation was included in Appendix D of the *Idaho Water Quality Status Report*. Appendix D, The Impaired Streams Segments Requiring Further Assessment, identified nutrients, sediment, and other habitat alterations as the major pollutants. The magnitude of the pollutants was determined to be medium. Nonirrigated cropland, pastureland, rangeland, and silviculture were identified as the major sources of pollutants in the upper Hangman Creek watershed.

1994 - 1996

- Listings in Appendix D from the 1992 *Idaho Water Quality Status Report* were later developed into the 1994/1996 §303 (d) list.

1998

- Hangman Creek below the confluence with the South Fork Hangman Creek was listed on the 1998 §303 (d) list for bacteria, nutrients, and sediment. Also, in 1998 the tributaries to Hangman Creek and South Fork Hangman Creek including the South Fork Hangman Creek were listed on the §303 (d) list for exceeding Idaho water quality standards for habitat alteration, nutrients, and sediment.

2002-2004

- Temperature was added as a pollutant in 2002 to the tributaries to Hangman and South Fork Hangman Creek including Hangman and the South Fork Hangman Creek, assessment unit ID17010306PN001_02.
- The most current list of water quality limited streams and stream segments, Section 5 of the 2002 Integrated Report, include two assessment units for the upper Hangman Creek subbasin. The larger of the two includes all streams above the confluence of Hangman Creek and South Fork Hangman Creek. South Fork Hangman, Hangman (above the confluence with the South Fork Hangman), Martin, Tenas, Conrad, Hill, and Bunnel Creek are included in this assessment unit (ID17010306PN001_02). This assessment unit was listed on the 2002 Integrated Report for exceeding temperature water quality standards.

  The smaller of the two assessment units, an approximately 500 meter length of Hangman Creek, includes Hangman Creek below the confluence of the South Fork Hangman Creek and above the Coeur d'Alene Tribal Reservation boundary (ID17010306PN001_03). This assessment unit was listed on the 2002 Integrated Report for exceeding bacteria, nutrients, and sediment water quality standards.

Key Findings

The *Upper Hangman Creek SBA and TMDL* document was written with the goal of restoring all beneficial uses, including aquatic life and secondary contact recreation within the watershed. Below is a list highlighting the findings of this report.

- Assessments of data collected during five Beneficial Use Reconnaissance Program (BURP) surveys reveal that all sites failed to support beneficial uses including those on tributary streams. Beneficial uses of the surface waters include cold water aquatic life, salmonid spawning (SS), and secondary contact recreation (SCR). Most failures were due to low fish numbers despite good macroinvertebrate and habitat numbers. Diminished fish density and diversity is likely a result of low flow. Failure to support beneficial uses was also due to temperature criteria violations. TMDLs are completed for sediment, bacteria, and temperature due to Idaho water quality criteria violations.
- Numeric targets for TMDLs include 80% bank stability and associated stream bank erosion reductions for sediment, 90% effective shade for thermal loading reduction, and recreation use of 126 *Escherichia coli* (*E. coli*) cfu/100ml for bacteria.
- Loading capacities, existing loads, and load allocations for all three pollutants are in Tables 9 through 16 of this document. Reductions in stream bank erosion of sediment vary from 9% in upper South Fork Hangman Creek to 73% at the lowest reaches of Hangman Creek and its South Fork. Bacteria load reductions in Hangman Creek and South Fork Hangman Creek vary considerably through time and range from 15% to 85%. Percent reductions in summer solar load vary from 15% in Bunnel Creek to 70% in South Fork Hangman Creek.
- Although listed for nutrients, the upper watershed had decreasing total phosphorus (TP) values as early as 1990. A subsequent sampling effort in the spring of 2005 revealed low TP values in all headwater streams. At this time nutrients were not determined to be impairing beneficial uses. Therefore, it is recommended that Hangman Creek above the Tribal boundary be delisted for nutrients.

<u>Sediment</u>

Sediment TMDLs were developed for two assessment units. Sediment generated from roads, mass failures, and stream bank erosion was characterized to determine the amount of sediment load reduction needed in order to restore all beneficial uses. Idaho’s water quality standard IDAPA 58.01.02.08 states:

> *“Sediment shall not exceed quantities specified in section 250 or 252, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in section 350.”*

Sediment was determined to be in excessive quantities and impairing the cold water aquatic life use designation. The target load capacity was set at 50% above natural background. Sediment loading allocations are displayed in Table D.

Table F. Sediment load analysis for upper Hangman Creek.

Source	Existing Load (tons/year)	Loading Capacity (tons/year)	Reduction (%)
Stream banks	753	339	55
Roads	270	135	50
Mass Failures	7	3.5	50
Total	**1030**	**477.5**	**54**

Temperature

Temperature TMDLs were written for Hangman (above and below the confluence with the South Fork Hangman Creek), South Fork Hangman, Tenas, Martin, Conrad, Hill and Bunnel Creek because of exceedances of Idaho's numeric water quality temperature standard. Solar radiation was determined to be the factor most easily controllable and manageable in reduction of stream temperatures. A decrease in solar radiation requires an increase in shading of the stream.

Potential Natural Vegetation (PNV) was selected as the desired target for this TMDL. If PNV targets are achieved yet stream temperatures are warmer than numeric criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply. As per IDAPA 58.01.02.200.09:

> *"When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401."*

The upper Hangman Creek Watershed Advisory Group (WAG) anticipates private land being managed according to Idaho Forest Practices Act (FPA) regulations. Should existing shade fall below the shade targets set by this TMDL, actions are encouraged to be taken by the land manager/landowner to reestablish vegetation with the goal of accelerating achievement of the shade targets. Refer to section 5 of the TMDL for location specific existing and potential solar loading analysis.

Table G. Average solar loading analysis.

Stream	Assessment Unit	Existing Shade (%)	Target Shade (%)	Existing summer load (kWH/day)	Potential summer load (kWh/day)	Solar load reduction (%)
Hangman	ID17010306PN001_02 ID17010306PN001_03	70	90	20,136.7	7,385.8	63
South Fork Hangman	ID17010306PN001_02	70	90	16,656.3	4,955.6	70
Tenas	ID17010306PN001_02	50	90	2,110.7	550.6	74
Martin	ID17010306PN001_02	70	90	4,081.8	1,261.1	69
Conrad	ID17010306PN001_02	80	90	3,808.5	1,835.4	52
Hill	ID17010306PN001_02	80	90	733.9	550.3	25
Bunnel	ID17010306PN001_02	90	90	596.5	504.7	15

<u>Bacteria</u>

Bacteria TMDLs were written for the two assessment units within the upper Hangman Creek subbasin. Bacteria TMDLs were written because water quality monitoring data indicated that the beneficial use of secondary contact recreation was not being fully supported. The source of bacteria is unknown. Further monitoring will be needed to determine the source of contamination. Known possible sources include domesticated and wild animals, and/or human contributions from recreation or septic systems.

The bacteria water quality standard is a concentration based standard. The target for the bacteria TMDL is set to the Idaho water quality standard IDAPA 58.01.02.251.01a which states:

> *"Waters designated for primary or secondary contact recreation are not to contain E. coli bacteria in concentrations exceeding a geometric mean of one hundred twenty-six (126) E. coli organisms per one hundred (100) ml based on a minimum of five (5) to seven (7) days over a thirty (30) day period."*

E. coli is used as an indicator of human pathogens, disease-causing organisms. *E. coli* is used because it is relatively more abundant than other pathogens, easy to test, and relatively harmless. Table F contains the calculated load capacity and existing load capacity based on flow information from within the subbasin.

Table H. Numbers of *E. coli* colonies in stream at loading capacity (minus a 10% margin of safety) and at the four geometric means, and the percent (%) reduction necessary to achieve the loading capacity.

Stream	Assessment Unit	Flow (cfs)	Load Capacity (cfu)	Estimated existing load (cfu)	% Reduction
Hangman Creek	ID17010306PN001_03	0.35	11,203	74,992	85
		0.266	8,542	25,571	67
		0.246	7,899	12,741	38
		0.232	7,450	6,388	0
South Fork Hangman Creek	ID17010306PN001_02	0.312	10,019	13,477	26
		0.238	7,643	11,355	33
		0.22	7,129	8,374	15
		0.21	6,744	11,251	40

Upper Hangman Creek in perspective

In relation to other TMDLs developed for watersheds within the similar geographic location and exhibiting similar climates, land use activities, and natural settings, pollutant reduction goals for upper Hangman Creek are about average. To develop this comparison four TMDLs were evaluated, three from the *St. Maries River SBA and TMDL* (IDEQ 2003) and one from the *Palouse River Tributaries SBA and TMDL* (IDEQ 2005).

Table G is intended to give a relative comparison between the upper Hangman Creek TMDLs and neighboring watersheds. Values displayed in the table are averaged values from similar TMDLs and are intended to provide a quick comparison of water quality impairment. The values given in Table G are not intended to direct management action.

Table I. Reductions required in watersheds neighboring upper Hangman Creek.

Associated TMDL	***Upper Hangman Creek TMDL***	***St. Maries River TMDL***			***Palouse River Tributaries TMDL***
Stream	**All waters above CDA Tribal Reservation**	**Alder Creek**	**Santa Creek**	**Tyson Creek**	**Deep Creek**
Sediment	54% reduction in sediment loading	57% above background 5% reduction in sediment loading	167% above background 44% reduction in sediment loading	71% above background 12% reduction in sediment loading	2900% above background, 96% reduction in sediment loading
Temperature	90% shade target Increase in shade from 15 – 74%		100% shade target Increase in shade from 5-85%		Existing shade 16-63% Increase in shade 24-70%
Bacteria	27% - 275% above water quality standard				48% above water quality standard

The St. Maries River and Palouse River Tributaries sediment TMDLs were developed using different modeling techniques. The different techniques used do not relate well with those techniques used to model sediment generation in the upper Hangman Creek sediment TMDL. Although the loads developed from the different modeling techniques may not relate directly to one another, the percent reductions needed to meet the TMDL goals are similar.

Summary

Recommended listing changes to the 2002 Integrated Report are included in Table H for the two assessment units addressed in the *Upper Hangman Creek SBA and TMDL*.

Table J. Summary of assessment outcomes.

Stream	Assessment Unit	Pollutant	TMDL(s) Analysis Completed	Recommended changes to the Integrated Report	Justification
Hangman Creek	ID17010306PN001_03	Sediment	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek	ID17010306PN001_03	Bacteria	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek	ID17010306PN001_03	Nutrients	No	Delist	Most recent data show attainment of Idaho water quality standard
Hangman Creek	ID17010306PN001_03	Temperature	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards
Hangman Creek[3]	ID17010306PN001_02	Temperature	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek[3]	ID17010306PN001_02	Sediment	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards
Hangman Creek[3]	ID17010306PN001_02	Bacteria	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards

[1] Section 4a of Integrated Report, Rivers with EPA Approved TMDLs.
[2] Section 5 of Integrated Report, Idaho's Impaired Waters list.
[3] Includes the following tributaries to Hangman Creek below the confluence with the South Fork Hangman Creek – Hangman Creek, South Fork Hangman Creek, Tenas Creek, Martin Creek, Conrad Creek, Hill Creek, and Bunnel Creek.

At this time the DEQ is seeking approval for only those assessment unit pollutant combinations that are listed in section 5 of the 2002 Integrated Report. These combinations include the Hangman Creek (ID17010306PN001_03) listing for sediment, bacteria, and nutrients, and also Hangman Creek (ID17010306PN001_02) listing for temperature.

TMDLs have been completed for assessment unit pollutant combinations that are not currently listed on the 2002 Integrated Report (table D, page xiv). These combinations include the Hangman Creek (ID171010306PN001_03) temperature combination and the Hangman Creek (ID17010306PN001_02) sediment and bacteria combination. Once formally listed in section 5 of the Integrated Report the TMDLs written for these combinations will be resubmitted to EPA for approval. Upon TMDL approval it is anticipated that the assessment unit pollutant combinations will be moved to section 4a of the Integrated Report. TMDLs for unlisted pollutants were completed in accordance to current information showing impairment of beneficial uses and exceedances of Idaho water quality standards.

Public Input and Meetings

In compliance with Idaho Code §39-3611(8), the development of the *Upper Hangman Creek Subbasin Assessment and TMDL* included extensive public participation by the Watershed Advisory Group (WAG) and other interested parties from within the subbasin. The Coeur d'Alene regional office of the Idaho DEQ solicited participation in a WAG in June 2006. A letter, map, and documentation explaining the TMDL and WAG process was sent to land owners/managers, residents, environmental groups, and state and federal agencies soliciting interest. Nine written response were received and the first Upper Hangman Creek WAG meeting was held on August 2, 2006.

Public meetings were held in September, October, November 2006, and January 2007. All meetings were open to the public and advertised at least one-week prior to the meeting. Meeting announcements were noted on the DEQ public meeting calendar on the internet, posted at the DEQ regional office in Coeur d'Alene, and advertised in local news papers.

WAG participants reviewed beneficial use designations in the watershed and water quality information to date. The WAG reviewed several drafts of the *Upper Hangman Creek SBA and TMDL* document and submitted comments to DEQ throughout the WAG meeting period. The comments submitted to DEQ by the WAG were incorporated into the final document.

On August 2, 2006, a WAG meeting was held to discuss the SBA and TMDL development process, the WAG's role in developing the document, beneficial uses within the area of interest, data used in development of the document, WAG operating procedures, and how to successfully navigate the upper Hangman Creek WAG webpage.

On September 20, 2006, a WAG meeting was held to discuss and review applicable beneficial uses and water quality criteria, the methods used to develop draft pollutant loads (temperature, sediment, and bacteria), past and present pollution control efforts, and upper Hangman Creek TMDL draft timelines and milestones.

On October 17, 2006, upper Hangman Creek draft TMDL finding were discussed. The WAG also discussed past and current pollution control efforts within the subbasin. Discussion of pollution control efforts focused on activities conducted on timber harvest and agricultural areas. Federal funding for non-point source pollution reduction under §319 of the Clean Water Act was also discussed.

On November 9, 2006, comments to the draft SBA and TMDL document were discussed at length.

On January 10, 2007, the current state and changes made to the document were discussed. The draft SBA and TMDL document timeline and milestones were updated, and the WAG unanimously approved the document for the public comment period.

The DEQ has complied with the WAG consultation requirements set forth in Idaho Code §39-3611. DEQ has provided the WAG with all available information concerning applicable water quality standards, water quality data, monitoring, assessments, reports, procedures, and schedules. All presentations and drafts provided at WAG meetings were made available on the DEQ website devoted to the Upper Hangman Creek WAG throughout the process.

DEQ utilized the knowledge, expertise, experience, and information of the WAG in developing this SBA and TMDL. DEQ also provided the WAG with an adequate opportunity to participate in drafting the SBA and TMDL and to suggest changes to the document.

1. Subbasin Assessment – Watershed Characterization

The overall purpose of the upper Hangman Creek subbasin assessment (SBA) and total maximum daily load (TMDL) document is to characterize and document pollutant loads within the upper Hangman Creek subbasin. The first portion of this document, the SBA, is partitioned into four major sections: watershed characterization, water quality concerns and status, pollutant source inventory, and a summary of past and present pollution control efforts (Sections 1 – 4). This information will then be used to develop TMDL calculations for each pollutant of concern for the upper Hangman Creek subbasin (Section 5).

1.1 Introduction

In 1972, Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act (CWA). The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Water Environment Federation 1987, p. 9). The act and the programs it has generated have changed over the years, as experience and perceptions of water quality have changed.

The CWA has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to insure "swimmable and fishable" conditions. This goal, along with a 1972 goal to restore and maintain chemical, physical, and biological integrity, relates water quality with more than just chemistry.

Background

The federal government, through the U.S. Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. The Idaho Department of Environmental Quality (DEQ) implements the CWA in Idaho, while the EPA oversees Idaho and certifies the fulfillment of CWA requirements and responsibilities.

Section 303 of the CWA requires DEQ to adopt water quality standards and to review those standards every three years (EPA must approve Idaho's water quality standards). Additionally, DEQ must monitor waters to identify those not meeting water quality standards. For those waters not meeting standards, DEQ must establish a TMDL for each pollutant impairing the waters. Further, the agency must set appropriate controls to restore water quality and allow the water bodies to meet their designated uses.

These requirements result in a list of impaired waters, formally called the "§303(d) list." This list is now referred to as Section 5 of the Integrated Report, describes water bodies not meeting water quality standards. Waters identified on this list require further analysis. A SBA and TMDL provide a summary of the water quality status and allowable pollutant loads for water bodies on the impaired waters list. The *Upper Hangman Creek SBA and TMDL* provides this summary for the currently listed waters in the upper Hangman Creek portion of the Subbasin above the Coeur d'Alene Tribal Reservation boundary.

The SBA section of this document (Sections 1 – 4) includes an evaluation and summary of the current water quality status, pollutant sources, and control actions in the upper Hangman

Creek Subbasin to date. While this assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up to date and accurate. The TMDL is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (Water quality planning and management, 40 CFR Part 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant.

Some conditions that impair water quality do not receive TMDLs. The EPA does consider certain unnatural conditions, such as flow alteration, human-caused lack of flow, or habitat alteration, that are not the result of the discharge of a specific pollutants as “pollution.” However, TMDLs are not required for water bodies impaired by pollution, but not by specific pollutants. A TMDL is only required when a pollutant can be identified and in some way quantified.

Idaho’s Role

Idaho adopts water quality standards to protect public health and welfare, enhance the quality of water, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

The state may assign or designate beneficial uses for particular Idaho water bodies to support. These beneficial uses are identified in the Idaho water quality standards (IDAPA 58.01.02) and include the following:

- Aquatic life support–cold water, seasonal cold water, warm water, salmonid spawning, modified
- Contact recreation–primary (swimming), secondary (boating)
- Water supply–domestic, agricultural, industrial
- Wildlife habitats
- Aesthetics

The Idaho legislature designates uses for water bodies. Industrial water supply, wildlife habitats, and aesthetics are designated beneficial uses for all water bodies in the state. If a water body is unclassified, then cold water and primary contact recreation (PCR) are used as additional default designated uses when water bodies are assessed.

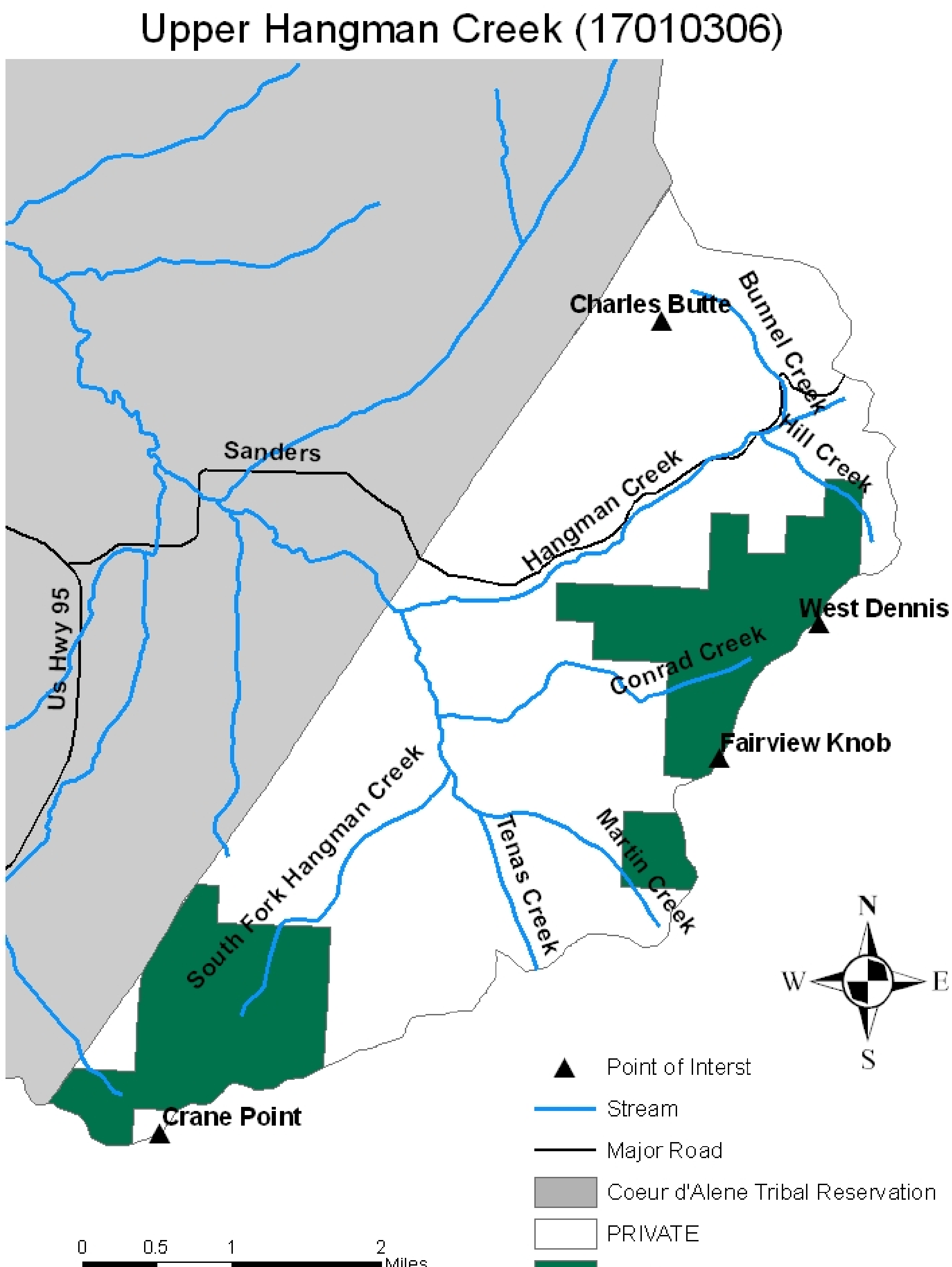
A SBA entails analyzing and integrating multiple types of water body data, such as biological, physical/chemical, and landscape data to address several objectives:

- Determine the degree of designated beneficial use support of the water body (i.e., attaining or not attaining water quality standards).
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the water body, particularly the identity and location of pollutant sources.
- Determine the causes and extent of the impairment when water bodies are not attaining water quality standards.

1.2 Physical and Biological Characteristics

The Hangman Creek watershed is approximately 86,000 acres (34,803 hectares) in size situated on the western edge of northern Idaho. Only the headwaters area above the Coeur d'Alene Tribal boundary, an area of about 10,000 acres (4,047 hectares), is addressed in this document (see Figure 1). Hangman Creek originates in a wooded canyon between Charles Butte and West Dennis Mountain, 4,806 feet (1465 m) above sea level, and flows southwest until it joins the South Fork Hangman Creek about 500 feet (152 m) above the Coeur d'Alene Tribal boundary. The South Fork Hangman Creek originates at the base of Crane Point and flows north to Hangman Creek. From the confluence with the South Fork, Hangman Creek turns northwest and flows through the Coeur d'Alene Tribal Reservation and on into Washington State until reaches its confluence with the Spokane River, near the city of Spokane, Washington.

Figure 1. Upper Hangman Creek Portion of Subbasin.

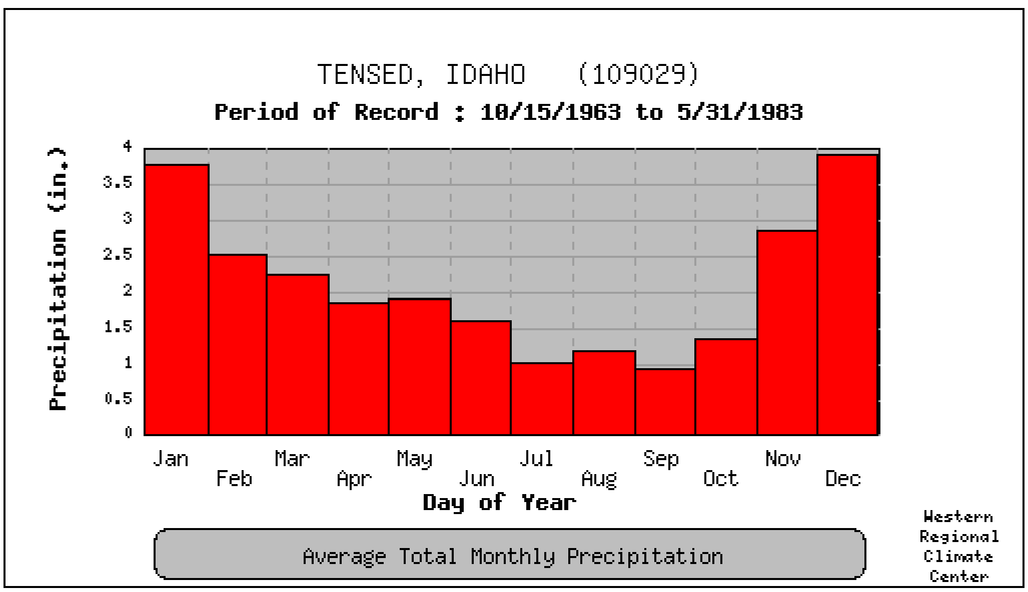


Climate

The climate of the Hangman Creek watershed is one of transition. Precipitation varies considerably from the Palouse region to the mountains. Total annual precipitation is about 20 inches (51 cm) on the northwest edge of the watershed and about 45 inches (114 cm) in the southern mountains. Precipitation can vary 20 inches in nine miles, two inches per mile, and in some cases as much as five inches per mile (BSWCD, 1981). The mountains on the west side of the watershed provide the first relief encountered by westerly winds as they reach the eastern extremities of the Palouse prairie. As the air is uplifted and cooled, a rain shadow results on the east side. The valley shape and arrangement of surrounding mountains also creates a venturi effect, which accelerates and cools the air. The combined effects of surface relief and prevailing wind patterns creates a multitude of micro-climates in the watershed (BSWCD, 1981).

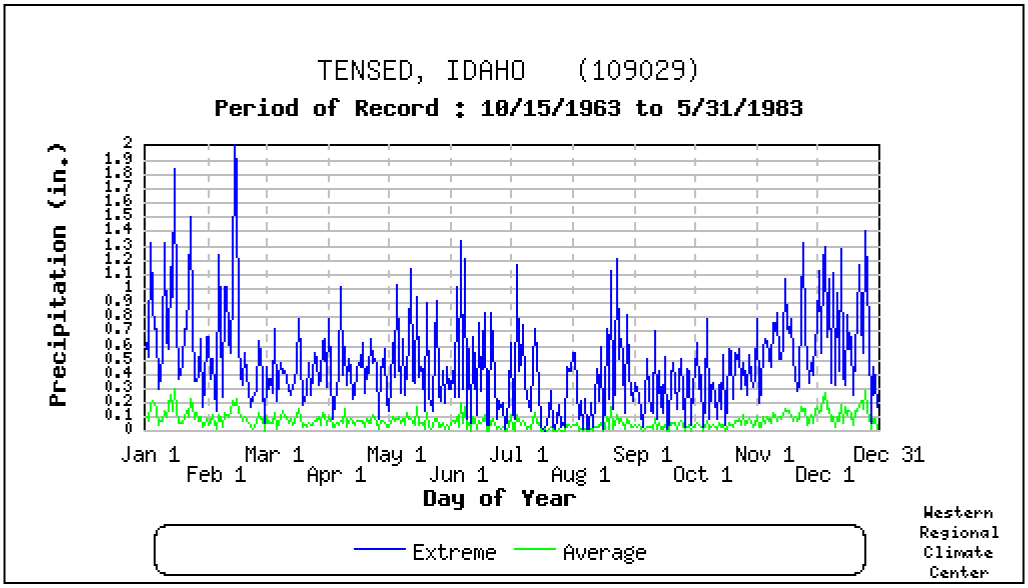
Precipitation is characteristic of cool moist winters and warmer drier summers. Average total monthly precipitation varies from close to four inches in December to as little as one inch in September (Figure 2).

Figure 2. Average Total Monthly Precipitation Measured at Tensed, Idaho from 1963 to 1983.



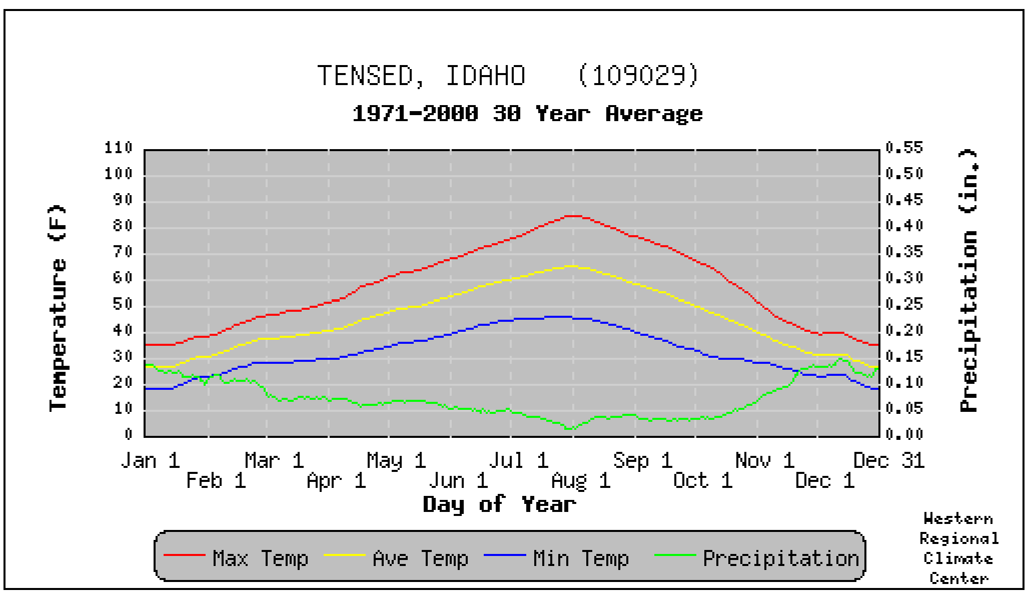
Average daily precipitation intensity is rather even throughout the year with winter days slightly higher at 0.2 to 0.3 inches and the remainder of the year at 0.1 inches (Figure 3). Extreme precipitation events are highly variable with the highest extremes (up to 2 inches) occurring during the months of January and February (Figure 3).

Figure 3. Average and Extreme Daily Precipitation Measured at Tensed, Idaho from 1963 to 1983.



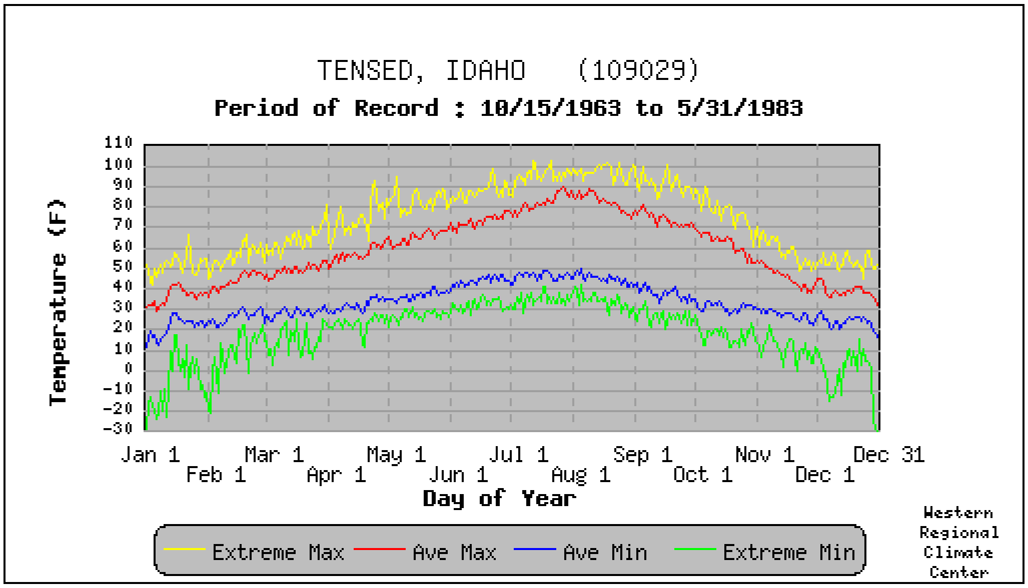
Average temperatures are also single modal with highest average temperatures in August and lowest average temperatures in January. Maximum average air temperatures are generally below 80°F (Figure 4).

Figure 4. 30 Year Normal (1971-2000) Average, Minimum and Maximum Air Temperatures for Tensed, Idaho.



Air temperature extremes on the other hand can exceed 80°F in May and can reach 100°F in July through September (Figure 5).

Figure 5. Extreme and Average Maximum and Minimum Air Temperatures Measured at Tensed, Idaho from 1963 to 1983.



Hangman Creek Subbasin Characteristics

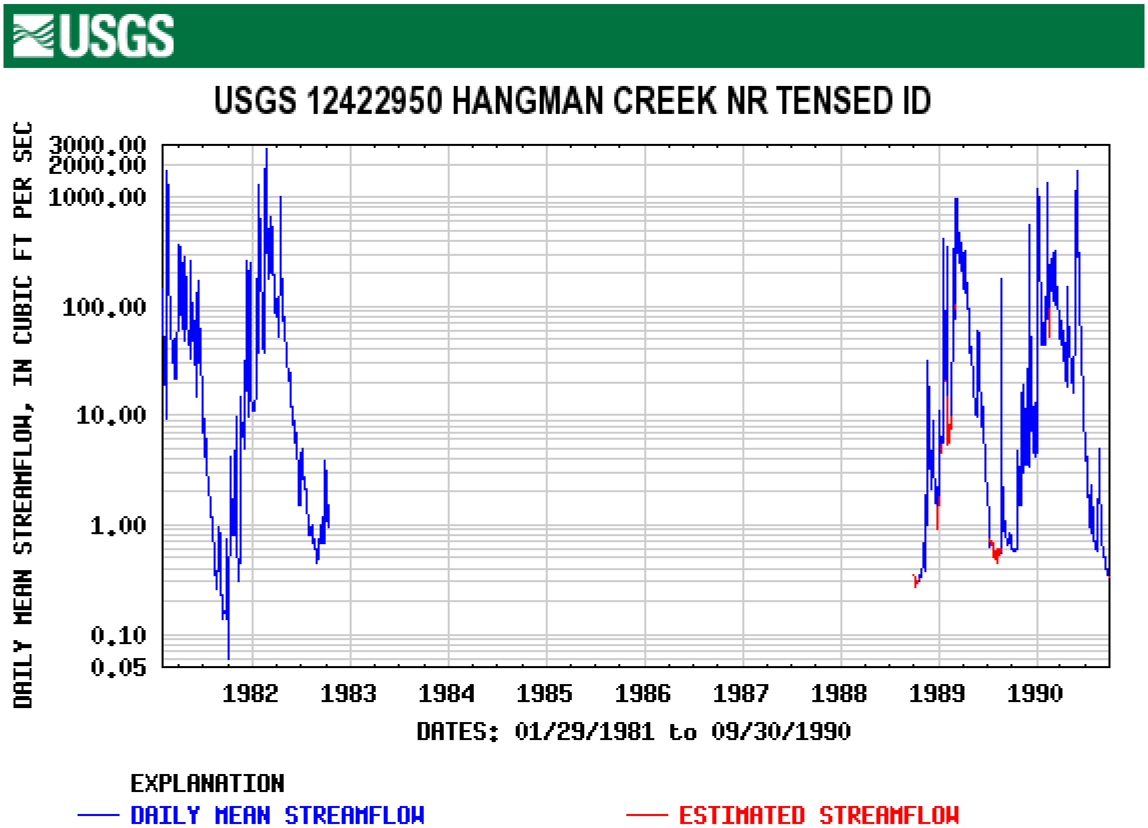
Hydrography

Hangman Creek is part of the Spokane River system with the majority of the watershed in Washington and its headwaters in Idaho. The subbasin in Idaho has the classic dendritic stream pattern with eight major sub-watersheds, including Mission Creek, Sheep Creek, Andrew Springs' Creek, Mineral Creek, Indian Creek, Squaw Creek, Lolo Creek and Hangman Creek (Fortis and Hartz, 1991). The subbasin area in Idaho is approximately 86,000 acres (34,803 hectares); 53,000 acres (21,448 hectares) are in forest land and 33,000 acres (13,355 hectares) are non-irrigated cropland, hayland and pasture.

Except for the headwaters, which are likely Rosgen (1996) A and B channel types, the majority of the watershed is Rosgen type C4 (Fortis and Hartz, 1991). The C4 type stream is characterized by a gradient of 1% or less, moderate sinuosity, a width/depth ratio averaging around 10, and a bottom substrate that is mostly sand/silt with some gravel. Hangman Creek is moderately entrenched with poor valley confinement and very unstable banks of unconsolidated, non-cohesive soils. Hangman Creek below Tensed is particularly prone to flooding and stream bank erosion.

Stream flow data is limited for upper Hangman Creek; however, what is available shows an extremely rapid snowmelt dominated system with annual variations in flow from less than 1cfs to 3000cfs (Figure 6). Peak flows occur early, generally before April and low flows occur in late summer. Monthly average and peak flows are highly variable from year to year depending on snow pack, the prevalence of rain-on-snow events and spring rain.

Figure 6. Measured Daily Streamflow for Hangman Creek near Tensed, Idaho from 1981 to 1990.



Geology and/or Soils

The lithology of upper Hangman Creek is rather simple with argillite and slate making up the materials in the mountains and loess filling the valley floor (Figure 7). The derivatives of that lithology include Precambrian light-colored siltite overlying multicolored fine-grained detritus and Pleistocene wind-blown loess of northern Idaho. Soil units in the headwaters of Hangman Creek proper include Pinecreek-Ahrs-Honeyjones and Reggear-Clarkia-Agatha (Figure 8). Elsewhere throughout the upper watershed are Taney-Cald and Santa-Taney-Moctileme soil units. The predominant soil unit along Hangman Creek below the confluence with the South Fork is Latahco-Cald-Moctileme soils.

Taney and Santa soils are very deep, undulating to hilly or steep, slowly permeable, moderately well drained silt loams on loess-covered hills (Weisel, 1980). These soils can have perched water tables in spring and be prone to flooding and high erodibility. Latahco-Cald-Moctileme soils are also very deep and moderately slowly permeable, but are somewhat poorly drained resulting in flooding and wetness in spring which may limit farming.

Figure 7. Hangman Creek Lithology.

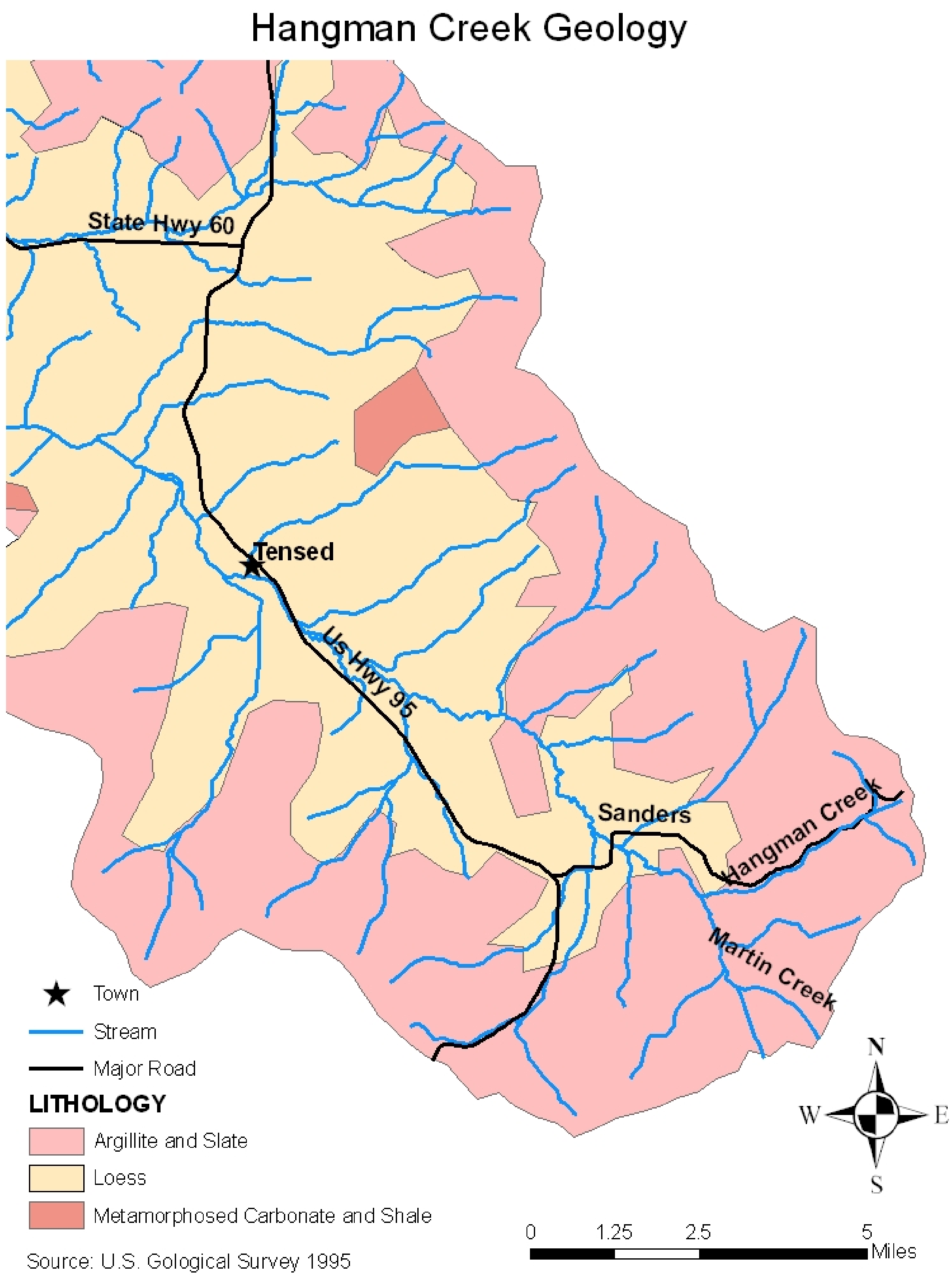
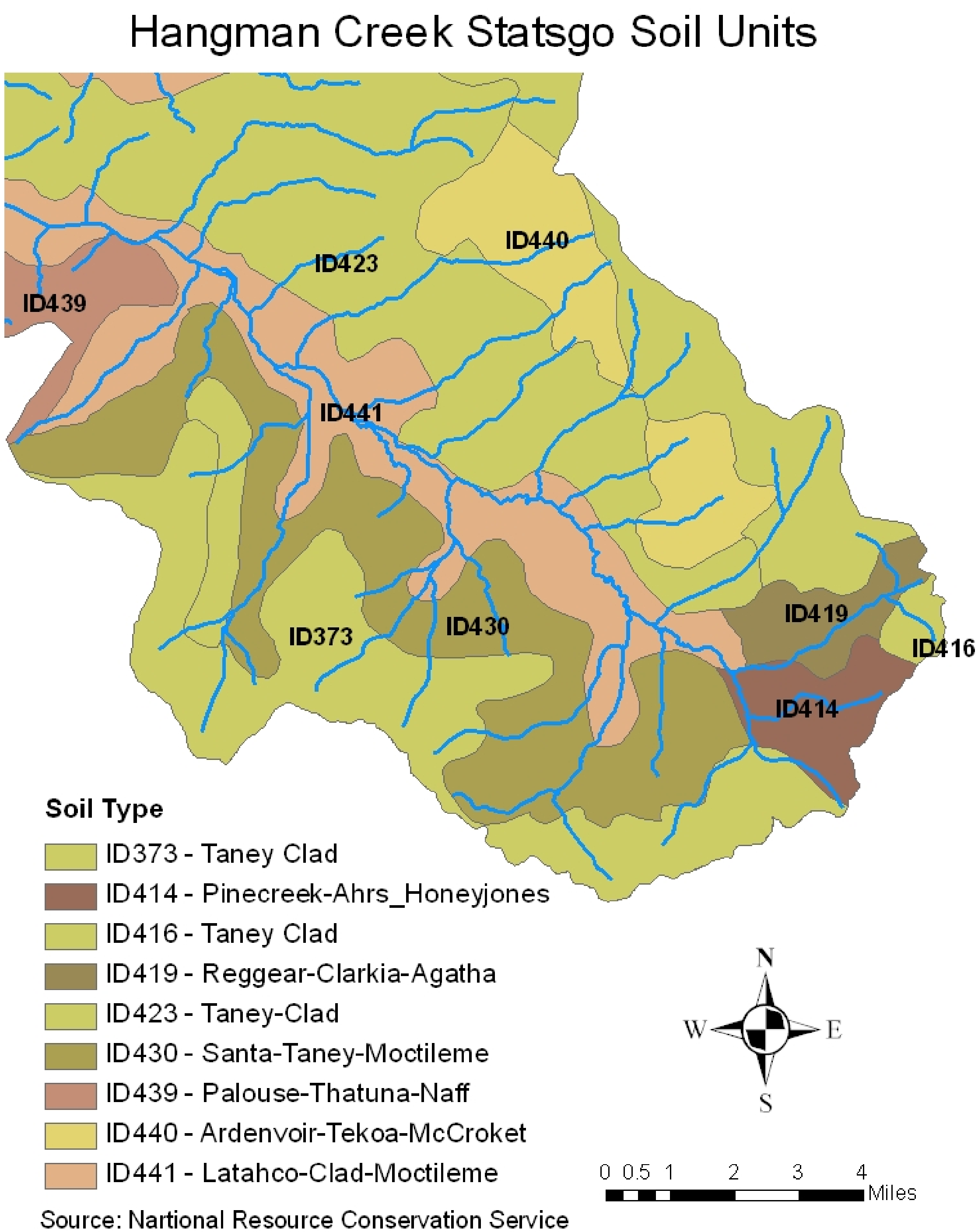


Figure 8. Hangman Creek Soils.



A major portion of upper Hangman Creek above the confluence with its South Fork is overlain with Pinecreek-Ahrs-Honeyjones and Reggear-Clarkia-Agatha soil groups. On the south side of Hangman Creek proper, the Pinecreek-Ahrs-Honeyjones group consists of very deep, well drained soils on mountains (NRCS, 2001). They formed in material weathered from metasedimentary rock with a thick mantle of volcanic ash. Pinecreek soils are on south-facing mountain slopes at elevations from 2,200 to 4000 feet (670-1,219 m). Ahrs soils are on east and west-facing mountain slopes and are loamy-skeletal with an ochric epipedon. Honeyjones soils also have an ochric epipedon but are on north-facing slopes.

On the north side of Hangman Creek is the Reggear-Clarkia-Agatha group, consisting of more variable soils. The Reggear series consists of moderately deep to fragipan, moderately well-drained soils on mountain slopes or hills on basalt plateaus. The Clarkia series consists of very deep poorly drained soils on floodplains, valley floors, and low stream terraces. They formed in mixed alluvium and permeability is moderately slow. Agatha soils are deep and well drained on benches, escarpments, and canyon sides. They formed in colluvium or residuum weathered from basalt with a loess mantle.

Topography

In general, the topography is undulating and hilly typical of the Palouse region. Headwaters areas are increasing in steepness as streams originate in surrounding mountains. The headwaters of Hangman Creek originate near mountains of 4300-4800 feet (1,310-1,463 m) in elevation and decrease to almost 2700 feet (823 m) at the Coeur d'Alene Tribal boundary. The South Fork Hangman Creek originates near 3300 feet (1,006 m) in elevation.

Vegetation

The upper Hangman Creek watershed is where Palouse hills meet northern Idaho hills and low relief mountains. Palouse hills were once dominated by fescue-wheatgrass grasslands that have largely been converted agriculture (wheat, peas, beans, and rapeseed). The northern Idaho hills and low relief mountains of the Northern Rockies ecoregion contain productive forests on deep rich soils. The dominant trees include grand fir, western red cedar, Douglas fir, and Ponderosa pine.

Fisheries and Aquatic Fauna

The following species were captured in 1963 by Coeur d'Alene Tribe personnel in upper Hangman Creek: rainbow trout, eastern brook trout, speckled dace, longnose dace, longnose sucker, northern pikeminnow, chiselmouth, redside shiner, brown bullhead, and tench (WDOE & SCCD, 1994). Water quality work in the 1980s and 1990s reported that catfish, redside shiners, and dace were the primary constituents of the Hangman Creek fishery (SCS, 1994). The creek also supported rainbow trout in the headwaters and in several isolated sections of lower Hangman Creek in the State of Washington at that time. Sculpin have also been observed in the upper watershed by IDFG personnel.

Idaho DEQ Beneficial Use Reconnaissance Program (BURP) crews in 2002 observed a number of frogs and small fish in the upper watershed. BURP electrofishing activities resulted in the capture of speckled dace, redside shiner, and rainbow trout in Hangman Creek below the South Fork Hangman Creek confluence; sucker, rainbow trout, redside shiner, and speckled dace at the mouth of South Fork Hangman Creek; and rainbow trout in Bunnel Creek.

Aquatic fauna probably include amphibians such as Columbia spotted frog, typical furbearers (muskrat, mink, and beaver), waterfowl, and a host of birds and other animals living or visiting from nearby uplands.

Upper Hangman Creek Subwatershed Characteristics

Only the headwaters area of Hangman Creek, that portion above the Coeur d'Alene Tribal Reservation Boundary, is considered in this subbasin assessment (see Figure A in Executive Summary). Included in this discussion are:

- Hangman Creek from its headwaters to approximately 500 feet (152 m) below the confluence with the South Fork Hangman Creek,
- Tributaries to upper Hangman Creek including Bunnel Creek and Hill Creek,
- South Fork Hangman Creek,
- Tributaries to South Fork Hangman Creek including Conrad Creek, Martin Creek, and Tenas Creek.

Stream Characteristics

Hangman Creek and South Fork Hangman Creek are second order streams, both of which are predominantly Rosgen B channel type in their headwaters and C or F channels at lower elevations. Gradients at the lower ends of these streams are generally 1% or greater. Both are trough-like valley types with generally low sinuosity. Both streams are generally 10 feet (3 m) wide with width/depth ratios near 10.

Bunnel Creek is first order, Rosgen B channel type with about 2% gradient near its mouth. It is moderately sinuous, but with a flat bottom valley type. This stream is less than 6.5 feet (2 m) wide but has width/depth ratios near 11, reflecting a very shallow system. The timber harvested section of upper Bunnel Creek has a braided channel.

Martin Creek is a first order, moderately sinuous stream with Rosgen C channel type and a gradient of 1.5% near its mouth. Channel widths were less than 10 feet (3 m) and width/depth ratios were less than 10.

1.3 Cultural Characteristics

Most of this portion of upper Hangman Creek watershed is private land with very small portions of Hill Creek, Conrad Creek, Martin Creek, and South Fork Hangman Creek in National Forest ownership. The predominant land use activity is timber harvesting with some grazing on small pastures along stream valleys and a small amount of residential development.

Presently the upper Hangman Creek watershed is used by Coeur d'Alene Tribal members for fishing, hunting, gathering, and ceremonial uses. Historically and today this area has been an important tribal trust resource.

2. Subbasin Assessment – Water Quality Concerns and Status

Water quality problems in the Hangman Creek subbasin have been monitored and documented since at least 1980 (BSWCD, 1981; Bauer and Wilson, 1983; Fortis and Hartz, 1991; SCS, 1994; WDOE and SCCD, 1994). The subbasin as a whole has experienced impacts from altered hydrology, rain on snow events, erosion from cropland fields, and stream bank erosion. Substantial work has already been done in the watershed through BMP planning and implementation to address some of these impacts. This SBA and TMDL addresses only that section of the Hangman Creek subbasin above the Coeur d'Alene Tribal boundary.

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

Hangman Creek above the Tribal boundary is listed in Section 5 of the 2002 Integrated Report for bacteria, nutrients, temperature, and sediment pollution. The remainder of Hangman Creek in Idaho from the Tribal boundary to the Washington state line was included on this list for nutrients and temperature pollutants. The court ordered schedule for completion of TMDLs for waters listed on that 1998 impaired waters list, indicates that the Hangman Creek TMDLs are to be completed in 2005.

Water body assessments that examined BURP and other data and completed by DEQ in 2002 determined that the assessment unit #ID17010306PN001_02 (which includes tributaries to Hangman Creek and Hangman Creek proper above its confluence with the South Fork Hangman Creek) was impacted by temperature. Assessment unit #ID17010306PN001_03 (mainstem Hangman Creek below the confluence with South Fork Hangman Creek) was determined to be impacted by bacteria, sediment, and nutrient pollutants.

Bacteria data collected by DEQ in 2002 subsequent to the 2002 assessment process showed violations of bacteria criteria for recreation uses in Hangman Creek and South Fork Hangman Creek above the Tribal boundary. Pursuant to current DEQ guidance tributaries not include in Section 5 of the Integrated Report may receive pollutant load allocations. Although not listed for bacteria, Hangman Creek above the South Fork confluence will receive a TMDL for bacteria pollution as well.

Section 303(d) of the CWA states that waters that are unable to support their beneficial uses and that do not meet water quality standards must be listed as water quality limited waters. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

About Assessment Units

Assessment units (AUs) now define all the waters of the state of Idaho. These units and the methodology used to describe them can be found in the *Water Body Assessment Guidance* second edition, WBAGII (Grafe *et al.* 2002).

AUs are groups of streams that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining AUs—although ownership and land use can change significantly over time, the AU remains the same.

Using assessment units to describe water bodies offers many benefits, the primary benefit being that all the waters of the state are now defined consistently. In addition, using AUs fulfills the fundamental requirement of EPA's 305(b) report, a component of the Clean Water Act (CWA) wherein states report on the condition of all the waters of the state. Because AUs are a subset of water body identification numbers (WBID), there is now a direct tie to the water quality standards for each AU, so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

However, the new framework of using AUs for reporting and communicating needs to be reconciled with the legacy of water quality impaired stream listings. Due to the nature of the court-ordered 1994 §303(d) listings, and the subsequent 1998 §303(d) list, all segments were added with boundaries from "headwater to mouth." In order to deal with the vague boundaries in the listings, and to complete TMDLs at a reasonable pace, DEQ set about writing TMDLs at the watershed scale, so that all the waters in the drainage are and have been considered for TMDL purposes since 1994.

The boundaries from the 1998 §303(d) listed segments have been transferred to the new AU framework, using an approach quite similar to how DEQ has been writing SBAs and TMDLs. All AUs contained in the listed segment were carried forward to the 2002 listings in Section 5 of the Integrated Report. AUs not wholly contained within a previously listed segment, but partially contained (even minimally), were also included on the 303(d) list. This was necessary to maintain the integrity of the 1998 §303(d) list and to maintain continuity with the TMDL program. These new AUs will lead to better assessment of water quality listing and de-listing.

When assessing new data that indicate full support, only the AU that the monitoring data represents will be removed (de-listed) from the impaired waters list.

Listed Waters

Table 1shows the pollutants listed and the basis for listing for each listed AU in the examined portion of the subbasin. Not all of the water bodies will require a TMDL, as will be discussed later. However, a thorough investigation, using the available data, was performed before this conclusion was made. This investigation, along with a presentation of the evidence of non-compliance with standards for several other tributaries, is contained in the following sections.

Table 1. Idaho's 2002 Integrated Report Section 5 listings in the upper Hangman Creek portion of the Subbasin.

Water Body Name	Assessment Unit ID Number	Boundaries	Pollutants	Listing Basis
Hangman Creek	ID17010306PN001_03	Below confluence with South Fork Hangman Creek	bacteria, nutrients, sediment	DEQ assessments
Hangman Creek	ID17010306PN001_02	Above Hangman Creek and South Fork Creek confluence	temperature	DEQ assessments

2.2 Applicable Water Quality Standards

Hangman Creek from its source to the Washington state line has been designated in the Idaho Water Quality Standards for cold water aquatic life and secondary contact recreation (IDAPA 58.01.02.110.13.P-1). Tributaries to Hangman Creek above the Tribal boundary, including South Fork Hangman Creek, Conrad Creek, Martin Creek, Tenas Creek, Hill Creek, and Bunnel Creek, are undesignated waters and as such are presumed to have cold water aquatic life and secondary contact recreation uses. Because of the documented presence of salmonids prior to 1975 (Coeur d'Alene tribe fish data), primarily rainbow trout, it is assumed that this headwaters area of Hangman Creek and associated tributaries have salmonid spawning as an existing use.

Beneficial Uses

Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as briefly described in the following paragraphs. The *Water Body Assessment Guidance*, second edition (Grafe *et al*. 2002) gives a more detailed description of beneficial use identification for use assessment purposes.

Existing Uses

Existing uses under the CWA are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards." The existing in-stream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.050.02, .02.051.01, and .02.053). Existing uses include uses actually occurring, whether or not the level of quality to fully support the uses exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water body that could support salmonid spawning, but salmonid spawning is not occurring due to other factors, such as dams blocking migration.

Designated Uses

Designated uses under the CWA are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained." Designated uses are simply uses officially recognized by the state. In Idaho these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Water quality must be sufficiently maintained to meet the most sensitive use. Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are specifically listed for water bodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.27 and .02.109-.02.160 in addition to citations for existing uses).

Presumed Uses

In Idaho, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations. These undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called "presumed uses," DEQ will apply the numeric cold water criteria and primary or secondary contact recreation criteria to undesignated waters. If in addition to these presumed uses, an additional existing use, (e.g., salmonid spawning) exists, because of the requirement to protect levels of water quality for existing uses, then the additional numeric criteria for salmonid spawning would additionally apply (e.g., intergravel dissolved oxygen, temperature). However, if for example, cold water aquatic life is not found to be an existing use, a use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

Hangman Creek from its source to the Washington state line is designated in the Idaho water quality standards for cold water aquatic life and secondary contact recreation (Table 2). Based on the presence of rainbow trout in the upper reaches of Hangman Creek, it is assumed that salmonid spawning is an existing use in the waters addressed in this subbasin assessment and TMDL.

Table 2. Upper Hangman Creek portion of Subbasin beneficial uses of the 2002 Integrated Report Section 5 listed streams.

Water Body	Assessment Unit	Uses	Type of Use
Hangman Creek	ID17010306PN001_02 ID17010306PN001_03	Cold water aquatic life Secondary contact recreation	Designated Uses
Hangman Creek	ID17010306PN001_02 ID17010306PN001_03	Salmonid spawning	Existing Use

Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of criteria, which include *narrative* criteria for pollutants such as sediment and nutrients and *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity (IDAPA 58.01.02.250) (Table 3).

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed numeric water quality criteria. If potential natural vegetation (PNV) targets are achieved yet stream temperatures are warmer than numeric criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply. As per IDAPA 58.01.02.200.09:

> *"When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401."*

Excess sediment is described by narrative criteria (IDAPA 58.01.02.200.08):

> *"Sediment shall not exceed quantities specified in Sections 250 and 252 or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350."*

Narrative criteria for excess nutrients are described in IDAPA 58.01.02.200.06, which states:

> *"Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses."*

Narrative criteria for floating, suspended, or submerged matter are described in IDAPA 58.01.02.200.05, which states:

> *"Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities."*

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.053. The procedure relies heavily upon biological parameters and is presented in detail in the *Water Body Assessment Guidance* (Grafe *et al*. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations.

Table 3 includes the most common numeric criteria used in TMDLs.

Figure 9 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

Table 3. Selected numeric criteria supportive of designated beneficial uses in Idaho water quality standards.

Designated and Existing Beneficial Uses				
Water Quality Parameter	**Primary Contact Recreation**	**Secondary Contact Recreation**	**Cold Water Aquatic Life**	**Salmonid Spawning (During Spawning and Incubation Periods for Inhabiting Species)**
Water Quality Standards: IDAPA 58.01.02.250				
Bacteria, ph, and Dissolved Oxygen	Less than 126 *E. coli*/100 ml[a] as a geometric mean of five samples over 30 days; no sample greater than 406 *E. coli* organisms/100 ml	Less than 126 *E. coli*/100 ml as a geometric mean of five samples over 30 days; no sample greater than 576 *E. coli*/100 ml	pH between 6.5 and 9.0 DO[b] exceeds 6.0 mg/L[c]	pH between 6.5 and 9.5 Water Column DO: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater Intergravel DO: DO exceeds 5.0 mg/L for a one day minimum and exceeds 6.0 mg/L for a seven day average
Tempera-ture[d]			22 °C or less daily maximum; 19 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average Bull trout: not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June – August; not to exceed 9 °C daily average in September and October
Turbidity			Turbidity shall not exceed background by more than 50 NTU[e] instantaneously or more than 25 NTU for more than 10 consecutive days.	
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131				
Tempera-ture				7 day moving average of 10 °C or less maximum daily temperature for June - September

[a] *Escherichia coli* per 100 milliliters
[b] dissolved oxygen
[c] milligrams per liter
[d] Temperature Exemption - Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the seven-day average daily maximum air

temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.
[e] Nephelometric turbidity units

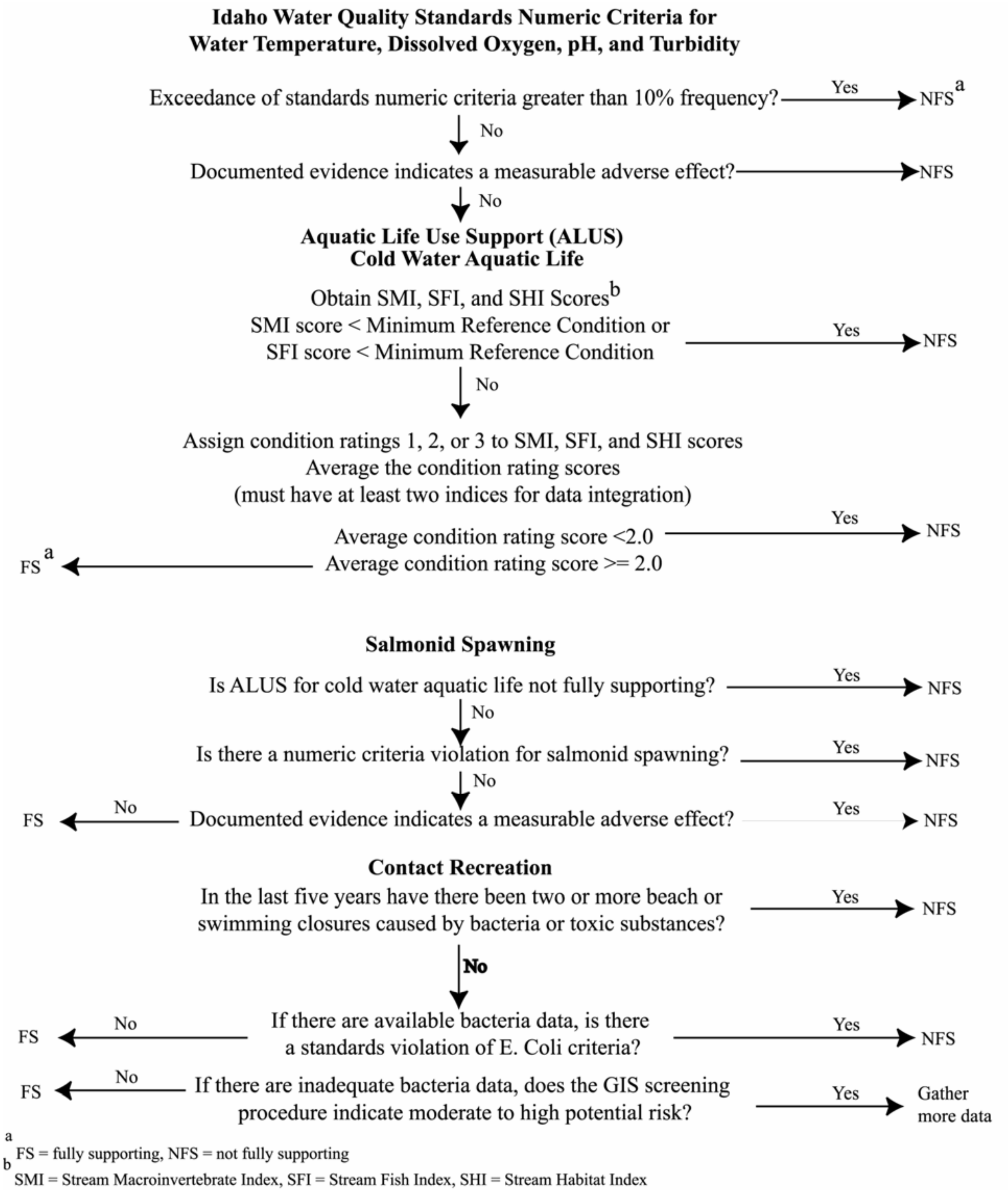


Figure 9. Determination Steps and Criteria for Determining Support Status of Beneficial Uses in Wadeable Streams: *Water Body Assessment Guidance*, Second Addition (Grafe *et al*. 2002)

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses in streams are naturally occurring stream characteristics that have been altered by humans. That is, streams naturally have sediment, nutrients, and the like, but when anthropogenic sources (human caused sources) cause these to reach unnatural levels, they are considered “pollutants” and can impair the beneficial uses of a stream.

Temperature

Temperature is a water quality factor integral to the life cycle of fish and other aquatic species. Different temperature regimes also result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or coldwater aquatic community is present. Many factors, natural and anthropogenic, affect stream temperatures. Natural factors include altitude, aspect, climate, weather, riparian vegetation (shade), and channel morphology (width and depth). Human influenced factors include heated discharges (such as those from point sources), riparian alteration, channel alteration, and flow alteration.

Elevated steam temperatures can be harmful to fish at all life stages, especially if they occur in combination with other habitat limitations such as low dissolved oxygen or poor food supply. Acceptable temperature ranges vary for different species of fish, with cold water species being the least tolerant of high water temperatures. Temperature as a chronic stressor to adult fish can result in reduced body weight, reduced oxygen exchange, increased susceptibility to disease, and reduced reproductive capacity. Acutely high temperatures can result in death if they persist for an extended length of time. Juvenile fish are even more sensitive to temperature variations than adult fish, and can experience negative impacts at a lower threshold value than the adults, manifesting in retarded growth rates. High temperatures also affect embryonic development of fish before they even emerge from the substrate. Similar kinds of affects may occur to aquatic invertebrates, amphibians and mollusks, although less is known about them.

Dissolved Oxygen

Oxygen is necessary for the survival of most aquatic organisms and essential to stream purification. Dissolved oxygen (DO) is the concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. While air contains approximately 20.9% oxygen gas by volume, the proportion of oxygen dissolved in water is about 35%, because nitrogen (the remainder) is less soluble in water. Oxygen is considered to be moderately soluble in water. A complex set of physical conditions that include atmospheric and hydrostatic pressure, turbulence, temperature, and salinity affect the solubility.

Dissolved oxygen levels of 6 mg/L and above are considered optimal for aquatic life. When DO levels fall below 6 mg/L, organisms are stressed, and if levels fall below 3 mg/L for a prolonged period, these organisms may die; oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. Dissolved oxygen levels below 1 mg/L are often referred to as hypoxic; anoxic conditions refer to those situations where there is no measurable DO.

Juvenile aquatic organisms are particularly susceptible to the effects of low DO due to their high metabolism and low mobility (they are unable to seek more oxygenated water). In addition, oxygen is necessary to help decompose organic matter in the water and bottom sediments. Dissolved oxygen reflects the health or the balance of the aquatic ecosystem.

Oxygen is produced during photosynthesis and consumed during plant and animal respiration and decomposition. Oxygen enters water from photosynthesis and from the atmosphere. Where water is more turbulent (e.g., riffles, cascades), the oxygen exchange is greater due to the greater surface area of water coming into contact with air. The process of oxygen entering the water is called aeration.

Water bodies with significant aquatic plant communities can have significant DO fluctuations throughout the day. An oxygen sag will typically occur once photosynthesis stops at night and respiration/decomposition processes deplete DO concentrations in the water. Oxygen will start to increase again as photosynthesis resumes with the advent of daylight.

Temperature, flow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. As flows decrease, the amount of aeration typically decreases and the instream temperature increases, resulting in decreased DO. Channels that have been altered to increase the effectiveness of conveying water often have fewer riffles and less aeration. Thus, these systems may show depressed levels of DO in comparison to levels before the alteration. Nutrient enriched waters have a higher biochemical oxygen demand (BOD) due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand results in lower instream DO levels.

Sediment

Both suspended (floating in the water column) and bedload (moves along the stream bottom) sediment can have negative effects on aquatic life communities. Many fish species can tolerate elevated suspended sediment levels for short periods of time, such as during natural spring runoff, but longer durations of exposure are detrimental. Elevated suspended sediment levels can interfere with feeding behavior (difficulty finding food due to visual impairment), damage gills, reduce growth rates, and in extreme cases eventually lead to death.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on streams and estuaries. For rainbow trout, physiological stress, which includes reduced feeding rate, is evident at suspended sediment concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species, although the data sets are less reliable. Adverse effects on habitat, especially spawning and rearing habitat presumably from sediment deposition, were noted at similar concentrations of suspended sediment.

Organic suspended materials can also settle to the bottom and, due to their high carbon content, lead to low intergravel DO through decomposition.

In addition to these direct effects on the habitat and spawning success of fish, detrimental changes to food sources may also occur. Aquatic insects, which serve as a primary food source for fish, are affected by excess sedimentation. Increased sedimentation leads to a macroinvertebrate community that is adapted to burrowing, thereby making the macroinvertebrates less available to fish. Community structure, specifically diversity, of the aquatic macroinvertebrate community is diminished due to the reduction of coarse substrate habitat.

Settleable solids are defined as the volume (milliliters [ml]) or weight (mg) of material that settles out of a liter of water in one hour (Franson *et al*. 1998). Settleable solids may consist of large silt, sand, and organic matter. Total suspended solids (TSS) are defined as the material collected by filtration through a 0.45 µm (micrometer) filter (Standard Methods 1975, 1995). Settleable solids and TSS both contain nutrients that are essential for aquatic plant growth. Settleable solids are not as nutrient rich as the smaller TSS, but they do affect river depth and substrate nutrient availability for macrophytes. In low flow situations, settleable solids can accumulate on a stream bottom, thus decreasing water depth. This increases the area of substrate that is exposed to light, facilitating additional macrophyte growth.

Bacteria

Escherichia coli or *E. coli*, a species of fecal coliform bacteria, is used by the state of Idaho as the indicator for the presence of pathogenic microorganisms. Pathogens are a small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa), which, if taken into the body through contaminated water or food, can cause sickness or even death. Some pathogens are also able to cause illness by entering the body through the skin or mucous membranes.

Direct measurement of pathogen levels in surface water is difficult because pathogens usually occur in very low numbers and analysis methods are unreliable and expensive. Consequently, indicator bacteria which are often associated with pathogens, but which generally occur in higher concentrations and are thus more easily measured, are assessed.

Coliform bacteria are unicellular organisms found in feces of warm-blooded animals such as humans, domestic pets, livestock, and wildlife. Coliform bacteria are commonly monitored as part of point source discharge permits (National Pollution Discharge Elimination System [NPDES] permits) issued be the EPA, but may also be monitored in nonpoint source arenas. The human health effects from pathogenic coliform bacteria range from nausea, vomiting, and diarrhea to acute respiratory illness, meningitis, ulceration of the intestines, and even death. Coliform bacteria do not have a known effect on aquatic life.

Coliform bacteria from both point and nonpoint sources impact water bodies, although point sources are typically permitted and offer some level of bacteria-reducing treatment prior to discharge. Nonpoint sources of bacteria are diffuse and difficult to characterize. Unfortunately, nonpoint sources often have the greatest impact on bacteria concentrations in water bodies. This is particularly the case in urban storm water and agricultural areas. *E. coli* is often measured in colony forming units (cfu) per 100 ml.

Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities. The excess nutrients result in accelerated plant growth and can result in a eutrophic or enriched system.

The first step in identifying a water body’s response to nutrient flux is to define which of the critical nutrients is limiting. A limiting nutrient is one that normally is in short supply relative to biological needs. The relative quantity affects the rate of production of aquatic biomass. Either phosphorus or nitrogen may be the limiting factor for algal growth, although phosphorous is most commonly the limiting nutrient in Idaho waters. Ecologically speaking, a resource is considered limiting if the addition of that resource increases growth.

Total phosphorus (TP) is the measurement of all forms of phosphorus in a water sample, including all inorganic and organic particulate and soluble forms. In freshwater systems, typically greater than 90% of the TP present occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel 1983). The remainder of phosphorus is mainly soluble orthophosphate, a more biologically available form of phosphorus than TP that consequently leads to a more rapid growth of algae. In impaired systems, a larger percentage of the TP fraction is comprised of orthophosphate. The relative amount of each form measured can provide information on the potential for algal growth within the system.

Nitrogen may be a limiting factor at certain times if there is substantial depletion of nitrogen in sediments due to uptake by rooted macrophyte beds. In systems dominated by blue-green algae, nitrogen is not a limiting nutrient due to the algal ability to fix nitrogen at the water/air interface.

Total nitrogen to TP ratios greater than seven are indicative of a phosphorus-limited system while those ratios less than seven are indicative of a nitrogen-limited system. Only biologically available forms of the nutrients are used in the ratios because these are the forms that are used by the immediate aquatic community.

Nutrients primarily cycle between the water column and sediment through nutrient spiraling. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available in the sediments or the water column, aquatic plants will store an abundance of such nutrients in excess of the plants' actual needs, a chemical phenomenon known as luxury consumption. When a plant dies, the tissue decays in the water column and the nutrients stored within the plant biomass are either restored to the water column or the detritus becomes incorporated into the river sediment. As a result of this process, nutrients (including orthophosphate) that are initially released into the water column in a dissolved form will eventually become incorporated into the river bottom sediment. Once these nutrients are incorporated into the river sediment, they are available once again for uptake by yet another life cycle of rooted aquatic macrophytes and other aquatic plants. This cycle is known as nutrient spiraling. Nutrient spiraling results in the availability of nutrients for later plant growth in higher concentrations downstream.

Sediment – Nutrient Relationship

The linkage between sediment and sediment-bound nutrients is important when dealing with nutrient enrichment problems in aquatic systems. Phosphorus is typically bound to particulate matter in aquatic systems, thus, sediment can be a major source of phosphorus to rooted macrophytes and the water column. While most aquatic plants are able to absorb nutrients over the entire plant surface due to a thin cuticle (Denny 1980), bottom sediments serve as the primary nutrient source for most sub-stratum attached macrophytes. The USDA (1999) determined that other than harvesting and chemical treatment, the best and most efficient method of controlling growth is by reducing surface erosion and sedimentation.

Sediment acts as a nutrient sink under aerobic conditions. However, when conditions become anoxic sediments release phosphorous into the water column. Nitrogen can also be released, but the mechanism by which it happens is different. The exchange of nitrogen between sediment and the water column is for the most part a microbial process controlled by the amount of oxygen in the sediment. When conditions become anaerobic, the oxygenation of ammonia (nitrification) ceases and an abundance of ammonia is produced. This results in a reduction of nitrogen oxides (NO_x) being lost to the atmosphere.

Sediments can play an integral role in reducing the frequency and duration of phytoplankton blooms in standing waters and large rivers. In many cases there is an immediate response in phytoplankton biomass when external sources are reduced. In other cases, the response time is slower, often taking years. Nonetheless, the relationship is important and must be addressed in waters where phytoplankton is in excess.

Floating, Suspended, or Submerged Matter (Nuisance Algae)

Algae are an important part of the aquatic food chain. However, when elevated levels of algae impact beneficial uses, the algae are considered a nuisance aquatic growth. The excess growth of phytoplankton, periphyton, and/or macrophytes can adversely affect both aquatic life and recreational water uses. Algal blooms occur where adequate nutrients (nitrogen and/or phosphorus) are available to support growth. In addition to nutrient availability, flow rates, velocities, water temperatures, and penetration of sunlight in the water column all affect algae (and macrophyte) growth. Low velocity conditions allow algal concentrations to increase because physical removal by scouring and abrasion does not readily occur. Increases in temperature and sunlight penetration also result in increased algal growth. When the aforementioned conditions are appropriate and nutrient concentrations exceed the quantities needed to support normal algal growth, excessive blooms may develop.

Commonly, algae blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, blue-green algae often produce toxins that can result in skin irritation to swimmers and illness or even death in organisms ingesting the water. The toxic effect of blue-green algae is worse when an abundance of organisms die and accumulate in a central area.

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water and can produce intense coloration of both the water and shorelines as cells accumulate along the banks. In extreme cases, algal blooms can also result in impairment of agricultural water supplies due to toxicity. Water bodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. The extent of the effect is dependent on both the type(s) of algae present and the size, extent, and timing of the bloom.

When algae die in low flow velocity areas, they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, a large algal bloom can substantially deplete DO concentrations near the bottom. Low DO in these areas can lead to decreased fish habitat as fish will not frequent areas with low DO. Both living and dead (decomposing) algae can also affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low DO levels caused by decomposing organic matter can lead to changes in water chemistry and a release of sorbed phosphorus to the water column at the water/sediment interface.

Excess nutrient loading can be a water quality problem due to the direct relationship of high TP concentrations on excess algal growth within the water column, combined with the direct effect of the algal life cycle on DO and pH within aquatic systems. Therefore, the reduction of TP inputs to the system can act as a mechanism for water quality improvements, particularly in surface-water systems dominated by blue-green algae, which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in an improvement in nutrients (phosphorus), nuisance algae, DO, and pH.

2.4 Summary and Analysis of Existing Water Quality Data

The water quality of the Hangman Creek subbasin in Idaho has been under scrutiny for a number of years. In 1981 the Benewah Soil and Water Conservation District initiated planning and implementation of BMPs to control sediment and nutrient pollution within the watershed (BSWCD, 1981). At that time it was written that,

> *"Water quality of Hangman Creek is severely impacted by non-irrigated agriculture. The water quality problems are associated with phosphate, nitrogen, suspended solids, turbidity, bacteria, and toxic chemicals. The uses of Hangman Creek for recreation, drinking water supply, agricultural water supply, and a healthy fishery are impaired. Indications are that the largest single contributor to these problems is cropland runoff."* (BSWCD, 1981)

It should be noted that stream bank erosion and to a more limited extent woodland roads were also sources of sediment within the watershed. As a result of the planning efforts much good work was done to organize farmers and to begin to implement voluntary BMPs throughout the watershed.

Flow Characteristics

As seen in Figure 6 (page 8), flows in Hangman Creek at Tensed, several miles downstream of Sanders, has considerable variation in annual flow with peaks of 1000 cfs or greater and lows below 1 cfs. In the upper part of the watershed above the Tribal boundary, flows can cease during the summer low flow season. All BURP visits into the area recorded flows less than 1cfs (see Table 4) in the early part of July. Such low flows exacerbate water quality problems (temperature, bacteria, and nutrients) and tend to limit habitat for aquatic life.

Table 4. Measured Discharge (cfs) at BURP Sites in upper Hangman Creek Watershed.

Stream	BURP ID	Date Sampled	Measured Discharge
Hangman Creek	2002SCDAA002	7/2/02	0.9 cfs
South Fork Hangman Creek	2002SCDAA003	7/2/02	0.8 cfs
Bunnel Creek	2002SCDAA005	7/8/02	0.4 cfs
South Fork Hangman Creek	2003SCDAA002	7/1/03	0.1 cfs
Martin Creek	2003SCDAA005	7/3/03	0.2 cfs

Water Column Data

Baseline monitoring associated with the BMP planning efforts was conducted in 1981 and 1982 (Bauer and Wilson, 1983). Four sampling stations on the mainstem Hangman Creek and 12 stations on associated tributaries were established and monitored periodically for suspended sediment, phosphorus, nitrogen, bacteria, and other water quality parameters (DO, pH, dissolved solids, total metals).

Suspended sediment sampling specifically targeted two early spring storm events to sample peak runoff. Sediment loads during the larger storm event (February 14-23, 1982) were variable across sampling stations, varying from 0.09 tons/acre at State Park tributary to 2.9 tons/acre in Hangman Creek at DeSmet, Idaho. Hangman Creek above Sanders station above the South Fork confluence produced 388 tons or 0.35 tons/acre during that same event. The Hangman Creek below Sanders station just above Smith Creek (which would include contributions from Indian Creek) recorded 5,124 tons or 1.44 tons/acre. Sediment yields were much smaller during the second event (March 1-5, 1982) ranging from 0.0005 to 0.2 tons/acre.

Average total phosphorus levels ranged from 0.16 mg/L to 1.32 mg/L for the twelve stations. Average total phosphorus levels above and below Sanders were 0.17 mg/L and 0.16 mg/L, respectively. These TP levels are greater than EPA's 1986 recommendations of 0.1 mg/L TP for flowing streams not entering reservoirs (EPA Gold Gook, 1986). Average inorganic nitrogen (NO_2+NO_3+NH_3) levels around the watershed varied from 0.23 mg/L to 6.8 mg/L. Inorganic nitrogen averaged 0.23 mg/L and 0.42 mg/L above and below Sanders, respectively.

Fecal coliform levels measured in Hangman Creek above Sanders exceeded water quality standards (126 *E. coli*/100ml) 36% of the time. Below Sanders coliform numbers exceed standards 25% of the time. At that time it was determined that bacteria were mostly from human sources and were suspected to be from aging or faulty septic systems.

No DO or metals problems were encountered through this sampling effort. However, pH and hardness were considered naturally very low. Iron was also considerably high by drinking water standards and high levels of suspended sediments were considered the likely source of the iron.

Fortis and Hartz (1991) conducted follow-up monitoring in the watershed at the same 16 stations sampled by Bauer and Wilson (1983). Sampling occurred during 1989-1990, and was intended to provide examination of post-BMP implementation. However, at that time BMPs in the lower part of the watershed had only been in place for a year and were not expected to have achieved their full potential. BMPs in the upper portion of the watershed had been in place for several years prior to re-sampling.

Suspended sediment levels decreased in upper Hangman Creek watershed over the eight year period. Sediment yields were less at DeSmet, Smith Creek, and above and below Sanders than they were eight years before. However, sediment yields in lower parts of the watershed (Lolo Creek, Andrews Springs, State Park, and Clay Pit) showed increases. These data are somewhat limited in scope because they were only taken during several storm events in each study.

Total phosphorus decreased at most stations in the post-implementation study, however inorganic nitrogen increased at most stations. Total phosphorus averaged 0.09 mg/L above Sanders and 0.1 mg/L below Sanders, a 47% and 37% decrease from baseline results, respectively. Phosphorus tends to bind with sediment particles and thus its control is more closely associated with sediment control. Nitrogen on the other hand is more water soluble and tends to be independent of sediment particles.

To our knowledge, no other nutrient sampling has occurred in the upper watershed above Sanders since the Fortis and Hartz (1991) study. Recently, sampling of total phosphorus was performed in several streams on April 29, 2005. Samples were taken from eight sites in six streams (Table 5). The average of all sites was less than 0.04 mg/L. Nutrient sampling occurred concurrently with stream bank assessment surveys, nutrient sampling locations can be found in Figures 13 and 14.

Table 5. Total phosphorus levels in samples taken on April 29, 2005.

Stream Name	Total Phosphorus (mg/L)
Tenas Creek	0.037
Upper Bunnel Creek	0.032
Lower Bunnel Creek	0.026
Parot Creek	0.054
Hangman Creek	0.037
South Fork Hangman Creek	0.045
South Fork Hangman Creek	0.035
Conrad Creek	0.042
Average	**0.0385**

In order to prevent nuisance algae growth and dissolved oxygen problems, EPA (1986) developed a national guideline for streams of 0.1 mg/L TP. More recently, EPA (2000) developed nutrient criteria for total phosphorus of 0.03 mg/L specific to Columbia Plateau sub-ecoregion streams based on the median of all seasons' 25th percentiles. These criteria provide EPA's most recent recommendations to states and authorized tribes for use in establishing their water quality standards. EPA further recommends that, wherever possible, states develop nutrient criteria that fully reflect localized conditions and protect specific designated uses.

Idaho's current nutrient water quality standards states (IDAPA 58.0.02.06);

> *"Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses."*

Data evaluated in this document does not indicate a violation of Idaho's nutrient water quality standard. Therefore, it is recommended that no nutrient TMDL be completed for the upper Hangman Creek watershed at this time. Data which led to the original nutrient listing is unsubstantiated and was collected within the Coeur d'Alene Tribal Reservation, an area that is not under Idaho DEQ jurisdiction.

The 2005 monitoring results within the Idaho/non tribal portion of the upper Hangman Creek watershed do not indicate that excessive nutrients are negatively affecting Idaho beneficial uses. DEQ is aware that monitoring results from the lower Hangman Creek watershed, outside of DEQ jurisdiction, indicate elevated nutrients and suggest beneficial use impairment. When a downstream TMDL is completed, it may be demonstrated that nutrient reductions are required to protect downstream beneficial uses. Idaho DEQ will evaluate nutrient contributions in the Idaho/non-tribal portion of the upper Hangman Creek watershed to meet targets at the Idaho/tribal border. It is anticipated that further remediation efforts directed at addressing other pollutants in this document, sediment, bacteria, and temperature, will likely also reduce nutrient inputs to the system

No bacteria, DO, pH, or temperature problems were recorded in the post-implementation study. The highest temperature recorded was 71ºF (21.5^{o}C) below the Sanders station. These were likely instantaneous temperature recordings taken at the time of other water quality sampling and may not represent maximum daily temperatures. Nor do they account for days when sampling did not occur.

Next, the National Resource Conservation Service (NRCS) formally known as the, Soil Conservation Service (SCS), conducted a preliminary investigation (SCS, 1994) to ascertain conditions in the Hangman Creek watershed and to address continued problems with flooding and erosion in the lower part of the watershed in Idaho. This evaluation rated the condition of the upper portion of the watershed and provided some bank erosion inventory data. The precise location of the inventory is unknown, but was presumably near Sanders. It was concluded that sediment was not a significant problem in the upper watershed and the overall sediment rating was good condition. There were some bank erosion and embeddedness seen that kept the reach examined from achieving an excellent condition rating. Stream bank stability was rated at 90% with erosion rates at 0.2 ft/yr on two foot high banks (equivalent to 9.5 tons/mile/year). No flowing water was seen in the inventory reach at the time of evaluation, only isolated pools with relatively high (73ºF or 23^{o}C) temperatures. It was noted that changes in land use had severely impacted natural hydrology of upper Hangman Creek. The animal waste rating also received a good condition rating and not considered a significant source of pollution. The aquatic habitat condition was fair resulting from over hanging banks and vegetation in poor condition. It was concluded that cold water aquatic life and salmonid spawning could be supported if hydrology could be restored.

The entire watershed in Washington and Idaho was the subject of a restoration project and management plan sponsored by the Spokane County Conservation District (WDOE and SCCD, 1994). That management plan identified the Sanders sub-watershed, an area including Mineral/Smith Creeks and Indian Creek as well as the upper portion of Hangman Creek above the Tribal boundary. This sub-watershed was ranked relatively high (13 of 38) for targeted implementation of best management practices. The ranking system evaluated sediment delivery, evidence of other water quality impairments, the potential for increases in intensity of land use, technical ability to correct problems, the likelihood of success, and the availability of established water quality monitoring sites. The Sanders sub-watershed sediment yield rating was considered moderate with 0.59 acre-feet/sq.mi. (1,157 tons/sq.mi.) annual yield.

The Idaho Department of Lands (IDL) conducted a cumulative watershed effects (CWE) assessment of the Hangman Creek headwaters area in 2002 (IDL, 2003). The CWE process consists of seven specific assessments including: erosion and mass failure hazards, canopy closure/stream temperature, channel stability, hydrologic risks, sediment delivery, nutrients, and beneficial uses/fine sediment assessment. All but one of these assessments resulted in a low risk rating. Bank stability was the only assessment that received a moderate rating due to some bank sloughing, low bank rock content, bank cutting, lack of large organic debris, channel bottom movement, and channel bottom shape and brightness. The canopy closure rating resulted from aerial photo cover estimates that were predominantly greater than 90% cover.

Seven (7) management problems were identified in the upper Hangman Creek watershed during the 2002 CWE assessment. Three (3) problems were associated with road fill slopes and identified as exhibiting increased erosion. Two (2) culvert problems and two (2) road drainage ditch problems were also identified (IDL 2003). DEQ conducted a culvert survey on September 27, 2006. The surveyor noted that a culvert on Tenas Creek, approximately four hundred meters above the Martin Creek confluence may be a barrier to fish passage. During the survey the culvert was not evaluated for possible sediment contributions. Further evaluation of the CWE identified problem culverts should be conducted.

In the spring of 2005 DEQ conducted stream bank surveys (Appendix D). Eroding stream bank lengths were measured and the amount of sediment contributed to the stream from the eroding banks was calculated. From these surveys results a load was then calculated and a load reduction was determined (Section 5.3 Estimates of Existing Pollutant Loads).

Temperature

Stream temperature data were collected by the Coeur d'Alene Tribe on Hangman Creek and its tributaries in the region above the Tribal boundary from 2002 to 2004 (see Appendix B). In general, all streams monitored met cold water aquatic life daily maximum criterion (22^{o}C or 71.6ºF). Hangman Creek at the South Fork Road had one day (July 24, 2004) that exceeded 22^{o}C (71.6ºF) by a half a degree. Most sites where temperatures were recorded in the spring showed violations of the salmonid spawning daily maximum criterion (13^{o}C or 55.4ºF). These violations usually occurred in the June 21^{st} to July 15^{th} portion of the default spring spawning season (March 15^{th} to July 15^{th}). Upper Hangman Creek in 2002 had a series of exceedances beginning with a one day excursion on June 15^{th} followed by June 24^{th} through June 28^{th} exceedances, and then July 7^{th} to the end of the spawning period (July 15^{th}). Further downstream and two years later (2004) Hangman Creek at the South Fork Road had several days where temperatures reached 13.5^{o} or 14^{o}C (56.3º or 57.7ºF), but then greatly exceeded criteria from June 21^{st} on to July 15^{th}. Stream temperatures at Hangman Forest also exceeded criteria from June 22, 2004 on to the end of the spawning period. Temperature recordings in the South Fork Hangman Creek had some data gaps, however the full season recording at the upper South Fork site showed no violations during 2003. At Martin Creek violations occurred from June 25^{th} on to the end of the spawning period.

Bacteria

Bacteria data were collected in Hangman Creek and the South Fork Hangman Creek in 2002 by the Idaho DEQ (Table 6). *Escherichia coli* (*E. coli*) numbers were high in Hangman Creek during the month of July, but dropped substantially in August. In the South Fork *E. coli* numbers were less consistent with some sampling events high and other low in both months. Most sampling events produced five-day geometric mean values that were in excess of the 126 cfu/100ml *E. coli* water quality standard for recreation uses.

Table 6. Bacteria sampling during 2002 for upper Hangman Creek watershed.

Hangman Creek			South Fork Hangman Creek		
Date Sampled	***E. Coli* (cfu/100ml)**	**5-day Geometric Mean**	**Date Sampled**	***E. Coli* (cfu/100ml)**	**5-day Geometric Mean**
7/8/2002	1100		7/8/2002	730	
7/22/2002	1300		7/22/2002	68	
7/26/2002	730		7/26/2002	64	
7/29/2002	2400		7/29/2002	26	
8/2/2002	99	757	8/2/2002	1000	152
8/5/2002	20	339	8/5/2002	1200	168
8/9/2002	59	193	8/9/2002	21	133
8/13/2002	31	97	8/13/2002	370	189

Biological and Other Data

The following fish species were captured in 1963 by Coeur d'Alene Tribe personnel in upper Hangman Creek: rainbow trout, eastern brook trout, speckled dace, longnose dace, longnose sucker, northern pikeminnow, chiselmouth, redside shiner, brown bullhead, and tench (WDOE and SCCD, 1994). Water quality work in the 1980s and 1990s reported that catfish, redside shiners, and dace were the primary constituents of the Hangman Creek fishery (SCS, 1994). The creek also supported rainbow trout in the headwaters and in several isolated sections of lower Hangman Creek in the State of Washington at that time. Sculpin have also been observed in the upper watershed by IDFG personnel.

Five BURP sites were sampled in 2002 and 2003 in the upper part of the Hangman Creek watershed above the Tribal boundary (see Appendix C for compilation of BURP data). BURP electrofishing activities resulted in the capture of speckled dace, redside shiner, and rainbow trout in Hangman Creek below the South Fork Hangman Creek confluence; sucker, rainbow trout, redside shiner, and speckled dace at the mouth of South Fork Hangman Creek; and rainbow trout in Bunnel Creek.

Status of Beneficial Uses

Beneficial uses in upper Hangman Creek were assessed in 2002 based primarily on temperature data. Although temperature data were available for only Indian Creek at the time, the entire assessment unit (ID17010306PN001_02) which includes South Fork Hangman Creek, Martin Creek, Bunnel Creek, Tenas Creek and Hangman Creek proper above the South Fork, was identified as being impaired due to temperature. Subsequent temperature data provided by the Coeur d'Alene Tribe for the headwaters streams shows violations of spring salmonid spawning criteria. That same 2002 assessment carried over from the original 1998 §303(d) list for Hangman Creek for the ID17010306PN001_03 assessment unit, which included Hangman Creek downstream from the South Fork confluence. That listing was for sediment, nutrients, and bacteria.

The results of the BURP visits were assessed in 2004 and found to be not supporting aquatic life uses primarily due to low stream fish index (SFI) scores (Table 7). Any average score less than two is considered an indication of non-support, and an average score of two or more is consider an indication of supporting beneficial uses. Although a stream may exhibit an average score of two or more, indicating full support, other data adhering to stringent DEQ standards as outlined in the *Water Body Assessment Guidance* (Grafe *et al*. 2002) may indicate that the water body is not supporting all beneficial uses.

Table 7. Water body assessment scores for five BURP sites in the upper Hangman Creek watershed.

BURPID	Stream	SMI	SMI Score	SFI	SFI Score	SHI	SHI Score	Ave. Score
2002SCDAA003	South Fork Hangman Creek	65.4	3	22.3	0	60	3	2
2002SCDAA005	Bunnel Creek	64.5	2	31.2	0	70	3	1.67
2002SCDAA002	Hangman Creek	49.9	2	8.6	0	61	3	1.67
2003SCDAA002	South Fork Hangman Creek	60.1	3	0	0	74	3	3
2003SCDAA005	Martin Creek	54.3	1	n.a.	n.a.	50	1	1

All streams except Martin Creek had good macroinvertebrate (SMI) and habitat (SHI) scores. However, these streams received the lowest scoring for fish diversity (SFI). This seemingly conflicting information may suggest that Hangman Creek headwaters may lack flow necessary to maintain a fishery or that impacts to Hangman Creek downstream are preventing the variety of habitats and migration corridors necessary to maintain a typical fishery in these headwaters. Another possibility is sediment from stream bank erosion is affecting spawning habitat and limiting fish production.

Conclusions

Due to a variety of factors, including pollutant listings for sediment and bacteria for Hangman Creek below the South Fork confluence, the water quality impairment listing for the assessment unit above the South Fork for temperature, and bacteria and temperature data from the headwaters area, it was decided that sediment, bacteria, and temperature TMDLs would be completed for all streams in this headwaters area above the Tribal boundary. Total phosphorus levels in the upper watershed had decreased below 0.1mg/L by 1990, the target level used in this watershed to indicate nutrient problems. More recent sampling of total phosphorus in the upper watershed showed values consistent with EPA numeric nutrient guidance. Thus, no nutrient TMDL will be completed. It is recommended that Hangman Creek above the Coeur d'Alene Tribal boundary be de-listed for nutrients.

2.5 Data Gaps

There has been very little water column data for sediment collected in this portion of the watershed since 1994. And no information is available on depth fines of spawning gravels or on sediment yields from land use activities. Therefore, the sediment TMDL will be based solely on the most recent bank erosion inventory taken by the DEQ in the spring of 2005 (Appendix D).

Flow is probably the confounding factor in this headwaters area. Little is known about the available flow throughout the year and what affect it has had on the assessed data. All BURP data collection events in this area had flows less than 1 cfs at the time of sampling (early July). Anecdotal information suggests that the streams in the headwaters area cease to flow for part of the summer, and remain as vernal pools in places until flow returns in the fall. This lack of flow may have a pronounced affect upon the fish community, the reason for the most recent 2004 non-support assessment. Additionally, low flow exacerbates bacteria concentrations and solar loading.

3. Subbasin Assessment–Pollutant Source Inventory

3.1 Sources of Pollutants of Concern

The upper portion of the Hangman Creek watershed above the Coeur d'Alene Tribe Boundary is largely forested with timber harvesting activities being the predominant use of the area. There are several open areas at the lowest part of this area that are used as grazing lands. Additionally, there are less than 20 homes and ranches along the main roads including Sanders Road and Martin Creek Road.

Point Sources

A point source of pollutants is characterized by having a discrete conveyance to surface water, such as a pipe, ditch, or other identified "point" of discharge into a receiving water body. There are no permitted point source discharges in this portion of the watershed. To our knowledge, there are no un-permitted point source discharges either.

Nonpoint Sources

Nonpoint sources of pollution are generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered to surface water. The primary sources of sediment and temperature pollution in the upper Hangman Creek watershed are riparian disturbance and stream bank erosion associated with timber harvesting activities, livestock grazing, and development. Bacterial sources possibly originate from seepage of pollutants from septic systems, livestock/animal containment and pasturing, and wildlife.

Pollutant Transport

Most of the timber harvesting activities result from private timber companies on private land, presumably practiced in accordance with the state's Forest Practices Act (FPA). Forest harvest activities and road construction are the major uses and impacts to the riparian plant communities in the upper watershed (WDOE and SCCD, 1994; IDL, 2003).

Some thermal pollution, caused by a lack of vegetative cover, and sediment appears to be from stream bank erosion at the lowest elevations of this segment. Vertical banks and a lack of vegetation are visible on aerial photos taken as part of the 2004 National Agriculture Imagery Program (NAIP) for several reaches near the Tribal boundary. It is anticipated that runoff from roads as well as from timber harvest activities increases hydrologic inputs which can accelerate bank erosion, however, the overall contribution from the land appears to be minimal (IDL, 2003).

Septic systems associated with homes in the area and livestock grazing activities are assumed to be the sources of bacteria in this portion of the watershed. Earlier water quality sampling in 1990 suggested that the primary source of bacteria was from human sources based on fecal coliform to fecal streptococcus ratios (Fortis and Hartz, 1991). The 2002 DEQ bacteria sampling (*E. coli*) did not test this hypothesis.

3.2 Data Gaps

Considerable information is needed on bacteria sources and loadings throughout the year. Continued bacteria monitoring could help to identify the source or sources of bacteria contamination and should include flow measurements. Identification of bacteria sources will be necessary in order to reduce bacteria concentration noted within the watershed.

4. Subbasin Assessment – Summary of Past and Present Pollution Control Efforts

Considerable effort was put into BMP implementation for the control of non-point source pollution in the Hangman Creek watershed in the 1980s and 1990s (BSWCD, 1981; Bauer and Wilson, 1983; Fortis and Hartz, 1991; SCS, 1994). Benewah County Soil Conservation District received state agricultural water quality program funding to implement BMP contracts on critical areas throughout the watershed in Idaho. Additional funding was provided by the Soil Conservation Service in the form of the Watershed Protection and Flood Prevention Program (P.L. 566)/Small Watershed Project funding to the conservation district. In upper Hangman Creek 79% of the 6,552 critical acres (2,651.5 hectares) received $304,861 in contracts for BMPs. Recent Conservation Reserve Program (CRP) contracts have probably increased the number and percentage of contracted acres (WDOE and SCCD, 1994).

Fortis and Hartz (1991) reported that BMP implementation in the upper part of the watershed resulted in decreases in suspended sediment, phosphorus, and bacteria concentrations in less than 10 years. In the lower part of the watershed, pollutant concentrations had not decreased, however, at that time BMPs had been in place only a year and not enough time had passed to show changes (Fortis and Hartz, 1991). These non-point source BMPs have largely been changes in agricultural practices such as conservation tillage, crop rotation, and grass swales.

5. Total Maximum Daily Loads

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA). Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the margin of safety is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human made pollutant sources. This can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the load capacity is determined. Then the load capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear on the surface.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 In-stream Water Quality Targets

In-stream water quality targets for TMDLs are variable depending on the nature of the pollutant. For bacteria, the in-stream target is the water quality standard for recreation uses.

For sediment and nutrients, no standards are available or practical. Thus we rely upon surrogate targets to achieve a level of pollution reduction necessary to achieve full support of beneficial uses. Stream temperatures are highly complicated and although temperature criteria exist, the use of riparian shade targets is a much more practical approach.

Design Conditions

Design conditions are those methods which were used to determine pollutant loads. Design conditions are discussed separately for sediment, temperature, and bacteria in this section.

Sediment

To quantify the seasonal and annual variability and critical timing of sediment loading, climate and hydrology must be considered. This sediment analysis characterizes sediment loads using average annual rates determined from empirical characteristics (i.e. bank erosion, road erosion) that developed over time within the influence of peak and base flow conditions. Annual erosion and sediment delivery are functions of a climate where wet water years typically produce the highest sediment loads. Additionally, the annual average sediment load is not distributed equally throughout the year. Erosion typically occurs during a few critical months. It is difficult to quantify these events, thus a single annual load from each source, the stream banks, roads, and mass failures, is calculated and presumed to represent annual average sediment loading from those sources.

In an attempt to reflect seasonal sediment loading, and current EPA guidance, daily sediment loads were developed for each stream based on sediment load targets. Stream flow data was used to determine sediment loads for each month. Refer to Appendix I for further information regarding these calculations. Although daily sediment load calculations were made the annual sediment load target should be followed due to the natural variability of sediment loading.

Temperature

There are several important contributors of heat to a stream including ground water temperature, air temperature and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most likely to be controlled or manipulated. The parameters that affect or control the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology affects how closely riparian vegetation grows together and water storage in the alluvial aquifer. The amount of shade provided by objects other than vegetation is not easy to change or manipulate. This leaves vegetation and morphology as the most likely sources of change in solar loading and, hence, temperature in a stream. The relationship between shade and a stream's temperature in the upper Hangman Creek watershed is briefly examined in Appendix B.

The upper Hangman Creek Watershed Advisory Group (WAG) anticipates private land being managed according to Idaho Forest Practices Act (FPA) regulations. Should existing shade fall below the shade targets set by this TMDL, actions are encouraged to be taken by the land manager/landowner to reestablish vegetation with the goal of accelerating achievement of the shade targets.

Current regulations under the Idaho FPA (IDAPA 20.02.01) do regulate the harvest of timber from the near stream vegetative communities. The FPA specifies that seventy-five percent (75%) of the current shade over a Class I stream be left after timber harvest activities, and that re-entry to the area be limited until shade recovers (IDAPA 20.02.01.07.e.ii). Refer to the Idaho FPA (IDAPA 20.02.01.07.e.ii) for further rules protecting near stream vegetation communities.

Near stream plant community

A riparian area is commonly defined as the transitional zone between the aquatic and terrestrial environments. Riparian areas occur as a belt along the banks of rivers, streams, and lakes. As a transitional zone between aquatic and upland environments, riparian systems often exhibit characteristics of both; but they are not as dry as upland environments and they are not quite as wet as aquatic or wetland systems.

As compared to the adjacent upland plant communities the riparian area allows for certain plant communities to grow that would not be capable of living in the drier upland areas. The vegetation composition differences between upland and riparian areas are particularly obvious in arid states where there are often abrupt shifts in vegetation. In less arid states, the transition between upland and riparian is often much less obvious because upland areas benefit from considerably greater rainfall.

Vegetation influences the physical processes of water movement, nutrient mobilization, and soil deposition, and is also the foundation for various ecological interactions including the formation of terrestrial and aquatic food webs and habitat (FISRWG 1998). Disturbances within plant communities may result in alterations to the flow patterns of surface and ground water, soil composition, shade reduction, and nutrient deposition, which in turn lead to changes in water quantity and quality, stream structure, sedimentation rate, temperature, and nutrient balance.

In upper Hangman Creek the difference between the riparian and upland plant communities is often times indiscernible. The vegetation which provides shade to streams in upper Hangman Creek may consist of riparian or upland plant communities but most often consist of a combination of both. Because of this difficulty the vegetation adjacent to the upper Hangman Creek waterways will be referred to as a riparian plant community.

Potential natural vegetation (PNV)

Depending on how much vertical elevation also surrounds the stream, vegetation further away from the riparian corridor can provide shade. However, riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. We can measure the amount of shade that a stream enjoys in a number of ways. Effective shade, that shade provided by all objects that intercept the sun as it makes its way across the sky, can be measured in a given spot with a solar pathfinder or with optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and the stream’s aspect. In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream, and can be measured using a densiometer, or estimated visually either on site or on aerial photography. All of these methods tell us information about how much the stream is covered and how much of it is exposed to direct solar radiation.

Potential natural vegetation (PNV) along a stream is that intact riparian plant community that has grown to its fullest extent and has not been disturbed or reduced in anyway. The PNV can be removed by disturbance either naturally (wildfire, disease/old age, wind-blown, wildlife grazing) or anthropogenically (domestic livestock grazing, vegetation removal, erosion). Although PNV is the desired target, it is recognized that PNV conditions seldom exist. Achieving these conditions will provide optimal shade and provide for an additional margin of safety in the TMDL loading calculations. The idea behind PNV as targets for temperature TMDLs is that PNV provides the most shade and the least achievable solar loading to the stream. Anything less than PNV results in the stream heating up from additional solar inputs. We can estimate PNV from models of plant community structure (shade curves for specific riparian plant communities), and we can measure existing vegetative cover or shade. Comparing the two will tell us how much excess solar load the stream is receiving, and what can be done to decrease solar gain.

Existing shade or cover was estimated for upper Hangman Creek above the Tribal boundary and its tributaries from visual observations of aerial photos taken during the 2004 National Agriculture Imagery Program (NAIP). These estimates were field verified by measuring shade with a solar pathfinder at systematically located points along the streams (see below for methodology). PNV targets were determined from an analysis of probable vegetation at these creeks and comparing that to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width. Existing and PNV shade (target effective shade) was converted to solar load from data collected on flat plate collectors at the nearest National Energy Research Laboratory weather stations collecting these data. In this case, an average of the two nearest stations at Kalispell, Montana and Spokane, Washington was used. The difference between existing and potential solar load, assuming existing load is higher, is the reduction necessary to bring the stream back into compliance with water quality standards (see Appendix B). PNV shade, or target effective shade, and loads are assumed to be the natural condition, thus stream temperatures under PNV conditions are considered to be the lowest achievable temperatures (so long as there are no point sources or any other anthropogenic sources of heat in the watershed).

Pathfinder Methodology

The solar pathfinder is a device that allows one to trace the outline of shade producing objects on monthly solar path charts. The percentage of the sun's path covered by these objects is the effective shade on the stream at the spot that the tracing is made. In order to adequately characterize the effective shade on a reach of stream, ten traces should be taken at systematic or random intervals along the length of the stream in question.

At each sampling location the solar pathfinder should be placed in the middle of the stream about one foot above the water. Follow the manufacturer's instructions (orient to true south and level) for taking traces. Systematic sampling is easiest to accomplish and still not bias the location of sampling. Start at a unique location such as 100 meters from a bridge or fence line and then proceed upstream or downstream stopping to take additional traces at fixed intervals (e.g. every 100 meters, every half-mile, every degree change on a GPS, every 0.5 mile change on an odometer, etc.). One can also randomly locate points of measurement by generating random numbers to be used as interval distances.

It is a good idea to take notes while taking solar pathfinder traces, and to photograph the stream at several unique locations. Pay special attention to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade producing species) are present. Additionally or as a substitution, one can take densiometer readings at the same location as solar pathfinder traces. This provides the potential to develop relationships between canopy cover and effective shade for a given stream.

Aerial Photo Interpretation

Canopy coverage estimates or expectations of shade based on plant type and density are provided for 200-foot elevation intervals or natural breaks in vegetation density. Each interval is assigned a single value representing the bottom of a 10% canopy coverage or shade class as described below (*adapted from the CWE process, IDL, 2000)*:

Cover class	Typical vegetation type
0 = 0 – 9% cover	agricultural land, denuded areas
10 = 10 –19%	agricultural land, meadows, open areas, clearcuts
20 = 20 – 29%	agricultural land, meadows, open areas, clearcuts
30 = 30 – 39%	agricultural land, meadows, open areas, clearcuts
40 = 40 – 49%	shrublands/meadows
50 = 50 – 59%	shrublands/meadows, open forests
60 = 60 – 69%	shrublands/meadows, open forests
70 = 70 – 79%	forested
80 = 80 – 89%	forested
90 = 90 –100%	forested

The visual estimates of shade in this TMDL were field verified with a solar pathfinder. The pathfinder measures effective shade and is taking into consideration other physical features that block the sun from hitting the stream surface (e.g. hillsides, canyon walls, terraces, man-made structures). The estimate of shade made visually from an aerial photo does not take into account topography or any shading that may occur from physical features other than vegetation. However, research has shown that shade and cover measurements are remarkably similar (OWEB, 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade.

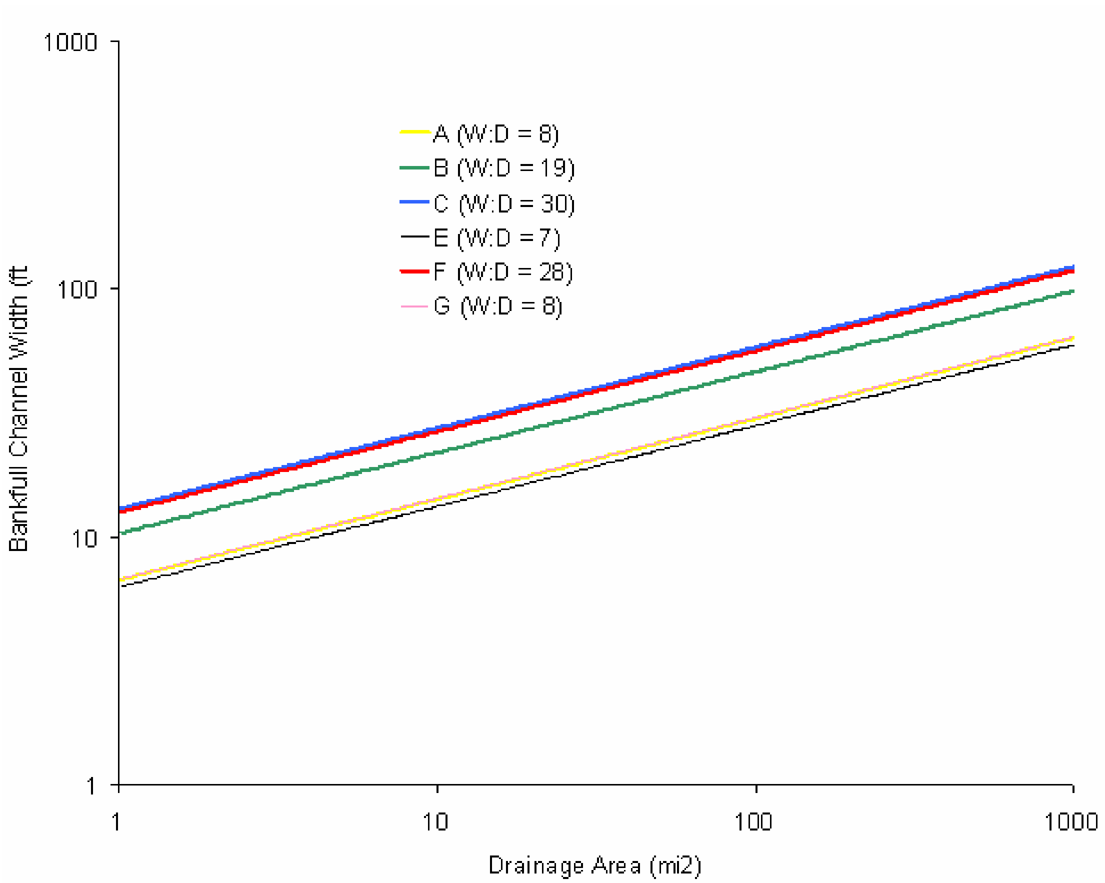
Stream Morphology

Measures of current bankfull width or near stream disturbance zone width may not reflect widths that were present under PNV. As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase such that streams become wider and shallow. Wider streams mean less vegetative cover to provide shading.

Shade target selection, which involves evaluating the amount of shade provided at PNV conditions, necessitates recognition of potential natural stream widths as well. In this TMDL appropriate stream widths for shade target selection were determined from analysis of existing stream widths and the relationship between drainage area and width-to-depth ratios (Rosgen, 1996). Figure 10 (from IDEQ, 2002) shows the relationship between drainage area and bankfull width for the various level 1 Rosgen channel types.

The streams in the upper Hangman Creek watershed are small given that only the portion above the Coeur d'Alene Tribal Reservation is involved. A sliding scale of stream widths was developed for the various streams in question with the lower ends of Hangman Creek and South Fork Hangman Creek receiving a 10 foot (3 m) wide channel (drainage areas for both are approximately 8-10 mi^2 or 5,120-6,400 acres) and decreasing upstream to headwaters areas with 1.5 foot (0.5 m) wide channels. Thus, small headwater streams such as Hill Creek and Bunnel Creek will have natural stream widths of 1.5 feet (0.5 m). Larger headwater streams such as Martin Creek and Conrad Creek will increase from 1.5 feet (0.5 m) in their headwaters to 3 feet (1 m) wide at their mouths. Finally, the largest streams (Hangman Creek and South Fork Hangman Creek) run the gamut from 1.5 feet (0.5 m) in their headwaters, then 3 feet (1 m), 6.5 feet (2 m), and 10 feet (3 m) at their lowest point in this portion of the watershed.

Figure 10. Bankfull Width as a Function of Width to Depth Ratio and Drainage Area.



Bacteria

In the case of bacteria and recreation uses, the warmer months of the year including late spring, summer and early fall are considered the critical time period to protect recreational users of surface waters from bacterial contamination. In this TMDL, bacteria data were collected during summer months so little is known about bacterial contamination in spring following runoff or in the fall. Bacterial contamination is also highly affected by flow. Thus, in this TMDL, bacteria loads are developed based on flow. Subsequent monitoring to implement this bacteria TMDL will require measurements of flow at the same time as bacteria sampling.

In this TMDL, *E. coli* data collected in July and August of 2002 did not have concomitant flow data. However, flow was measured at the bacteria sample locations several days prior to sampling during the BURP crew visits. Flow measured by the BURP crew was 0.9 cfs in Hangman Creek and 0.8 cfs in South Fork Hangman Creek on July 2, 2002. Bacteria sampling commenced on July 8, 2002 and continued approximately every week until August 13, 2002. In order to estimate flow during the bacteria sampling events, flow data from the USGS gauging station (12422950) near Tekoa, Washington (below the confluence of Hangman and Little Hangman Creek) provided by the Coeur d'Alene Tribe, was used to estimate flow at the bacteria sampling locations. Table 8 shows the mean daily flow at the Tekoa gage, the change in flow from one sample date to the next (as a fraction of the difference), and the flow estimates for Hangman Creek and South Fork Hangman Creek based on that change. Negative change, although counterintuitive, results from an increase in flow during the latter date.

Flow at the Tekoa gage decreased from 3.25 cfs on July 2nd to 0.72 cfs on August 2nd with rates of change varying from 29%, 48%, 6%, 13%, and 26% over the range of sample dates. For the remaining three sample dates in August flow increased at the Tekoa gage to 0.9 cfs on August 13th with flow increases ranging from 5% to 11%. These rates of change were applied to the flow measured at the Hangman Creek and South Fork Hangman Creek BURP sites on July 2, 2002. Thus, Hangman Creek's flow decreased from 0.9 cfs to 0.2 cfs, then increased to 0.24 cfs during the course of bacteria sampling. The South Fork's flow decreased from 0.8 cfs to 0.18 cfs, and then increased to 0.22 cfs.

Table 8. Mean daily flow measured at the Tekoa gage and estimated for Hangman Creek and its South Fork.

Mean Daily Flow (cfs)				
Sample Date	Tekoa Gage	Date to Date Change in Flow (as a fraction)	Hangman Creek Estimate	South Fork Hangman Creek Estimate
7/2/2002	3.25		0.90[a]	0.80[a]
7/8/2002	2.31	0.2892	0.64	0.57
7/22/2002	1.19	0.4848	0.33	0.29
7/26/2002	1.12	0.0588	0.31	0.28
7/29/2002	0.976	0.1286	0.27	0.24
8/2/2002	0.724	0.2582	0.20	0.18
8/5/2002	0.802	-0.1077	0.22	0.20
8/9/2002	0.841	-0.0486	0.23	0.21
8/13/2002	0.88	-0.0464	0.24	0.22

a = These are measured flows during BURP visit.

Target Selection

Sediment

Sediment targets for this TMDL are based on stream bank erosion, road erosion, and mass failure quantitative allocations in tons/year. The reduction in stream bank erosion prescribed in this TMDL is directly linked to the improvement of riparian vegetation density to armor stream banks thereby reducing lateral recession, trapping sediment and reducing stream energy, which in turn reduces stream erosivity and instream sediment loading. It is assumed that by reducing chronic sediment, there will be a decrease in subsurface fine sediment that will ultimately improve the status of beneficial uses.

It is assumed that natural background sediment loading rates from bank erosion equate to 80% bank stability as described in Overton and others (1995), where banks are expressed as a percentage of the total estimated bank length. Natural condition stream bank stability potential is generally 80% or greater for Rosgen A, B, and C channel types in plutonic, volcanic, metamorphic, and sedimentary geology types. Therefore, an 80% bank stability target based on stream bank erosion inventories shall be the target for sediment.

Road erosion and mass failure estimates of sediment delivery were determined from the CWE assessment of the upper Hangman Creek area (IDL, 2003). Sediment delivery from road erosion was determined from the CWE score for forest roads and the relationship between these scores and sediment export developed by McGreer (1997).

Forest road sediment yield was estimated using the relationship between the CWE score and the sediment yield per mile of road (Figure 11). The relationship was developed for roads on a Kaniksu granitic terrain in the LaClerc Creek (Washington) watershed (McGreer 1997). Its application to roads on geologies of the upper Hangman Creek conservatively estimates (overestimates) sediment yields from these systems. The watershed CWE score was used to develop sediment tons per mile, which was multiplied by the estimated road mileage.

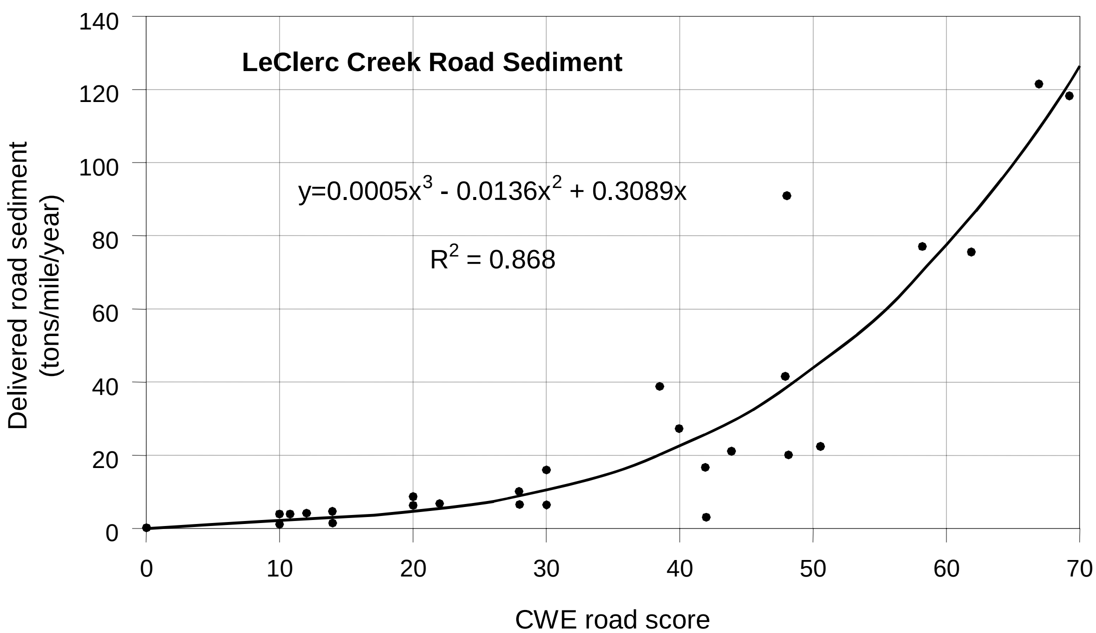


Figure 11. Sediment export from roads based on CWE scores.

Additional research and analysis methods support the use of the sediment export delivery values used to calculate sediment generation associated with forest roads. WEPP:Road is an interface of the Water Erosion Prediction Project (WEPP) soil erosion model that allows users to easily describe numerous road erosion conditions (USFS 1999). When evaluating sediment delivery to the stream using WEPP roads the Moscow, Idaho climate station was used to supply precipitation information to the model. Road width (forty feet), road length (two hundred feet), fill gradient (50%), and fill length (fifteen feet) were held constant. Road design, soil texture, percent rock, buffer gradient and length, road surface, and traffic level were all manipulated. Manipulation of these variables resulted in a predicted forest road erosion rate ranging from 0 tons/mile/year to 11 tons/mile/year, with an average of 3.38 tons/mile/year. The average WEPP Road output of 3.38 tons/mile/year using the McGreer equation is equal to a road CWE score of 15.5. The consistency between the two approaches suggests that the application of the relationship in figure 11 is appropriate.

Manipulation of variables can result in drastically different sediment yields. This variability is most likely what is occurring in upper Hangman Creek. To determine site specific sediment generation from forest roads within upper Hangman Creek extensive monitoring needs to be completed.

The volume estimate and percent delivery from mass failures, provided by the CWE assessment (IDL, 2003) was converted directly to tons of sediment using a bulk density of 100 lbs/ft^3. Target values for road erosion and mass failure are based on the concept of 50% above background is threshold. It is assumed here that background is zero for these sources, which may be accurate for roads, but incorporates a margin of safety for mass failures as no natural mass failures are assumed. Therefore, a target based on 50% reduction in these events was used for this TMDL.

Fifty percent above natural background was chosen as a sediment target following modeling results from EPA approved TMDLs developed for northern Idaho water bodies. EPA approved TMDLs for which 50% above natural background was modeled to be protective include Priest River (IDEQ, 2001), St. Maries River (IDEQ, 2003), St. Joe River (IDEQ, 2003), and the Kootenai/Moyie River TMDL (IDEQ, 2006). Modeling results from the Lower Clark Fork River draft TMDL (2006) also indicate a target of 50% above natural background as protective of all beneficial uses.

All sediment contribution from roads and mass failures were determined to be anthropogenically caused, with no amount contributing to natural background, and existing load reductions set at 50%. This assumption does not account for naturally occurring mass failure events. The small portion of the load calculated above the load capacity for mass failures (0.3% or 3.5 tons) of the total existing load could be considered an additional margin of safety. The IDL CWE (IDL 2003) report conducted within the watershed did include a mass failure hazard rating analysis. The analysis analyzed the topographic, geologic, and soil characteristics of the watershed and determined that the mass failure hazard rating was low. Because of this low rating accounting for any natural occurring mass failures may be an overestimate of sediment contribution.

Temperature

A single effective shade target of 90% was developed for all streams in this portion of the watershed. Because stream widths are small, no greater than 3m, just about any tree or large shrub community, deciduous or conifer is anticipated to provide the maximum amount of shade. Shade curves developed for other TMDLs in the Northwest (South Fork Clearwater, Idaho; Walla Walla River, Oregon; Willamette River, Oregon; Mattole River, N. California) all show that maximum shading occurs at stream widths less than three meters. Because existing shade was evaluated on 10% intervals with the lowest value representing that interval (i.e. 90% represents the shade class of 90% to 100%), the target is also based on this value. Hence the effective shade target for all streams in this TMDL is 90%.

Bacteria

Bacteria targets are set at the water quality standard for recreation uses or 126 cfu/100ml of *E. coli*. For any given flow, the number of colonies the water body can contain and still meet this target is derived from multiplying the flow (converted to milliliters) by 1.26cfu.

Monitoring Points

Sediment

Sediment loadings are based on stream bank erosion inventories conducted on representative reaches, road erosion, and mass failures. Future implementation monitoring should include continued use of erosion inventories on representative reaches in the watershed and the CWE assessment of roads and mass failures. Each reach evaluated in the stream bank inventory for this TMDL represents similar types of reaches in the watershed. It is not necessary to sample these exact locations again. Other reaches for each type represented should be evaluated to take into account variation in the type.

Temperature

Solar loadings in this TMDL are based on aerial photo interpretation. These interpretations are field verified at specific locations. Future monitoring should include continued use of aerial photo interpretation with field verification. Solar pathfinder field verification does not need to take place in exact locations where current field verifications were taken.

Bacteria

Increased monitoring of bacteria is needed to ascertain the source(s) and extent of bacterial contamination in the watershed. Currently it is not known whether the bacteria are from animal or human sources. Future monitoring should include more site specific monitoring, more times of the year, DNA analysis of animal source, and subsequent flow measurements.

5.2 Load Capacity

Loading capacities for pollutants in these TMDLs are based on achieving specific targets. For sediment and bacteria in most cases a 10% margin of safety is taken "off the top" by removing 10% of the loading capacity from consideration. Temperature loading capacities or solar loading capacities are based on potential natural vegetation levels blocking solar radiation. As such, an implicit margin of safety is included in the loading capacity because no less solar loading can be achieved.

Sediment

Bank stability of 80% produces an erosion rate based on the recession rate and stream size evaluated in each stream bank erosion inventory (see Appendix D). Thus, each inventoried reach (Figure 14) and the length of stream that the inventory represents has a proposed erosion rate (tons/mile/year) and a proposed total erosion rate (tons/yr) (see Table 9a). These values as seen on each inventory worksheet and Table 9a represents the loading capacity of the stream. Loading capacities vary from less than 5 tons/mile/year on small forested streams (Bunnel Creek, Hill Creek, and upper Conrad Creek) to 19 tons/mile/year on larger forested segments (upper South Fork Hangman Creek, middle Hangman Creek, lower Conrad Creek, and middle to upper Martin Creek) to greater than 50 tons/mile/year on lower segments of Hangman Creek, South Fork Hangman Creek, and Martin Creek.

The loading capacity of the streams for road erosion and mass failures is based on a 50% above background threshold value (Washington Forest Practices Board, 1995) and previous modeling efforts from within northern Idaho. In this TMDL it is assumed that zero loading from these sources is background. Therefore a reduction of 50% is imposed in this TMDL to help mitigate the effects of human disturbance in the watershed.

Temperature

The loading capacity for stream temperature is based on the solar loading to a stream with 90% effective shade. We use the summer average solar loading (average of six months from April through September) as a benchmark. One hundred percent solar loading to a flat plate collector with zero tilt as measured at the National Renewable Energy Laboratory Spokane station averages 5.7 $kWh/m^2/day$ for this summer period. If 90% of that loading is blocked by effective shade, then only 10% of that loading or 0.57 $kWh/m^2/day$ reaches the stream at target conditions. The loading capacity of 0.57 $kWh/m^2/day$ is listed in Tables 10 through 16 as Potential Summer Load.

<u>Bacteria</u>

The bacteria loading capacity is based on flow (Table 8) and the *E. coli* water quality standard of 126cfu/100ml. Flow (cfs) was converted to milliliters and then multiplied by 1.26. Figures 12 and 13 show the relationship between flows and the number of *E. coli* colonies the stream can contain and still meet the water quality standard. A flow of 1cfs can contain 35,679 cfu of *E. coli* at loading capacity. Figures 11 and 12 also show existing bacteria loads in Hangman Creek and South Fork Hangman Creek based on 5-day geometric means.

Figure 12. Loadings of *E. Coli* bacteria in Hangman Creek based on flow. The loading capacity does not reflect any reductions from a margin of safety.

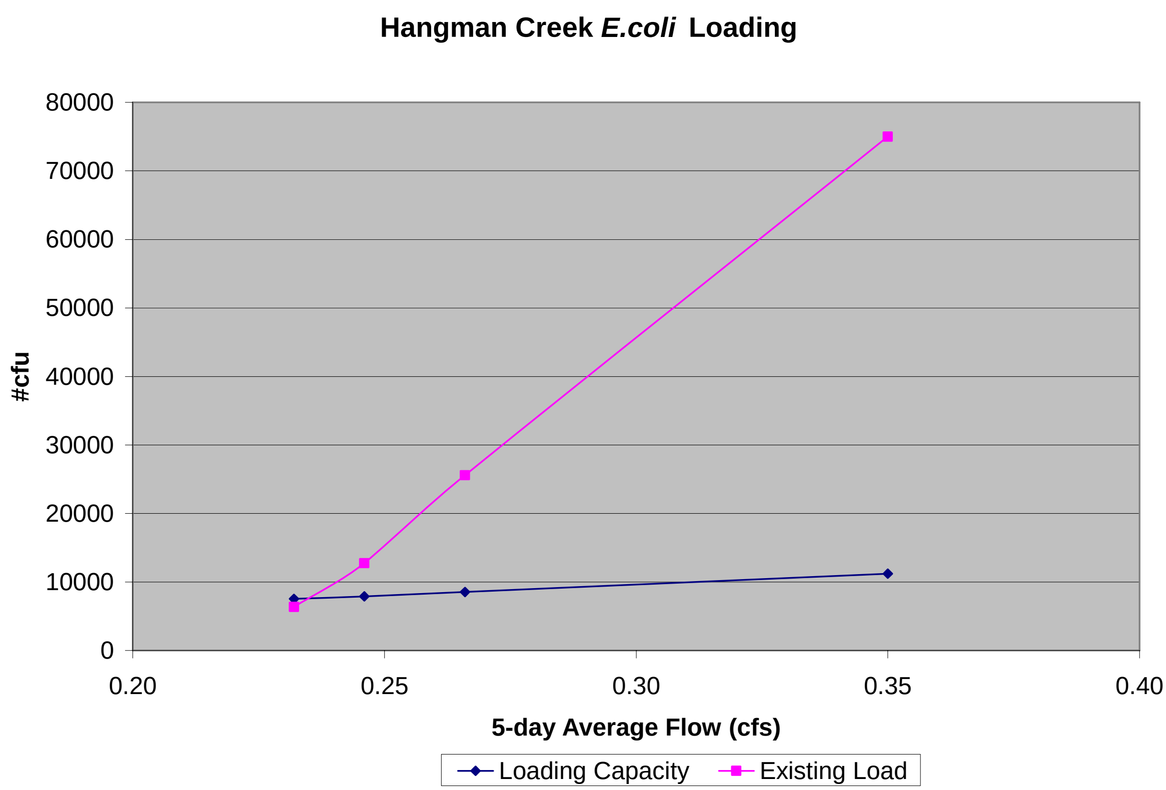
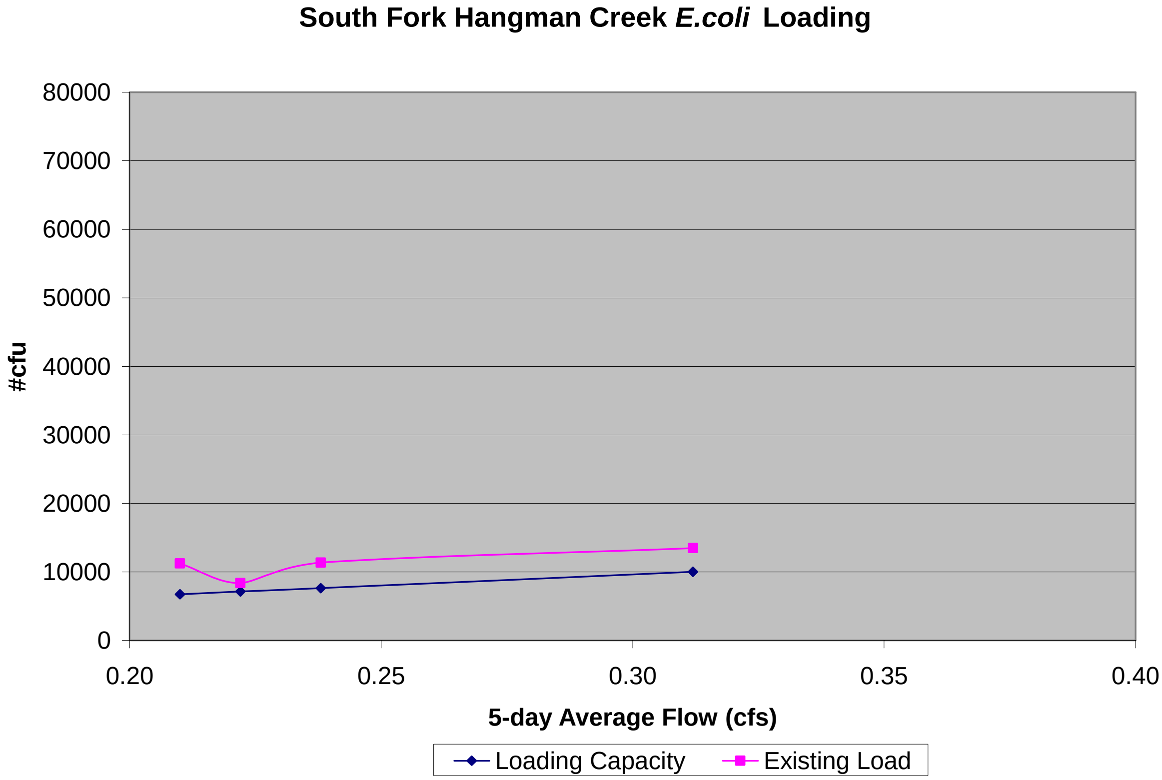


Figure 13. Loadings of *E. Coli* bacteria in South Fork Hangman Creek based on flow. The loading capacity does not reflect any reductions from a margin of safety.



5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading," (Water quality planning and management, 40 CFR § 130.2(I)). An estimate must be made for each point source. Nonpoint sources are typically estimated based on the type of sources (land use) and area (such as a subwatershed), but may be aggregated by type of source or land area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

<u>Sediment</u>

Forest road sediment yield was estimated using the relationship between the CWE road score and sediment yield per mile of road developed by McGreer (1998) for the LeClerc Creek watershed. The CWE road score of 17.2 produced by the CWE assessment of the upper Hangman Creek watershed (IDL, 2003) resulted in a sediment yield of 3.8 tons/mile/year. The CWE assessment (IDL, 2003) indicated that there were 71 miles of forest road in the portion of the watershed analyzed. This results in a sediment yield from roads of 270 tons/year (Table 9b).

Three mass failures were evaluated in the upper watershed by the CWE assessment (IDL, 2003). Mass failure volume estimates were 20, 10 and 10 cubic yards (yds^3) with percent delivery ratings of 20%, 5%, and 5%, respectively. The combination results in a total of 5 yds^3 delivered to the streams from mass failure. Using an average bulk density of 100 lbs/ft^3, that 5 yds^3 weighs slightly less than 7 tons (Table 9b).

Existing stream bank erosion rates were measured at eight reaches in the upper Hangman Creek watershed (see Figures 13 and 14). These eight reaches were used to represent larger portions of the upper watershed under evaluation (see Figure 14). For example, Reach 1 was a 785 foot (239 m) stretch of middle Martin Creek that was used to represent 6,562 feet (2,000 m) of middle to upper Martin Creek and 8,858 feet (2,700 m) of middle to lower Conrad Creek; an area of mixed forest and shrub that was deemed similar due to elevation, stream size and history of land use. Reach 2 represents 1,969 feet (600 m) of lower Martin Creek. Reach 3 represents intact forest on 3,117 feet (950 m) of Bunnel Creek, 4,921 feet (1,500 m) of upper Hangman Creek, 5,577 feet (1,700 m) of Hill Creek and 3,609 feet (1,100 m) of upper Conrad Creek. Reach 4 represents gallery forest along roads from 8,858 feet (2,700 m) of the South Fork Hangman Creek and 6,562 feet (2,000 m) of middle Hangman Creek. Reach 5 was measured approximately three miles downstream of the Tribal boundary outside of the upper watershed area under investigation. Reach 5 was used to represent brushy areas at the widest portion of the upper watershed; 3,150 feet (960 m) of lower Hangman Creek and 755 feet (230 m) of lower South Fork Hangman Creek. Reach 6 was measured on lower Tenas Creek, a small tributary to Martin Creek. This reach was sampled in a freshly harvested forest area to provide some idea of erosion from such activities. Reach 6 represents 3,117 feet (950 m) of Tenas Creek. Reach 7 was also sampled in a recently harvested area on upper Bunnel Creek. This reach represents 3,937 feet (1,200 m) of upper Bunnel Creek. Finally, Reach 8 was sampled in a brushy area along lower South Fork Hangman Creek, and was used to represent 6,594 feet (2,010 m) of that creek.

Table 9a. Sediment Loading Analysis for the upper Hangman Creek Watershed. The Proposed Total Erosion includes the removal of 10% as a margin of safety.

Reach Number	Segment Measured	Segments Represented	Existing		Proposed		Percent (%) Reduction
			Erosion Rate (t/mi/yr)	Total Erosion (tons/yr)	Erosion Rate (t/mi/yr)	Total Erosion – 10% MOS (tons/yr)	
1	Upper Martin Creek	Middle to upper Martin, Middle to lower Conrad	22.4	37.5	19.4	29.3	22
2	Lower Martin Creek	Lower Martin Creek	95.9	35.8	52	17.5	51
3	Lower Bunnel Creek	Lower Bunnel, Hill Creek, upper Conrad, upper Hangman	1.7	5.5	4.7	13.8	0
4	Upper South Fork Hangman Creek	Upper South Fork Hangman, middle Hangman	19.1	55.7	19.3	50.8	9
5	Hangman Creek	Lowest portion of Hangman and South Fork Hangman	730.2	435.7	196	116.9*	73
6	Tenas Creek	Lower Tenas Creek	15	8.9	12.8	6.8	23
7	Upper Bunnel Creek	Upper Bunnel Creek	2.3	1.7	4.2	2.8	0
8	Lower South Fork Hangman Creek	Lower South Fork Hangman Creek	137.6	171.8	90.3	101.5	41
Total	Watershed	Above Tribal Boundary		752.6		339.4	55

*No margin of safety has been subtracted from Reach 5 due to over estimation.

Existing erosion rates vary from approximately 2 tons/mile/year in the forested areas of Bunnel Creek, Hill Creek, and upper Conrad and Hangman Creeks to 730 tons/mile/year on lowest portions Hangman and South Fork Hangman Creeks (Table 9a). Middle to upper Martin Creek and middle to lower Conrad Creek erosion rates were near 22 tons/mile/year. Likewise, upper South Fork Hangman Creek and middle Hangman Creek had erosion rates of 19 tons/mile/year. Whereas the lower portions of the South Fork and Martin Creek had rates around 95 to 137 tons/mile/year. The heavily harvested area of Tenas Creek had an erosion rate of 15 tons/mile/year compared to the 2 tons/mile/year on the slightly older harvested area on upper Bunnel Creek.

Table 9b. Sediment Allocations by Source.

Source	Existing Load (tons/year)	Loading Capacity (tons/year)	Reduction (%)
Stream banks	753	339	55
Roads	270	135	50
Mass Failure	7	3.5	50
Total	**1030**	**477.5**	**54**

In terms of total annual erosion, the entire watershed above the Tribal boundary released more than twice as much sediment than load capacity (Table 9b). Reductions in road and mass failure sediment delivery were pre-determined at 50% (Washington Forest Practices Board, 1995). For stream banks, reduction for the whole watershed above the Tribal boundary is about 55%. Martin Creek and most of Conrad Creek together released about 73 tons from their banks compared to the 7 tons/year released from the forested areas around much smaller Bunnel Creek, Hill Creek, upper Conrad Creek, and the very tip of Hangman Creek (Table 9a). Upper South Fork Hangman Creek and middle Hangman Creek together released about 56 tons/year, whereas the lower portion of South Fork Hangman Creek released 172 tons/year alone. The lowest 0.6 miles (966 m) of Hangman Creek and South Fork Hangman Creek released the greatest amount of sediment at 436 tons/year, however, that is based on data collected at Reach 5 several miles below these reaches. It is likely that actual releases from this area are less due to reduced stream flows and slightly better riparian vegetation and bank conditions. This provides a built in margin of safety for Reach 5, thus a 10% MOS was not subtracted from its loading capacity.

Upper Bunnel Creek and Tenas Creek provide data on likely erosion from forest harvest activities on these smaller headwater streams. Erosion from upper Bunnel Creek is less than that from Tenas Creek, which may reflect slight differences in time since harvest, with upper Bunnel Creek having more time to recover.

Temperature

Streams assessed in this portion of the Hangman Creek watershed were assigned existing shade values at natural break intervals (see Figure 13). Existing shade values ranged from 40% to 90%.

Existing summer solar loads were calculated by multiplying the flat plate collector solar load value (5.7 kWh/m^2/day) by one minus the existing shade value (as a fraction) for a particular reach of stream. Thus, if existing shade is 70%, then the existing load is calculated as 1 - 0.7 = 0.3 x 5.7 kWh/m^2/day = 1.71 kWh/m^2/day.

Tables 10 through 16 show existing shade values and their corresponding existing summer solar load for all streams evaluated. Because solar load is provided on an area basis, total stream loads (in kWh/day) were calculated by first deriving the stream reach area (m^2) from the length times stream width, and then multiplying that area times the existing summer load in kWh/m^2/day.

Bacteria

E. coli was sampled eight times over a two month period from July 8, 2002 to August 13, 2002 at two locations (Hangman Creek and South Fork Hangman Creek). To our knowledge no flow measurements were taken at the time of sampling for bacteria. Therefore, in order to produce existing loads the most recent flow measurements taken during BURP monitoring visits (July 2, 2002) were used to estimate flows during bacteria sampling. At that time flow was measured at 0.9cfs and 0.8cfs in Hangman Creek and South Fork Hangman Creek, respectively. Flow was measured during the sampling dates at the Tekoa gage, which was used to produce the relative difference in flow during subsequent bacteria sampling dates. Loadings based on the first through the fourth running geometric mean calculated from the eight samples (Table 6) were produced at these flows and displayed in Table 9c and Figures 12 and 13 (see Appendix F for loading analysis).

Table 9c. Numbers of *E. coli* colonies in stream at loading capacity (minus 10% MOS) and at the four measured geometric means, and the percent (%) reduction necessary to achieve the loading capacity.

Stream	Flow (cfs)	Load Capacity (cfu/cfs at time of bacteria sampling)	Geometric means (cfu/cfs at time of bacteria sampling)	% Reduction
Hangman Creek	0.35	11,203	74,992	85
	0.266	8,542	25,571	67
	0.246	7,899	12,741	38
	0.232	7,450	6,388	0
South Fork Hangman Creek	0.312	10,019	13,477	26
	0.238	7,643	11,355	33
	0.222	7,129	8,374	15
	0.21	6,744	11,251	40

Figure 14. Existing shade values for various reaches in the upper Hangman Creek watershed

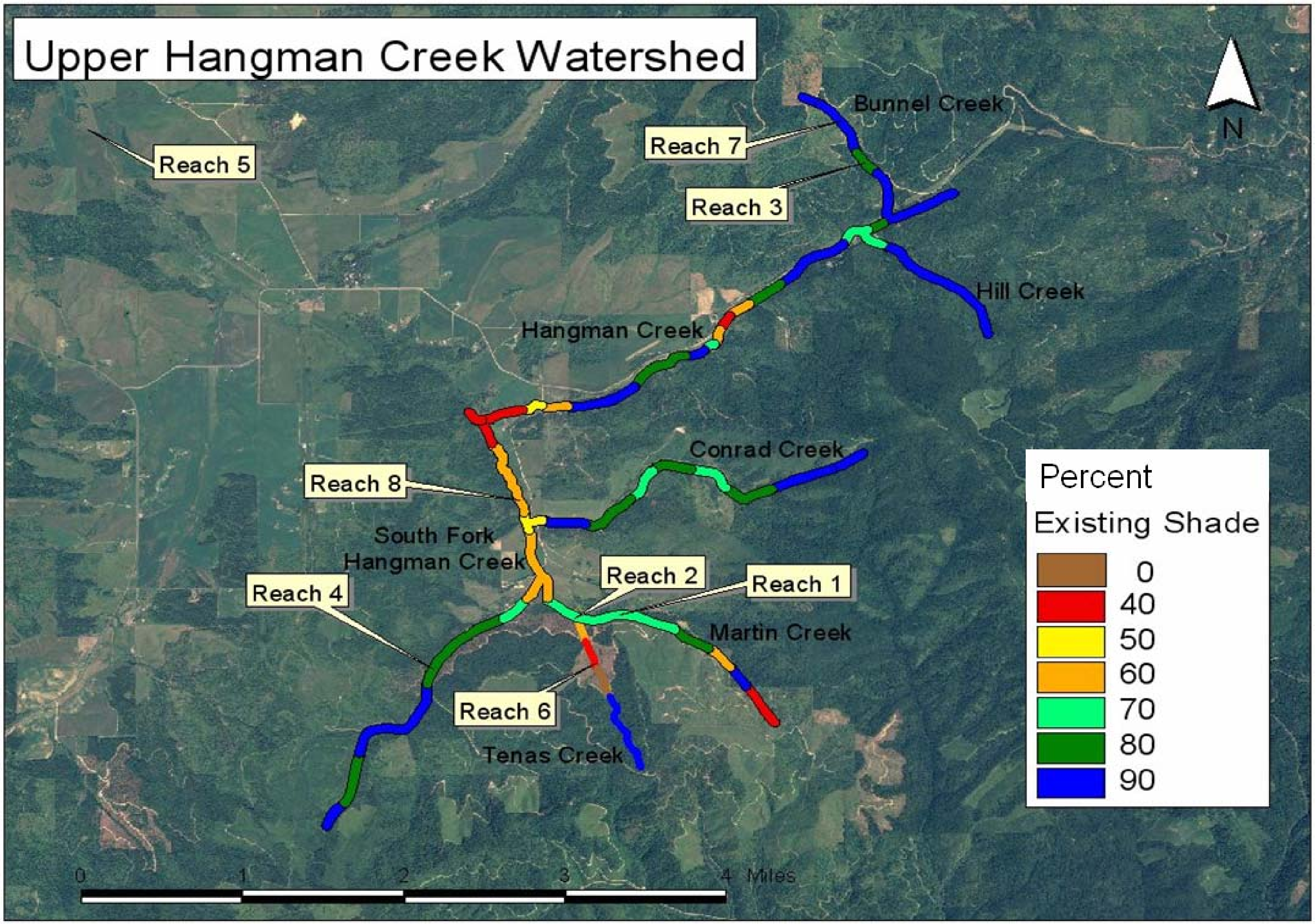


Figure 15. Stream bank erosion representative reaches.

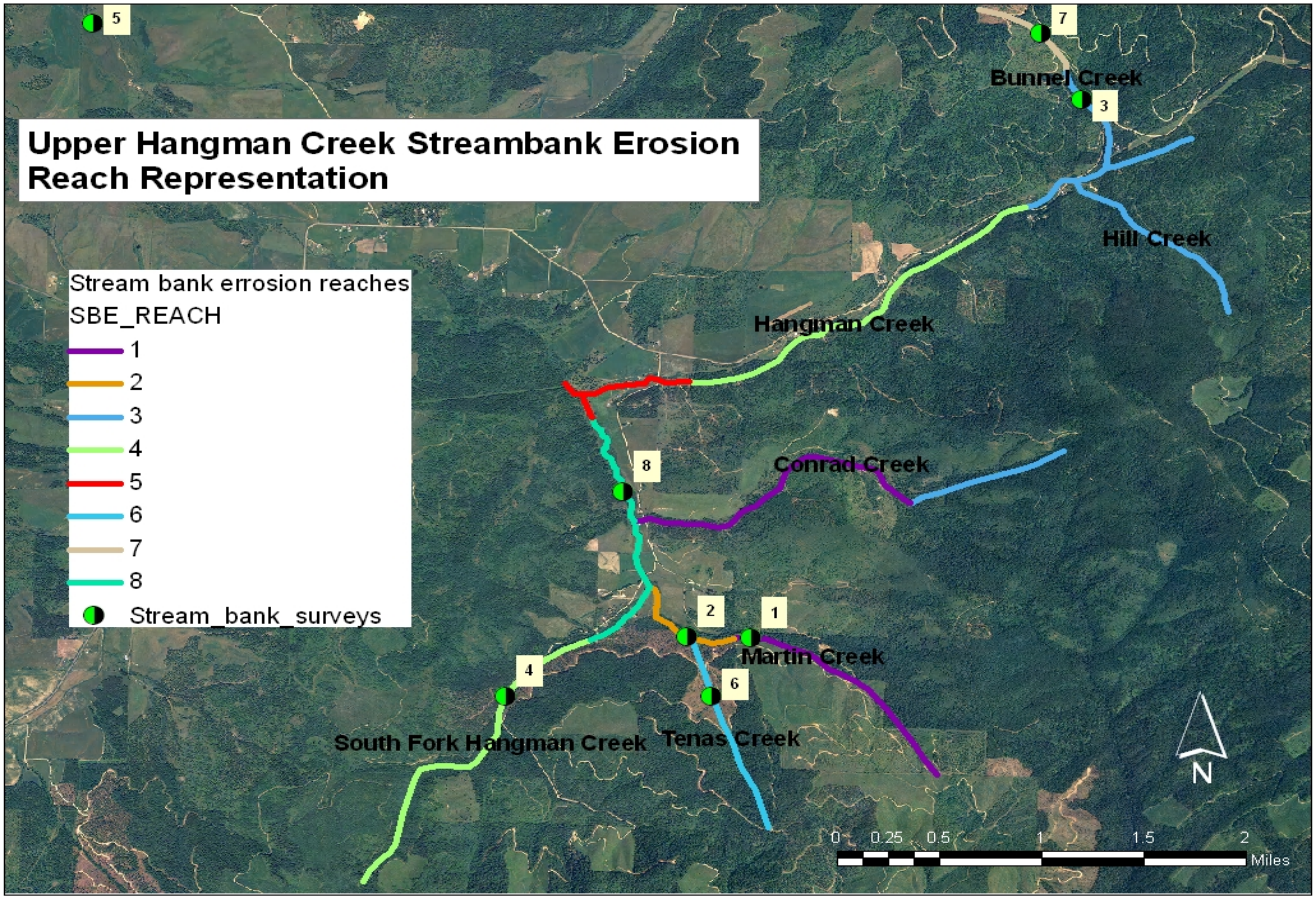


Table 10. Solar loading analysis for Hangman Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.5 (headwtr)	0.9	0.57	0.9	0.57	0.00	805	402.5	229.43	0.5	229.43	0
0.2	0.8	1.14	0.9	0.57	-0.57	322	322	367.08	1	183.54	-183.54
0.2	0.7	1.71	0.9	0.57	-1.14	322	322	550.62	1	183.54	-367.08
0.6	0.9	0.57	0.9	0.57	0.00	966	1932	1101.24	2	1101.24	0
0.3	0.8	1.14	0.9	0.57	-0.57	483	966	1101.24	2	550.62	-550.62
0.2	0.6	2.28	0.9	0.57	-1.71	322	644	1468.32	2	367.08	-1101.24
0.1	0.4	3.42	0.9	0.57	-2.85	161	322	1101.24	2	183.54	-917.7
0.1	0.6	2.28	0.9	0.57	-1.71	161	322	734.16	2	183.54	-550.62
0.15	0.7	1.71	0.9	0.57	-1.14	241	723	1236.33	3	412.11	-824.22
0.1	0.9	0.57	0.9	0.57	0.00	161	483	275.31	3	275.31	0
0.3	0.8	1.14	0.9	0.57	-0.57	483	1449	1651.86	3	825.93	-825.93
0.4	0.9	0.57	0.9	0.57	0.00	644	1932	1101.24	3	1101.24	0
0.2	0.6	2.28	0.9	0.57	-1.71	322	966	2202.48	3	550.62	-1651.86
0.15	0.5	2.85	0.9	0.57	-2.28	241	723	2060.55	3	412.11	-1648.44
0.3 (boundary)	0.4	3.42	0.9	0.57	-2.85	483	1449	4955.58	3	825.93	-4129.65
Average	**0.7**	**1.7**	**0.9**	**0.6**	**-1.1**	**Total**	**12957.5**	**20136.7**		**7385.8**	**-12750.9**

Table 11. Solar loading analysis for South Fork Hangman Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Segment Length (meters)	Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.5(headwtr)	0.9	0.57	0.9	0.57	0.00	805	402.5	229.43	0.5	229.43	0.00
0.3	0.8	1.14	0.9	0.57	-0.57	483	241.5	275.31	0.5	137.66	-137.66
0.7	0.9	0.57	0.9	0.57	0.00	1127	1127	642.39	1	642.39	0.00
0.7	0.8[a]	1.14	0.9	0.57	-0.57	1127	1127	1284.78	1	642.39	-642.39
0.3	0.7	1.71	0.9	0.57	-1.14	483	483	825.93	1	275.31	-550.62
0.5	0.6	2.28	0.9	0.57	-1.71	805	1610	3670.80	2	917.70	-2753.10
0.1	0.5	2.85	0.9	0.57	-2.28	161	322	917.70	2	183.54	-734.16
0.5	0.6[b]	2.28	0.9	0.57	-1.71	805	2415	5506.20	3	1376.55	-4129.65
0.2(mouth)	0.4	3.42	0.9	0.57	-2.85	322	966	3303.72	3	550.62	-2753.10
Average	**0.7**	**1.8**	**0.9**	**0.6**	**-1.2**	**Total**	**8694**	**16656.3**		**4955.6**	**-11700.7**

[a] solar pathfinder measurements = 88.8%; [b] solar pathfinder measurements = 61.6%

Table 12. Solar loading analysis for Hill Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Segment Length (meters)	Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
1	0.9	0.57	0.9	0.57	0.00	1609	804.5	458.57	0.5	458.57	0.00
0.2	0.7	1.71	0.9	0.57	-1.14	322	161	275.31	0.5	91.77	-183.54
Average	**0.8**	**1.1**	**0.9**	**0.6**	**-0.6**	**Total**	**965.5**	**733.9**		**550.3**	**-183.5**

Table 13. Solar loading analysis for Conrad Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Segment Length (meters)	Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.7(headwtr)	0.9	0.57	0.9	0.57	0.00	1127	563.5	321.20	0.5	321.20	0.00
0.3	0.8	1.14	0.9	0.57	-0.57	483	241.5	275.31	0.5	137.66	-137.66
0.3	0.7	1.71	0.9	0.57	-1.14	483	483	825.93	1	275.31	-550.62
0.2	0.8	1.14	0.9	0.57	-0.57	322	322	367.08	1	183.54	-183.54
0.2	0.7	1.71	0.9	0.57	-1.14	322	322	550.62	1	183.54	-367.08
0.4	0.8	1.14	0.9	0.57	-0.57	644	644	734.16	1	367.08	-367.08
0.3	0.9	0.57	0.9	0.57	0.00	483	483	275.31	1	275.31	0.00
0.1	0.5	2.85	0.9	0.57	-2.28	161	161	458.85	1	91.77	-367.08
Average	**0.8**	**1.4**	**0.9**	**0.6**	**-0.8**	**Total**	**3220**	**3808.5**		**1835.4**	**-1973.1**

Table 14. Solar loading analysis for Bunnel Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Segment Length (meters)	Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.6	0.9[a]	0.57	0.9	0.57	0.00	966	483	275.31	0.5	275.31	0.00
0.2	0.8[b]	1.14	0.9	0.57	-0.57	322	161	183.54	0.5	91.77	-91.77
0.3	0.9	0.57	0.9	0.57	0.00	483	241.5	137.66	0.5	137.66	0.00
Average	**0.9**	**0.8**	**0.9**	**0.6**	**-0.2**	**Total**	**885.5**	**596.5**		**504.7**	**-91.8**

[a] solar pathfinder measurements = 90.1%; [b] solar pathfinder measurements = 88.5%

Table 15. Solar loading analysis for Martin Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.2(headwtr)	0.4	3.42	0.9	0.57	-2.85	322	161	550.62	0.5	91.77	-458.85
0.2	0.9	0.57	0.9	0.57	0.00	322	161	91.77	0.5	91.77	0.00
0.2	0.6	2.28	0.9	0.57	-1.71	322	161	367.08	0.5	91.77	-275.31
0.15	0.8	1.14	0.9	0.57	-0.57	241	120.5	137.37	0.5	68.69	-68.69
0.8	0.7[a]	1.71	0.9	0.57	-1.14	1287	1287	2200.77	1	733.59	-1467.18
0.2(mouth)	0.6	2.28	0.9	0.57	-1.71	322	322	734.16	1	183.54	-550.62
Average	**0.7**	**1.9**	**0.9**	**0.6**	**-1.3**	**Total**	**2212.5**	**4081.8**		**1261.1**	**-2820.6**

[a] solar pathfinder measurements = 72.3%

Table 16. Solar loading analysis for Tenas Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.6(headwtr)	0.9	0.57	0.9	0.57	0.00	966	483	275.31	0.5	275.31	0.00
0.2	0	5.7	0.9	0.57	-5.13	322	161	917.70	0.5	91.77	-825.93
0.2	0.4[a]	3.42	0.9	0.57	-2.85	322	161	550.62	0.5	91.77	-458.85
0.2(mouth)	0.6	2.28	0.9	0.57	-1.71	322	161	367.08	0.5	91.77	-275.31
Average	**0.5**	**3.0**	**0.9**	**0.6**	**-2.4**	**Total**	**966**	**2110.7**		**550.6**	**-1560.1**

[a] solar pathfinder measurements = 43.9%

5.4 Load Allocation

There are no known or anticipated point sources of pollutants in this portion of the watershed. Therefore all load allocations are for nonpoint sources and there are no wasteload allocations. No attempt was made to differentiate between different activities or sources. Therefore, the entire available loads are allocated as a whole to the nonpoint source activities and background conditions that may create the pollutant.

Sediment

The loading capacity in Table 9b is assumed to be the available loading capacity or the stream bank loading capacity minus a 10% margin of safety, and represents the available sediment load to be allocated. Because loading capacities for roads and mass failures were not determined, a threshold reduction of 50% was applied (Washington Forest Practices Board, 1995). Intensive row crop farming does not occur in this portion of the watershed. It is assumed that negligible amounts of sediment are entering the streams as runoff from the small amount of pasture land, and that the majority of sediment loading comes from stream banks, roads, and mass failures as the result of bank perturbations or increased hydrology or runoff volumes from land use activities. Therefore, the available loading capacity is allocated to these three nonpoint sources. It is implied that all nonpoint source activities should not increase bank erosion greater than the 80% bank stability target, and that forest land use activities should reduce road and mass failure sediment delivery by 50%.

All streams except Bunnel Creek require a reduction in existing stream bank sediment loading to achieve loading capacity (minus 10% MOS) (Table 9a). Reach 4 representing upper South Fork Hangman Creek and middle Hangman Creek had an existing erosion rate (19.1 tons/mile/year) slightly less than its proposed erosion rate (19.3 tons/mile/year), however, due to the removal of 10% of the proposed total for a MOS, existing total erosion was slightly greater than proposed total erosion resulting in the need for 9% reduction. Lower Hangman Creek, lower South Fork Hangman Creek, and lower Martin Creek require the largest reduction in sediment loading to meet targets. The watershed as a whole above the Tribal boundary requires a 54% reduction in sediment loading to meet loading capacity (Table 9b).

Temperature

All streams require some reduction in solar loading to achieve loading capacity. In Tables 10 through 16 existing summer load was subtracted from potential summer load to reflect the amount of load reduction necessary to achieve potential or target loads. Bunnel Creek and Hill Creek require the least with 15% and 25% reduction, respectively. Percent reductions in summer load to achieve potential load for the remaining streams are 52% for Conrad Creek, 63% for Hangman Creek, 69% for Martin Creek, 70% for South Fork Hangman Creek, and 74% for Tenas Creek.

The loading analysis is based on effective shade provided by riparian vegetation. The load allocation is to nonpoint source activities and background conditions that may have an effect on riparian vegetation and its shading potential. It is implied that nonpoint source activities should not reduce effective shade below potential natural vegetation target levels.

Because potential summer loads are based on the concept of achieving shade levels under potential natural vegetation, an inherent margin of safety is implied as no better shade conditions are considered achievable.

Bacteria

Because sources are not often continuous in their discharge and bacteria are not long-lived, bacteria concentrations vary considerably from one time period to the next. This is reflected in the changing geometric mean throughout the sampling period in Hangman Creek and South Fork Hangman Creek (Table 6). Percent reductions in bacteria numbers necessary to achieve loading capacities (minus a 10% MOS) vary for each geometric mean calculated (Table 9c). In Hangman Creek, necessary reductions steadily decline through the sampling period from an 85% reduction for the first geometric mean down to 0% reductions for the fourth geometric mean. In the South Fork, this relationship does not exist with the fourth geometric mean showing the highest necessary reduction (40%) and the other geo-means variable (26%, 33%, and 15% reductions necessary for the first through the third geo-means, respectively).

The sources of the bacterial contamination are not known. To our knowledge there are no confined animal feeding operations of any size in the upper watershed. However, there may be a few barnyard or pastured animals with direct access to the creeks. Bauer and Wilson (1983) suspected that bacterial contamination in the Hangman Creek watershed was from human sources, most likely aging or malfunctioning septic systems resulting in discharge to the creeks. However, there are not many homes in this portion of the watershed and the problem is not likely due to a concentration of malfunctioning systems.

Substantial additional work needs to be done to isolate the source or sources of bacterial contamination in these creeks. That work includes more site specific sampling and possibly DNA analysis to determine the animal source of the *E. coli* bacteria.

Margin of Safety (MOS)

Stream bank sediment and bacteria loading analyses included a 10% margin of safety by removing 10% of the loading capacity from consideration. Reach 5 calculations of sediment loading did not have a 10% MOS removed because the erosion inventory was based on an area further downstream that is likely to have greater erosion. Thus, an implicit margin of safety is contained within the erosion inventory for Reach 5. For temperature, an inherent margin of safety is implied as no better shade conditions are considered achievable.

Seasonal Variation

Sediment delivery to a stream is highly coupled to seasonal events. The majority of bank erosion and sediment delivery occurs during high runoff, high flow events associated with spring snowmelt and rains. It is often difficult to monitor these events, thus sediment loading analysis is based on sediment delivery from stream banks integrated over an entire year. In an attempt to reflect seasonal sediment loading, and current EPA guidance, daily sediment loads were developed for each stream based on sediment load targets. Stream flow data was used to determine sediment loads for each month. Refer to Appendix I for further information regarding these calculations. Although daily sediment load calculations were made the annual sediment load target should be followed due to the natural variability of sediment loading.

Temperature problems are associated with the certain times of the year that water quality criteria for temperature apply. Water temperatures increase in response to warming air temperatures in spring and summer. Critical time periods for water temperature are during spring and fall salmonid spawning time periods, as well as during peak temperatures in mid summer. Effective shade and its associated riparian community and bank stability, helps keep water cool during warming trends in spring summer and early fall.

Bacterial contamination in streams can be highly variable depending on types of releases, the bacteria's short lived nature, and seasonal hydrology. The summer sampling that has occurred, the results of which have been used in this loading analysis, may be the result of summer low flow conditions. One cannot conclude from these data that *E. coli* contamination is high during other times of the year. Much more sampling is needed to adequately characterize the nature of bacterial contamination throughout the year.

Reasonable Assurance

All allocations are directed at nonpoint source activities. There are no known point sources in this portion of the Hangman Creek watershed. Sediment loading is based on stream bank erosion inventories, road, and mass failure assessments. All future monitoring should include stream bank erosion inventories, road, and mass failure assessments in affected reaches. Additional monitoring to verify impacts to or improvements of beneficial uses can include depth fines monitoring in spawning gravels.

Temperature monitoring should include measurements of effective shade and water temperature continuous recording instruments in affected reaches.

Bacteria monitoring should expand to include all times of the year, more site specific monitoring in an effort to locate specific sources of bacteria, and DNA analysis to determine animal origin of bacteria.

Background

Sediment and temperature TMDLs are based on the concept of meeting background conditions. Sediment targets (80% bank stability) that erosion inventories are based on imply that stream banks are 80% stable under natural conditions. There is no allowance in this sediment TMDL for disturbance of stream banks above background conditions.

Temperature targets are based on achieving potential natural vegetation effective shade levels. There is no allowance in this temperature TMDL for disturbance of riparian shade above these natural conditions.

The bacteria TMDL is based on existing water quality standards to protect recreation uses of these water bodies. Background bacteria conditions are unknown but should be investigated. *E. coli* TMDL levels should be adjusted based on the source or sources of the bacterium.

Reserve

No reserves for future pollutant additions have been made in these TMDLs. All pollutant levels are based on achieving background riparian and stream bank conditions or achieving bacterial standards.

Construction Storm Water and TMDL Waste Load Allocations

Construction Storm Water

The Clean Water Act requires operators of construction sites to obtain permit coverage to discharge storm water to a water body or to a municipal storm sewer. In Idaho, EPA has issued a general permit for storm water discharges from construction sites. In the past storm water was treated as a non-point source of pollutants. However, because storm water can be managed on site through management practices or when discharged through a discrete conveyance such as a storm sewer, it now requires a National Pollution Discharge Elimination System (NPDES) Permit.

The Construction General Permit (CGP)

If a construction project disturbs more than one acre of land (or is part of larger common development) that will disturb more than one acre), the operator is required to apply for permit coverage from EPA after developing a site-specific Storm Water Pollution Prevention Plan.

Storm Water Pollution Prevention Plan (SWPPP)

In order to obtain the Construction General Permit operators must develop a site-specific Storm Water Pollution Prevention Plan. The operator must document the erosion, sediment, and pollution controls they intend to use, inspect the controls periodically and maintain the best management practices (BMPs) through the life of the project.

Construction Storm Water Requirements

When a stream is on Idaho's impaired waters list and has a TMDL developed DEQ may incorporates a gross waste load allocation (WLA) for anticipated construction storm water activities. TMDLs developed now and in the past that do not have a WLA for construction storm water activities will be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate Best Management Practices.

Typically there are specific requirements you must follow to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for post-construction storm water management. Sediment is usually the main pollutant of concern in storm water from construction sites. The application of specific best management practices from *Idaho's Catalog of Storm Water Best Management Practices for Idaho Cities and Counties* is generally sufficient to meet the standards and requirements of the General Construction Permit, unless local ordinances have more stringent and site specific standards that are applicable.

5.5 Implementation Strategies

DEQ and designated management agencies (DMA) responsible for TMDL implementation will make every effort to address past, present, and future pollution problems in an attempt to link them to watershed characteristics and management practices designated to improve water quality and restore the beneficial uses of the water body. Any and all solutions to help restore beneficial uses of a stream will be considered as part of a TMDL implementation plan in an effort to make the process as effective and cost efficient as possible. Using additional information collected during the implementation phase of the TMDL, DEQ and the designated management agencies will continue to evaluate suspect sources of impairment and develop management actions appropriate to deal with these issues.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that the TMDL goals are not being met or significant progress is not being made toward achieving the goals.

Time Frame

Five years has been allotted for meeting load allocations for bacteria after implementation actions have been completed.

For sediment, twenty years after implementation strategies have been implemented has been allotted for meeting load allocations. This time frame should allow for two to three large channel forming events to occur in the stream.

Twenty years has been allotted to reach PNV shade levels, however, a substantial time frame may be needed to reach PNV after implementation strategies have been completed.

Approach

TMDLs will be implemented through continuation of ongoing pollution control activities in the watershed. The designated WAG, DMAs, and other appropriate public process participants, are expected to:

- Develop best management practices (BMPs) to achieve load allocations.
- Give reasonable assurance that management measures will meet load allocations through both quantitative and qualitative analysis of management measures.
- Adhere to measurable milestones for progress.
- Develop a timeline for implementation, with reference to costs and funding.
- Develop a monitoring plan to determine if BMPs are being implemented, if individual BMPs are effective, if load allocations and waste load allocations are being met and whether or not water quality standards are being met.

The designated management agencies will recommend specific control actions and will then submit the implementation plan to DEQ. DEQ will act as a repository for approved implementation plans and conduct 5-year reviews of progress toward TMDL goals.

Responsible Parties

In addition to the designated management agencies, the public, through the WAG and other equivalent processes or organizations, will be provided with opportunities to be involved in developing the implementation plan to the maximum extent practical.

Monitoring Strategy

Monitoring will be conducted using the DEQ-approved monitoring procedure at the time of sampling.

5.6 Conclusions

Water body assessment unit ID17010306PN001_02 includes tributaries to Hangman Creek (Bunnel Creek, Hill Creek, South Fork Hangman Creek, Martin Creek, Conrad Creek, and Tenas Creek) and Hangman Creek itself above the confluence with South Fork Hangman Creek. This assessment unit was assessed in 2002 and subsequently listed for temperature. Water body assessment unit ID17010306PN001_03 includes the mainstem Hangman Creek from its confluence with the South Fork Hangman Creek downstream into the Coeur d'Alene Tribal Reservation boundary. This assessment unit retained the original 1998 §303(d) listing for habitat alteration, sediment, bacteria, and nutrients. Due to downstream conditions and the availability of recent data, it was decided that all listed pollutants would be analyzed in all streams, Hangman Creek proper from its source to the Tribal boundary and associated tributaries.

No TMDL was completed for habitat alteration as a matter of DEQ policy. Additionally, due to recent data showing low levels of total phosphorus, it is recommended that this portion of the Hangman Creek watershed be de-listed for nutrients. TMDLs have been completed on all streams for sediment and temperature, and on Hangman Creek and South Fork Hangman Creek for bacteria.

The methods used to quantify pollutant loads (sediment, temperature and bacteria) for development of this TMDL are not intended to be used to quantify site specific pollutant reductions associated with TMDL implementation activities. Rather, the best available method shall be used when calculating load reductions.

The goal of the methods used to quantify sediment and bacteria loads was to estimate current pollutant loads as of April 2005 and existing shade in June 2004. Load reductions made after April 2005 addressing sediment and bacteria, and June 2004 addressing temperature can be applied towards the Hangman Creek TMDL implementation goals.

Table 17. Summary of assessment outcomes.

Stream	Assessment Unit	Pollutant	TMDL(s) Analysis Completed	Recommended changes to the Integrated Report	Justification
Hangman Creek	ID17010306PN001_03	Sediment	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek	ID17010306PN001_03	Bacteria	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek	ID17010306PN001_03	Nutrients	No	Delist	Most recent data show attainment of Idaho water quality standard
Hangman Creek	ID17010306PN001_03	Temperature	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards
Hangman Creek[3]	ID17010306PN001_02	Temperature	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek[3]	ID17010306PN001_02	Sediment	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards
Hangman Creek[3]	ID17010306PN001_02	Bacteria	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards

[1] Section 4a of Integrated Report, Rivers with EPA Approved TMDLs.
[2] Section 5 of Integrated Report, Idaho's Impaired Waters list.
[3] Includes the following tributaries to Hangman Creek below the confluence with the South Fork Hangman Creek – Hangman Creek, South Fork Hangman Creek, Tenas Creek, Martin Creek, Conrad Creek, Hill Creek, Bunnel Creek.

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GIS Coverages

Glossary

305(b)

Refers to section 305 subsection "b" of the Clean Water Act. The term "305(b)" generally describes a report of each state's water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.

§303(d)

Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

Adsorption

The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules

Aeration

A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.

Aerobic

Describes life, processes, or conditions that require the presence of oxygen.

Alevin

A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk.

Algae

Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.

Alluvium

Unconsolidated recent stream deposition.

Ambient

General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with

	episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).
Anaerobic	Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
Aquatic	Occurring, growing, or living in water.
Aquifer	An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs.
Assemblage (aquatic)	An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996).
Assessment Unit (AU)	A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit.
Assimilative Capacity	The ability to process or dissipate pollutants without ill effect to beneficial uses.
Bankfull width	The stream stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure.
Bedload	Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.
Beneficial Use	Any of the various uses of water, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

Beneficial Use Reconnaissance Program (BURP)
A program for conducting systematic biological and physical habitat surveys of water bodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers

Best Management Practices (BMPs)
Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

Biochemical Oxygen Demand (BOD)
The amount of dissolved oxygen used by organisms during the decomposition (respiration) of organic matter, expressed as mass of oxygen per volume of water, over some specified period of time.

Biological Integrity
1) The condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).

Biomass
The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often expressed as grams per square meter.

Biota
The animal and plant life of a given region.

Clean Water Act (CWA)
The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation's water resources.

Coliform Bacteria
A group of bacteria predominantly inhabiting the intestines of humans and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms (also see Fecal Coliform Bacteria, *E. Coli*, and Pathogens).

Colluvium
Material transported to a site by gravity.

Community	A group of interacting organisms living together in a given place.
Criteria	In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.
Cubic Feet per Second	A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.
Decomposition	The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes.
Depth Fines	Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 millimeters depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 centimeters).
Designated Uses	Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.
Discharge	The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).
Dissolved Oxygen (DO)	The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.

Disturbance

Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.

E. coli

Short for *Escherichia coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans, but their presence in water is often indicative of fecal contamination. *E. coli* are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Ecology

The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.

Ecological Indicator

A characteristic of an ecosystem that is related to, or derived from, a measure of a biotic or abiotic variable that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability. Ecological indicators are often used within the multimetric index framework.

Ecosystem

The interacting system of a biological community and its non-living (abiotic) environmental surroundings.

Effective Shade

That shade provided by all objects that intercept the sun as it makes its way across the sky.

Environment

The complete range of external conditions, physical and biological, that affect a particular organism or community.

Erosion

The wearing away of areas of the earth's surface by water, wind, ice, and other forces.

Eutrophic

From Greek for "well nourished," this describes a highly productive body of water in which nutrients do not limit algal growth. It is typified by high algal densities and low clarity.

Exceedance
A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.

Existing Beneficial Use or Existing Use
A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).

Existing Shade
Shade estimated to be provided to the stream under the current vegetative and topographic conditions.

Fauna
Animal life, especially the animals characteristic of a region, period, or special environment.

Fecal Coliform Bacteria
Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria, *E. coli*, and Pathogens).

Flow
See *Discharge*.

Fully Supporting
In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe *et al*. 2002).

Fully Supporting Cold Water
Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions.

Geographical Information Systems (GIS)
A georeferenced database.

Geometric Mean
A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.

Gradient
The slope of the land, water, or streambed surface.

Ground Water	Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.
Growth Rate	A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population.
Habitat	The living place of an organism or community.
Headwater	The origin or beginning of a stream.
Hydrologic Unit	One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.
Hydrologic Unit Code (HUC)	The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.
Hydrology	The science dealing with the properties, distribution, and circulation of water.
Inorganic	Materials not derived from biological sources.
Instantaneous	A condition or measurement at a moment (instant) in time.
Intergravel Dissolved Oxygen	The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.

Limiting Factor

A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates.

Limnology

The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.

Load Allocation (LA)

A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).

Load(ing)

The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.

Load(ing) Capacity (LC)

A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.

Loam

Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.

Loess

A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.

Luxury Consumption

A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a water body, such that aquatic plants take up and store an abundance in excess of the plants' current needs.

Macroinvertebrate

An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.

Macrophytes

Rooted and floating vascular aquatic plants, commonly referred to as water weeds. These plants usually flower and bear seeds. Some forms, such as duckweed and coontail (*Ceratophyllum sp.*), are free-floating forms not rooted in sediment.

Margin of Safety (MOS)

An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.

Mass Failures

A general term for the down slope movement of soil and rock material under the direct influence of gravity.

Mean

Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.

Median

The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; 6 is the median of 1, 2, 5, 7, 9, 11.

Metric

1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.

Milligrams per Liter (mg/L)

A unit of measure for concentration. In water, it is essentially equivalent to parts per million (ppm).

Million Gallons per Day (MGD)

A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

Monitoring

A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a water body.

Mouth

The location where flowing water enters into a larger water body.

National Pollution Discharge Elimination System (NPDES)
A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

Natural Condition
The condition that exists with little or no anthropogenic influence.

Nitrogen
An element essential to plant growth, and thus is considered a nutrient.

Nonpoint Source
A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Nuisance
Anything that is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient
Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

Organic Matter
Compounds manufactured by plants and animals that contain principally carbon.

Orthophosphate
A form of soluble inorganic phosphorus most readily used for algal growth.

Parameter
A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.

Pathogens

A small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa) that can cause sickness or death. Direct measurement of pathogen levels in surface water is difficult. Consequently, indicator bacteria that are often associated with pathogens are assessed. *E. coli*, a type of fecal coliform bacteria, are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Perennial Stream

A stream that flows year-around in most years.

Periphyton

Attached microflora (algae and diatoms) growing on the bottom of a water body or on submerged substrates, including larger plants.

pH

The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

Phosphorus

An element essential to plant growth, often in limited supply, and thus considered a nutrient.

Plankton

Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.

PNV Shade or Target Effective Shade

Shade generated by an intact riparian plant community that has grown to its fullest extent and has not been disturbed or reduced in anyway.

Point Source

A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.

Pollutant

Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution

A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.

Population

A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.

Protocol

A series of formal steps for conducting a test or survey.

Qualitative

Descriptive of kind, type, or direction.

Quantitative

Descriptive of size, magnitude, or degree.

Reach

A stream section with fairly homogenous physical characteristics.

Reconnaissance

An exploratory or preliminary survey of an area.

Reference

A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments.

Reference Condition

1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).

Reference Site

A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.

Respiration

A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

Riffle	A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.
Riparian	Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.
River	A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.
Runoff	The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
Settleable Solids	The volume of material that settles out of one liter of water in one hour.
Species	1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.
Stream	A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.
Subbasin	A large watershed of several hundred thousand acres. This is the name commonly given to 4^{th} field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)
A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.

Subwatershed
A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6^{th} field hydrologic units.

Surface Water
All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.

Suspended Sediments
Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Total Maximum Daily Load (TMDL)
A TMDL is a water body’s load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Total Suspended Solids (TSS)
The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson *et al*. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

Tributary
A stream feeding into a larger stream or lake.

Turbidity
A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity

depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

Wasteload Allocation (WLA)

The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

Water Body

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Column

Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water Pollution

Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water Quality

A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

Water Quality Criteria

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.

Water Quality Limited

A label that describes water bodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

Water Quality Limited Segment (WQLS)

Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."

Water Quality Standards

State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water Table

The upper surface of ground water; below this point, the soil is saturated with water.

Watershed

1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a water body.

Water Body Identification Number (WBID)

A number that uniquely identifies a water body in Idaho and ties in to the Idaho water quality standards and GIS information.

Wetland

An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.

Appendix A. Unit Conversion Chart

Table A-1. Metric - English unit conversions.

	English Units	Metric Units	To Convert	Example
Distance	Miles (mi)	Kilometers (km)	1 mi = 1.61 km 1 km = 0.62 mi	3 mi = 4.83 km 3 km = 1.86 mi
Length	Inches (in) Feet (ft)	Centimeters (cm) Meters (m)	1 in = 2.54 cm 1 cm = 0.39 in 1 ft = 0.30 m 1 m = 3.28 ft	3 in = 7.62 cm 3 cm = 1.18 in 3 ft = 0.91 m 3 m = 9.84 ft
Area	Acres (ac) Square Feet (ft^2) Square Miles (mi^2)	Hectares (ha) Square Meters (m^2) Square Kilometers (km^2)	1 ac = 0.40 ha 1 ha = 2.47 ac 1 ft^2 = 0.09 m^2 1 m^2 = 10.76 ft^2 1 mi^2 = 2.59 km^2 1 km^2 = 0.39 mi^2	3 ac = 1.20 ha 3 ha = 7.41 ac 3 ft^2 = 0.28 m^2 3 m^2 = 32.29 ft^2 3 mi^2 = 7.77 km^2 3 km^2 = 1.16 mi^2
Volume	Gallons (gal) Cubic Feet (ft^3)	Liters (L) Cubic Meters (m^3)	1 gal = 3.78 L 1 L= 0.26 gal 1 ft^3 = 0.03 m^3 1 m^3 = 35.32 ft^3	3 gal = 11.35 L 3 L = 0.79 gal 3 ft^3 = 0.09 m^3 3 m^3 = 105.94 ft^3
Flow Rate	Cubic Feet per Second (cfs)[a]	Cubic Meters per Second (m^3/sec)	1 cfs = 0.03 m^3/sec 1 m^3/sec = 35.31cfs	3 ft^3/sec = 0.09 m^3/sec 3 m^3/sec = 105.94 ft^3/sec
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[b]	3 ppm = 3 mg/L
Weight	Pounds (lbs)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 lb
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 3 °C = 37.4 °F

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 cfs.

[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water.

Appendix B. State and Site-Specific Water Quality Standards and Criteria and Temperature Data Analysis

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies with species. For spring spawning salmonids, the default spawning and incubation period recognized by DEQ is generally from March 15th to July 1st each year (Grafe *et al*., 2002). Fall spawning can occur as early as August 15th and continue with incubation on into the following spring up to June 1st. As per IDAPA 58.01.02.250.02.e.ii., the water quality criteria that need to be met during that time period are:

> 13^{o}C as a daily maximum water temperature,
>
> 9^{o}C as a daily average water temperature.

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of highest annual MWMT air temperatures) is compared to the daily maximum criterion of 13^{o}C. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during these time periods. If potential natural vegetation targets are achieved yet stream temperatures are warmer than these criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply. As per IDAPA 58.01.02.200.09:

> *"When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401."*

Section 401 relates to point source wastewater treatment requirements. In this case if temperature criteria for any aquatic life use is exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3^{o}C (IDAPA 58.01.02.401.03.a.v.).

Temperature Data versus Shade

Temperature data were available from the Coeur d'Alene Tribe for a variety of locations and streams in the upper Hangman Creek area. Graphs for the most recent continuous recordings are included in this appendix. In general, most sites had salmonids spawning criteria violation in the spring and fall during the default salmonids spawning period (March 15 to July 15 for spring spawning and August 15 through October for fall spawning). Table B1 shows the percentage of time that daily maximum criteria (13C) violations occurred during these two seasons at the various recording sites. The exact location of temperature recorder placement is unknown, so general stream locations are provided. Only a few sites could be processed through DEQ's Tempdata spreadsheet to calculate daily average (9C) violations in that manner.

Table B1. Percent of Spawning Periods with Criteria Violations.

Stream Name and Location	Year	13C Criteria Violations (% of spring spawning period)	13C Criteria Violations (% of fall spawning period)	9C Criteria Violations (% of spring spawning period)	9C Criteria Violations (% of fall spawning period)
Martin Creek	2002	66.7	24.5		
Martin Creek	2004	25	18	55	58
Upper Hangman Creek	2002	27.8	n.a.		
Hangman Creek @ South Fork Road	2003	45	50		
Hangman Creek @ South Fork Road	2004	25	44		65
Lower South Fork Hangman Creek	2003	n.a.	0		
Lower South Fork Hangman Creek	2004	n.a.	23		56
Upper South Fork Hangman Creek	2002	0	0		
Upper South Fork Hangman Creek	2003	0	1.8		
Upper South Fork Hangman Creek	2004	n.a.	3		35
Hangman Forest	2003	38.9	38.7		
Hangman Forest	2004	15.4	13.8		

In order to determine the relationship between stream temperature and existing shade, these data on daily maximum (13C) criteria violations were used to compare to stream shade. A variety of shade parameters were examined (e.g. the stream's average existing shade, the stream's percent reduction in solar loading), however, the stream's lowest recorded existing shade value provided the best relationship (see Figures B1 and B2). Streams where the lowest existing shade is 60% had fewer days of violations then those streams where the lowest existing shade is 40%.

Figure B1. Percent Criteria Violations (13C) for the Fall Spawning Period versus Lowest Existing Shade

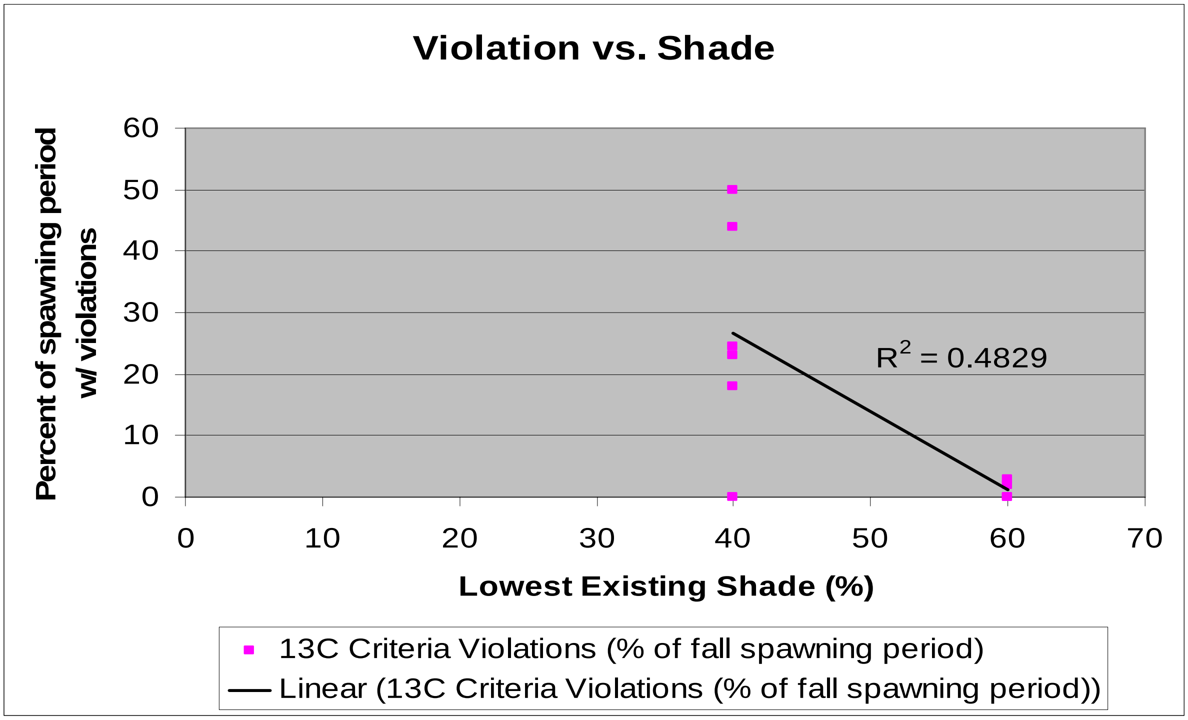
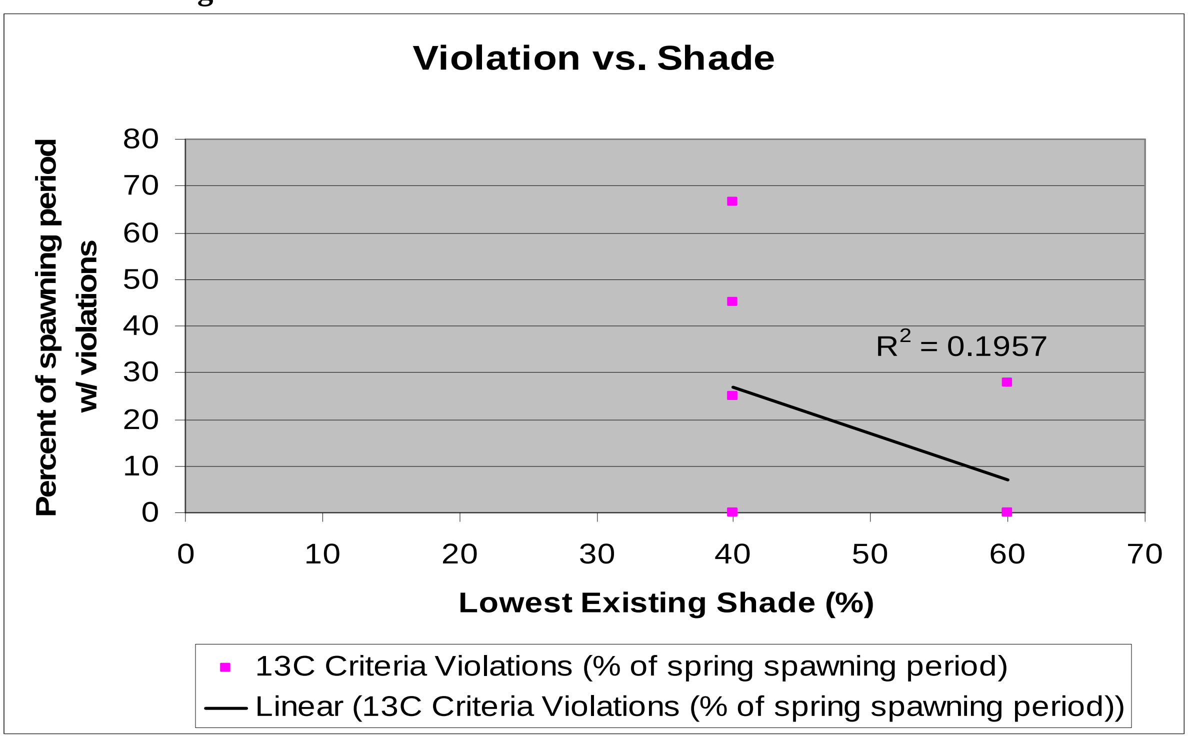
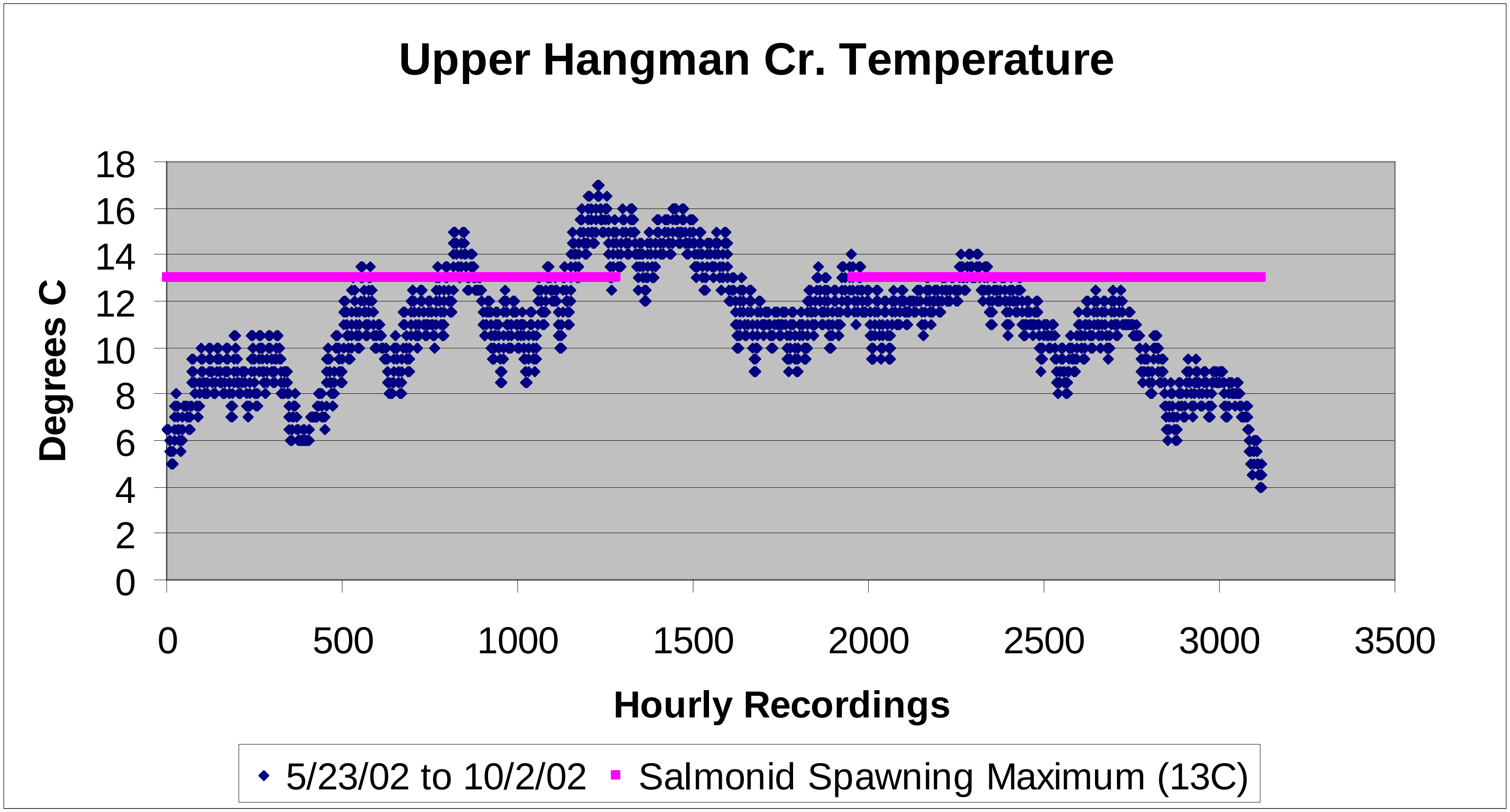
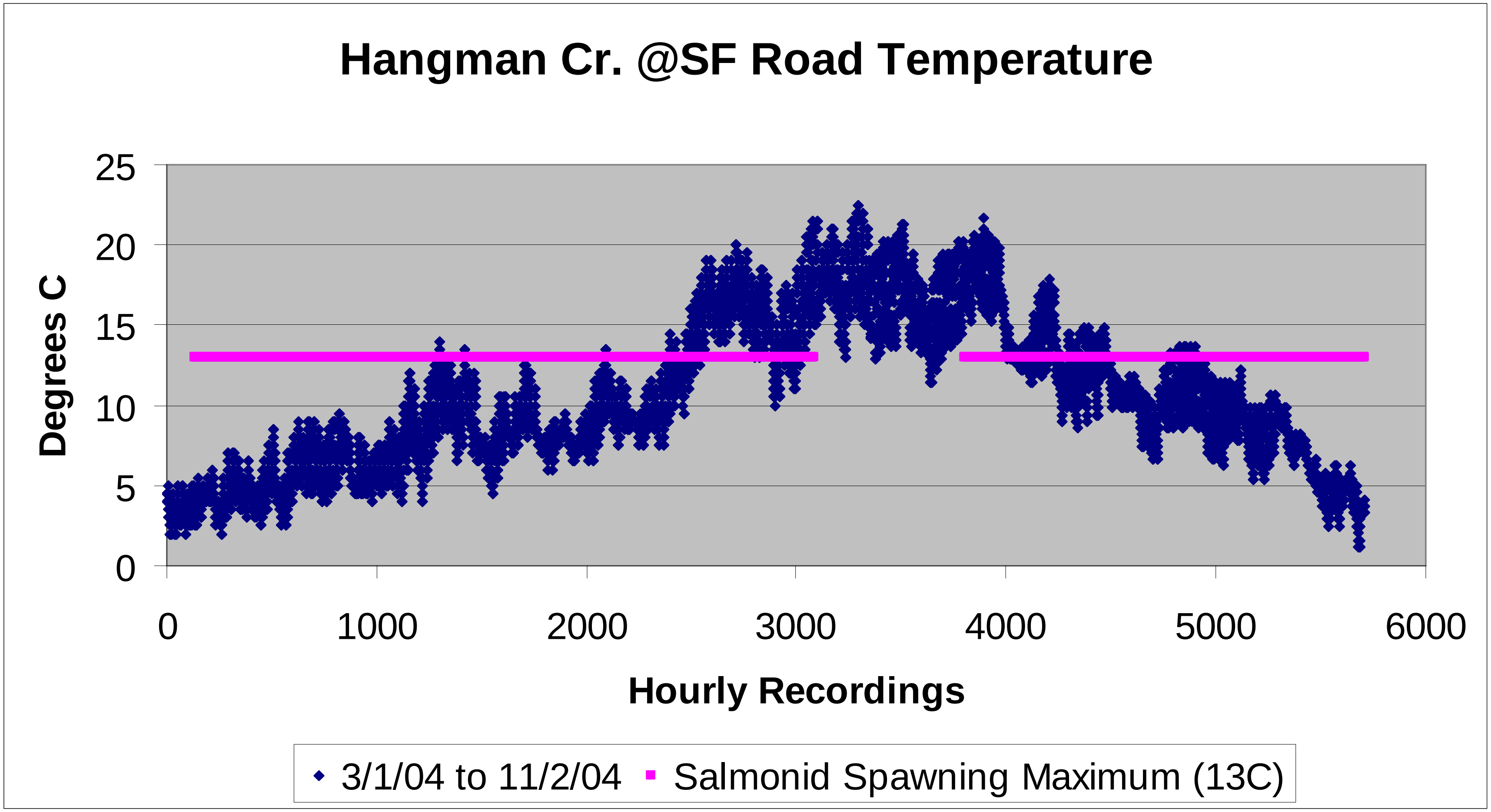
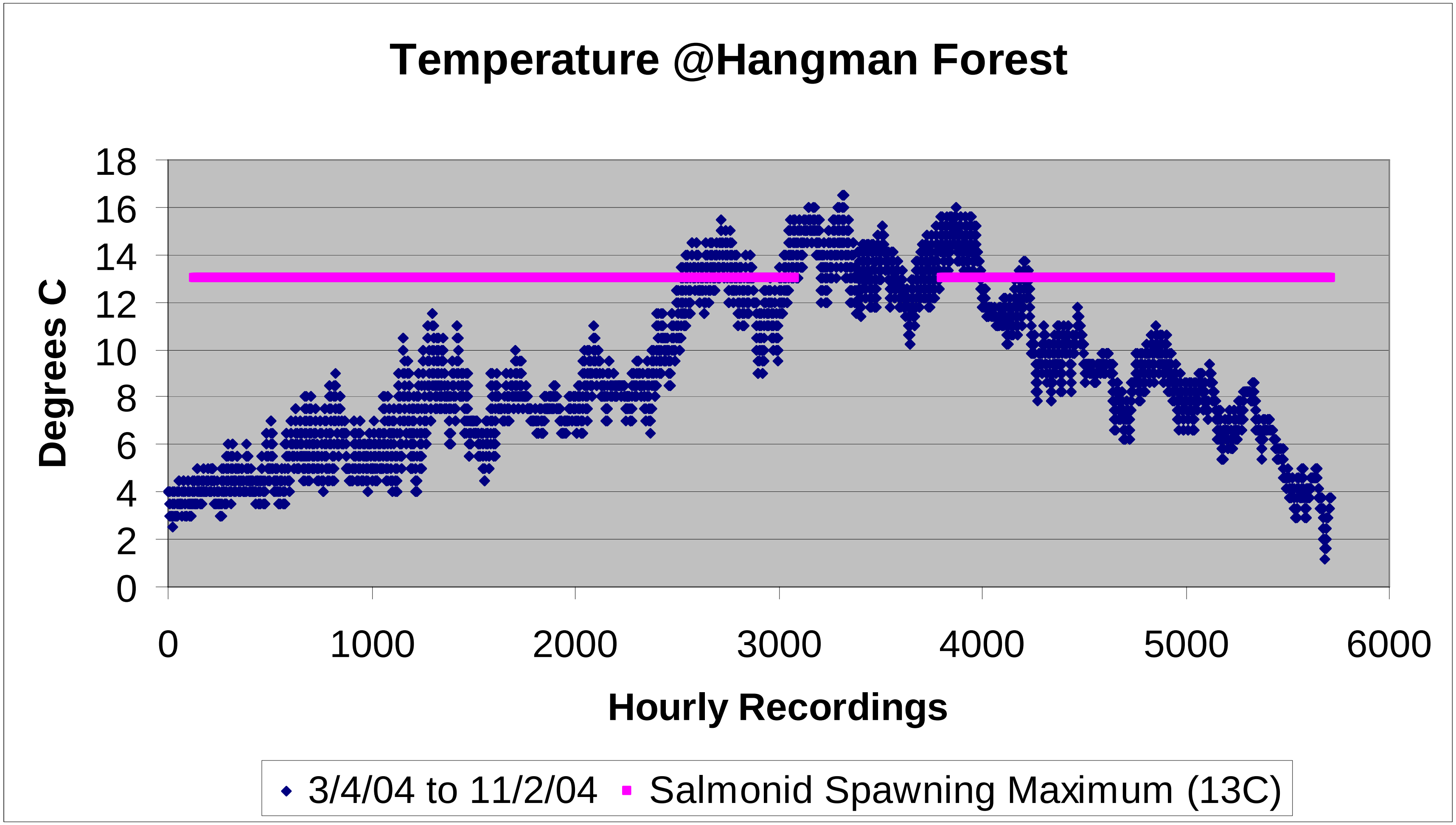


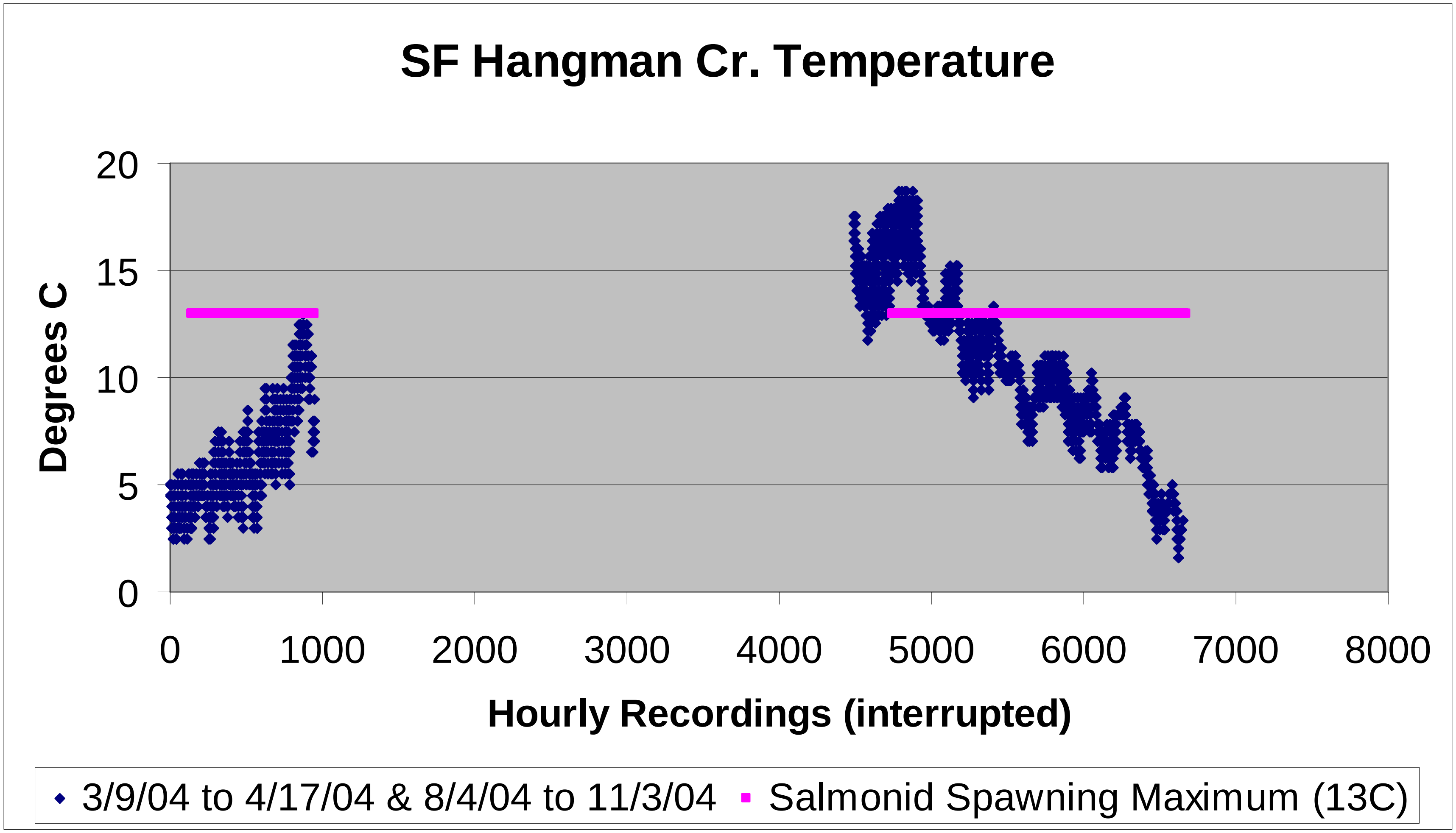
Figure B2. Percent Criteria Violations (13C) for the Spring Spawning Period versus Lowest Existing Shade

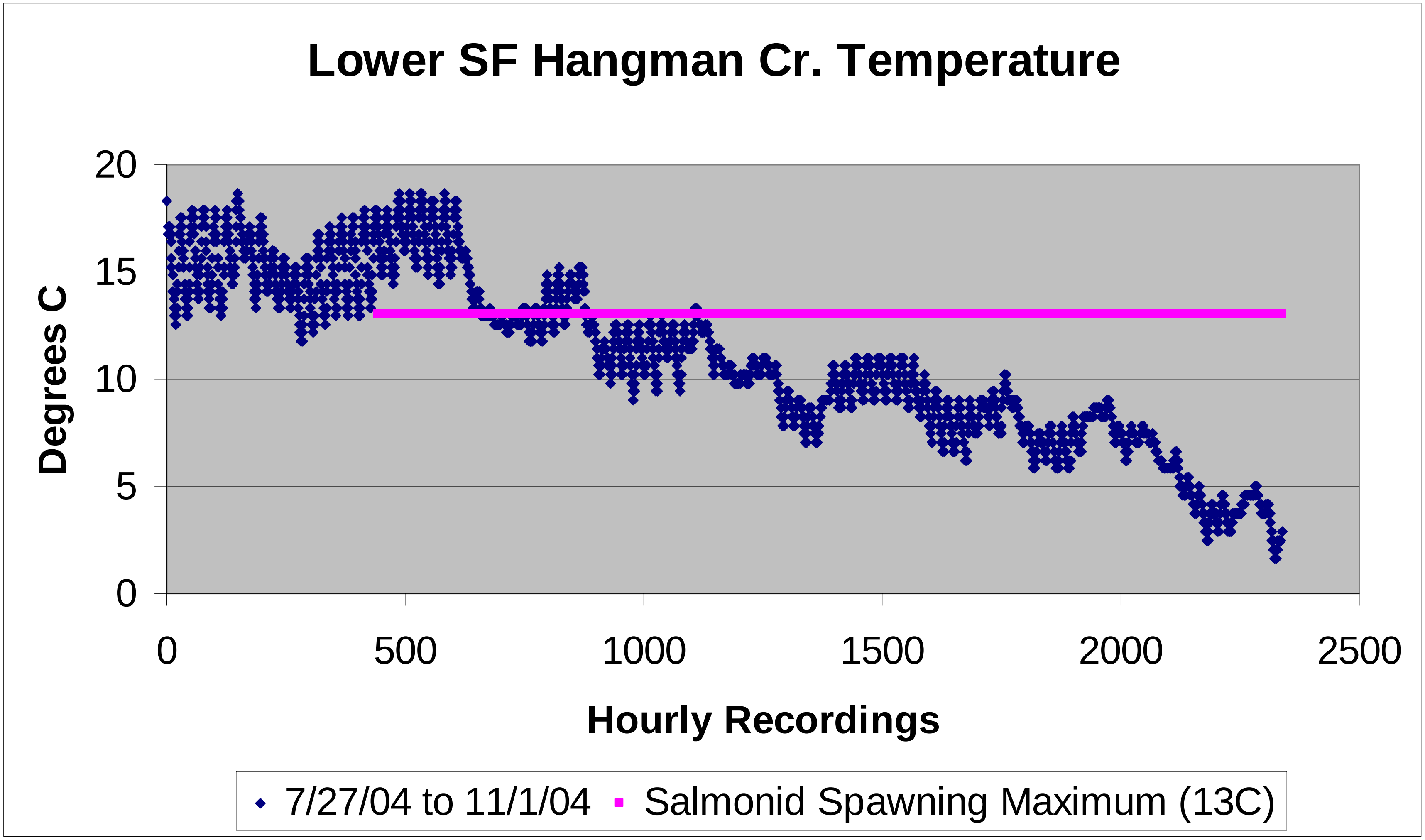


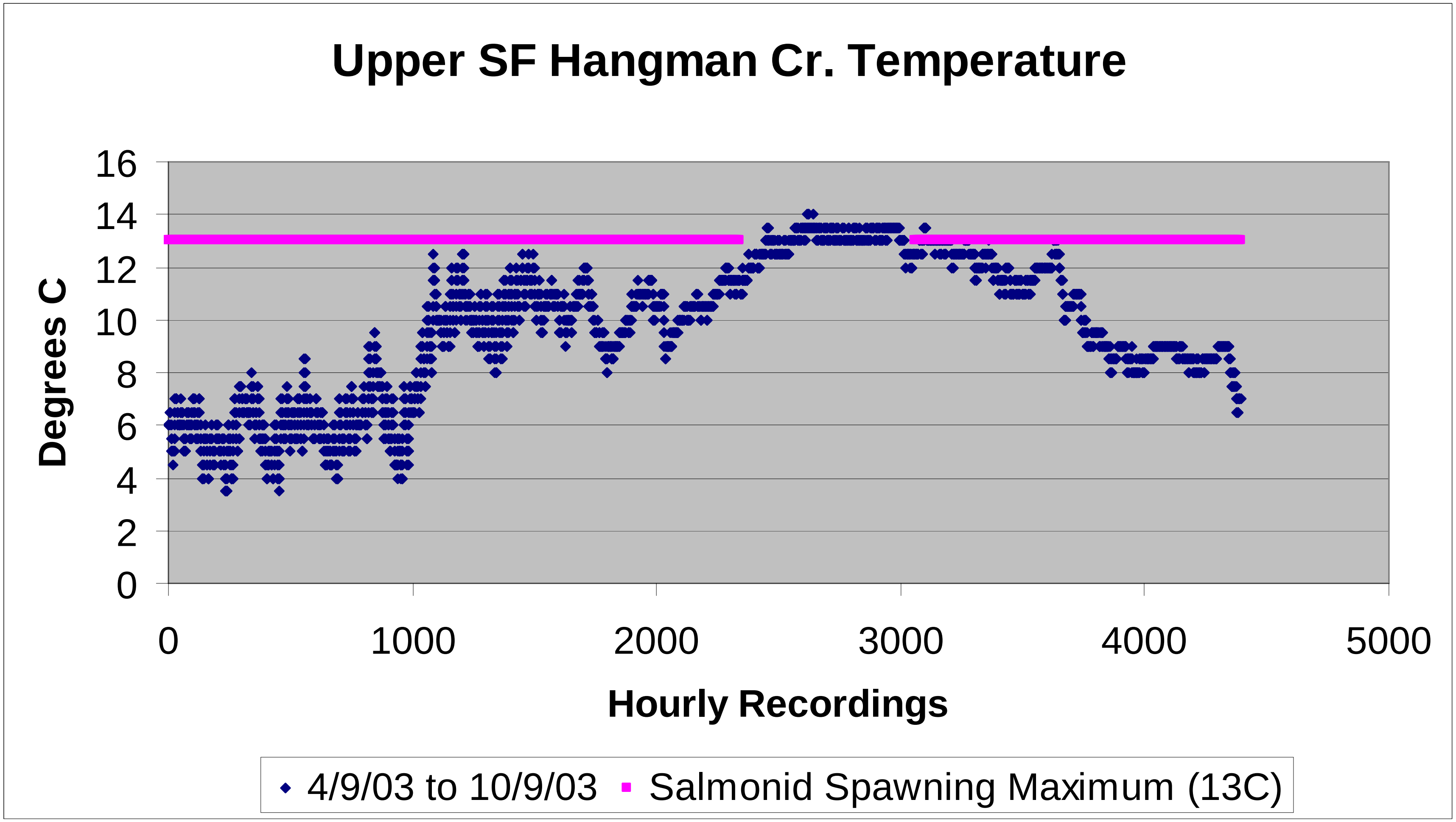

Upper Hangman Cr. Temperature
Degrees C
18
16
14
12
10
8
6
4
2
0
0
500
1000
1500
2000
2500
3000
3500
Hourly Recordings
5/23/02 to 10/2/02
Salmonid Spawning Maximum (13C)

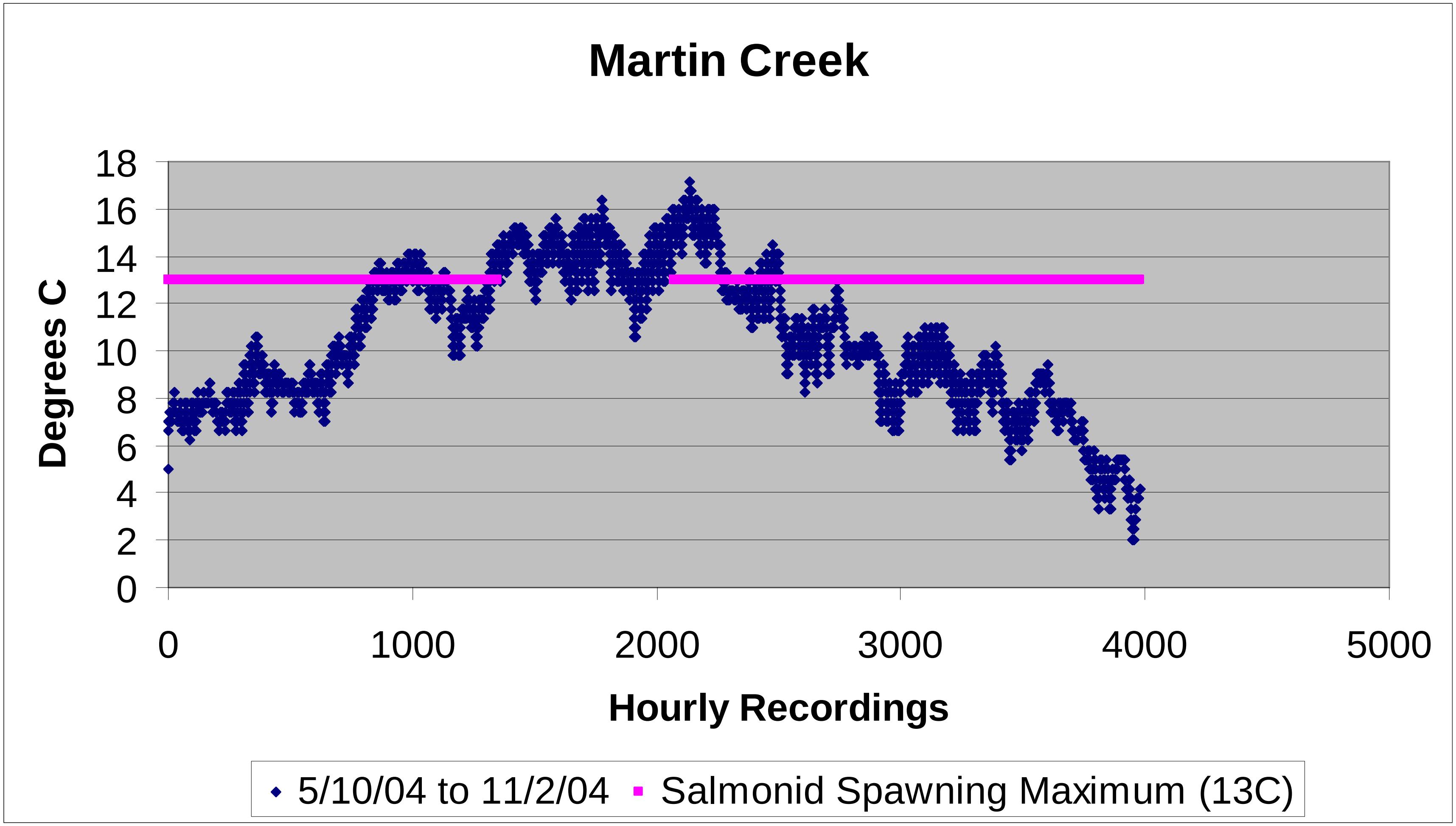

Hangman Cr. @SF Road Temperature
Degrees C
0
5
10
15
20
25
0
1000
2000
3000
4000
5000
6000
Hourly Recordings
3/1/04 to 11/2/04
Salmonid Spawning Maximum (13C)


Temperature @Hangman Forest
Degrees C
0
2
4
6
8
10
12
14
16
18
0
1000
2000
3000
4000
5000
6000
Hourly Recordings
3/4/04 to 11/2/04
Salmonid Spawning Maximum (13C)


SF Hangman Cr. Temperature
Degrees C
20
15
10
5
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Hourly Recordings (interrupted)
3/9/04 to 4/17/04 & 8/4/04 to 11/3/04
Salmonid Spawning Maximum (13C)


Lower SF Hangman Cr. Temperature
Degrees C
20
15
10
5
0
0
500
1000
1500
2000
2500
Hourly Recordings
7/27/04 to 11/1/04
Salmonid Spawning Maximum (13C)


Upper SF Hangman Cr. Temperature
Degrees C
0
2
4
6
8
10
12
14
16
0
1000
2000
3000
4000
5000
Hourly Recordings
4/9/03 to 10/9/03
Salmonid Spawning Maximum (13C)


Martin Creek
Degrees C
0
2
4
6
8
10
12
14
16
18
0
1000
2000
3000
4000
5000
Hourly Recordings
5/10/04 to 11/2/04
Salmonid Spawning Maximum (13C)

Appendix C. Data Sources and BURP Data

Table C-1. Data sources for upper Hangman Creek watershed Assessment.

Water Body	Data Source	Type of Data	When Collected
Hangman, South Fork Hangman, Tenas, Martin, Bunnel	Don Zaroban, IDEQ	Stream bank erosion inventory	March 2005
Hangman, South Fork Hangman, Tenas, Martin, Bunnel	Don Zaroban, IDEQ	Solar pathfinder	March 2005
Hangman, South Fork Hangman	DEQ, CDARO	Bacteria	July, Aug. 2002
Hangman, South Fork Hangman, Martin	Coeur d'Alene Tribe	Temperature	2002-2004

Table C-2. BURP data collected within upper Hangman Creek watershed.

BURP ID	STREAM	ECOREGION	DATESAMPLED	SHI	BankCoverPercent	PercentFinesRaw	BankStabPercent	
2002SCDAA002	HANGMAN CREEK	COLUMBIA BASIN	7/2/2002	61	92.00	0.10	0.81	
2002SCDAA003	SOUTH FORK HANGMAN CREEK	COLUMBIA BASIN	7/2/2002	60	92.50	0.05	0.82	
2002SCDAA005	BUNNEL CREEK	NORTHERN ROCKIES	7/8/2002	70	94.50	0.18	0.96	
2003SCDAA002	SOUTH FORK HANGMAN CREEK	COLUMBIA BASIN	7/1/2003	74	60.00	0.09	0.99	
2003SCDAA005	MARTIN CREEK	NORTHERN ROCKIES	7/3/2003	50	48.00	0.49	0.76	
		BFHeightAvg	BFWidthAvg	Flow	PoolRiffleRatio	AvgWetDepth	AvgWetWidth	WDRatio
2002SCDAA002	HANGMAN CREEK	4.5	760.5	0.89	1.88	0.36	3.73	31.11
2002SCDAA003	SOUTH FORK HANGMAN CREEK	4.5	765.5	0.77	5.04	0.46	2.33	15.22
2002SCDAA005	BUNNEL CREEK	4.5	770.5	0.39	0.30	0.09	1.43	47.78
2003SCDAA002	SOUTH FORK HANGMAN CREEK	3	199.5	0.1	0.44	0.05	1.53	92.00
2003SCDAA005	MARTIN CREEK	3	203	0.2	0.34	0.08	2.00	75.00

BURPID	STREAM	Date Sampled	HUC	Total Abundance	Low Abund Flag	Taxa Richness	% Dom TopTaxa	% Dom Top3	% Dom Top5	% Scrapers	% EPT	Sum EPT Taxa
2002SCDAA002	HANGMAN CREEK	7/2/2002	17010306	536		26	44.59	69.40	78.54	58.02	18.66	10
2002SCDAA003	SOUTH FORK HANGMAN CREEK	7/2/2002	17010306	580		32	40.00	70.69	78.10	63.28	36.03	17
2002SCDAA005	BUNNEL CREEK	7/8/2002	17010306	551		34	29.40	47.91	59.35	7.44	41.92	19
2003SCDAA002	SOUTH FORK HANGMAN CREEK	7/1/2003	17010306	506		25	52.17	68.18	79.05	11.86	26.28	11
2003SCDAA005	MARTIN CREEK	7/3/2003	17010306	505		26	37.82	63.76	73.66	45.94	79.41	14

BURPID	STREAM	HBI	H Prime	% Ephem	% Plec	% Trich	Count Ephem Taxa	Count Plec Taxa	Count Trich Taxa	Sum Obligate CWB Taxa	Sum Obligate CWB	% Obligate CWB	# Clinger Taxa
2002SCDAA002	HANGMAN CREEK	6.42	1.02	14.37	3.36	0.93	6	1	3	1	13	2.43	9
2002SCDAA003	SOUTH FORK HANGMAN CREEK	6.67	1.06	30.52	3.28	2.24	9	3	5	1	5	0.86	13
2002SCDAA005	BUNNEL CREEK	5.70	1.37	12.89	24.32	4.72	9	7	3	3	22	3.99	16
2003SCDAA002	SOUTH FORK HANGMAN CREEK	5.13	1.28	13.64	10.47	2.17	4	4	3	4	6	1.19	12
2003SCDAA005	MARTIN CREEK	5.13	1.00	50.50	27.92	0.99	6	5	3	2	2	0.40	14

BURPID	STREAM	# Long Lived Taxa	% Clingers	% Long Lived	MBI	# Elmidae Taxa	# Predator Taxa	% Elmidae	% Predator	# Scrapers Taxa	SMI	TPI	Sum TPI Taxa
2002SCDAA002	HANGMAN CREEK	1	69.59	1.49	4.06	2	6	50.37	4.85	5	49.91	10.57	3
2002SCDAA003	SOUTH FORK HANGMAN CREEK	1	77.24	1.72	4.72	2	8	40.17	5.52	9	65.40	11.01	4
2002SCDAA005	BUNNEL CREEK	2	36.30	2.18	3.93	1	6	0.73	12.52	5	64.46	10.09	10
2003SCDAA002	SOUTH FORK HANGMAN CREEK	1	28.85	6.32	3.68	1	6	0.40	10.08	5	60.05	10.27	6
2003SCDAA005	MARTIN CREEK	2	63.56	1.98	4.21	2	6	1.39	22.97	5	54.25	10.85	7

Appendix D. Stream Bank Erosion Inventories

Tables below summarize information collected during stream bank erosion surveys completed in March 2005 and conducted by Idaho DEQ.

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Hangman Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 5		*Upstream:* 47.12043,-116.8278	
Date Collected:		4/28/2005	*Downstream:* 47.12138,-116.8304	
Field Crew:	Zaroban & Valverde		**Landuse and Notes:** impacted brush	
Data Reduced By:	Mark Shumar		represents 960m of Hangman and 230m of SF	

Streambank Erosion Calculations

Average Bank Height	3.38	ft
Total Inventoried Bank Length	856	ft
Inventoried Bank to Bank Length	1712	ft
Erosive Bank Length	638	ft
Bank to Bank Eroding Segment Length	1276	ft
Percent Eroding Bank	0.7453271	%
Eroding Area	4312.88	ft^2
Recession Rate	0.61	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	118.388556	tons/year/sample reach
Erosion Rate (Er)	730.247168	tons/mile/year
Feet of similar stream type	2294	ft
Eroding Bank Extrapolation	4695.56075	ft
Total Streambank Erosion	435.658822	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
730.2471679	435.65882	195.953472	116.90406	73.1661442

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	1157.312	ft^2
Erosion over sampled reach (with load reduction (20%)	31.76821	tons/yr/sample
Erosion Rate	195.9535	tons/mile/year
Feet of Similar Stream Type	2294	ft
Eroding Bank Extrapoltation (with reduction)	1260	ft
Total Streambank Erosion	116.9041	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	3
Vegetative/cover on Banks (0-3)	2
Bank/Channel Shape - downcutting (0-3)	2
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	13
Recession Rate	**0.61**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	SF Hangman Creek	**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 4	*Upstream:* 47.06642,-116.7846	
Date Collected:	4/28/2005	*Downstream:* 47.067588,-116.784	
Field Crew:	Zaroban & Valverde	**Landuse and Notes:** road,slash,forest	
Data Reduced By:	ark Shumar	represents 2700m of SF and 2000m of Hangman	

Streambank Erosion Calculations

Average Bank Height	1.27	ft
Total Inventoried Bank Length	681	ft
Inventoried Bank to Bank Length	1362	ft
Erosive Bank Length	134.5	ft
Bank to Bank Eroding Segment Length	269	ft
Percent Eroding Bank	0.19750367	%
Eroding Area	341.63	ft^2
Recession Rate	0.16	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	2.459736	tons/year/sample reach
Erosion Rate (Er)	19.0710809	tons/mile/year
Feet of similar stream type	14739	ft
Eroding Bank Extrapolation	6091.01322	ft
Total Streambank Erosion	55.6962248	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
19.07108088	55.696225	19.312128	56.400192	-1.26394052

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	345.948	ft^2
Erosion over sampled reach (with load reduction (20%)	2.490826	tons/yr/sample
Erosion Rate	19.31213	tons/mile/year
Feet of Similar Stream Type	14739	ft
Eroding Bank Extrapoltation (with reduction)	6168	ft
Total Streambank Erosion	56.40019	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	2
Bank Condition (0-3)	1
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	9
Recession Rate	**0.16**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	SF Hangman Creek	**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Reach 8	*Upstream:*	47.08323,-116.77227	
Date Collected:	4/29/2005	*Downstream:*	47.08402,-116.77214	
Field Crew:	Zaroban, Valverde & Clyne	**Landuse and Notes:**	brushy	
Data Reduced By:	Mark Shumar			

Streambank Erosion Calculations

Average Bank Height	2.5	ft
Total Inventoried Bank Length	594	ft
Inventoried Bank to Bank Length	1188	ft
Erosive Bank Length	181	ft
Bank to Bank Eroding Segment Length	362	ft
Percent Eroding Bank	0.3047138	%
Eroding Area	905	ft^2
Recession Rate	0.38	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	15.4755	tons/year/sample reach
Erosion Rate (Er)	137.56	tons/mile/year
Feet of similar stream type	6000	ft
Eroding Bank Extrapolation	4018.56566	ft
Total Streambank Erosion	171.793682	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
137.56	171.79368	90.288	112.7574	34.36464088

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	594	ft^2
Erosion over sampled reach (with load reduction (20%)	10.1574	tons/yr/sample
Erosion Rate	90.288	tons/mile/year
Feet of Similar Stream Type	6000	ft
Eroding Bank Extrapoltation (with reduction)	2637.6	ft
Total Streambank Erosion	112.7574	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	2
Bank Condition (0-3)	2
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	11
Recession Rate	**0.38**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Bunnel Creek		**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Reach 7		*Upstream:*	47.12201,-116.73049	
Date Collected:		4/29/2005	*Downstream:*	47.12285,-116.73244	
Field Crew:	Zaroban et al.		**Landuse and Notes:**	harvested forest	
Data Reduced By:	Mark Shumar				

Streambank Erosion Calculations

Average Bank Height	0.88	ft
Total Inventoried Bank Length	538	ft
Inventoried Bank to Bank Length	1076	ft
Erosive Bank Length	59	ft
Bank to Bank Eroding Segment Length	118	ft
Percent Eroding Bank	0.10966543	%
Eroding Area	103.84	ft^2
Recession Rate	0.05	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.23364	tons/year/sample reach
Erosion Rate (Er)	2.29297249	tons/mile/year
Feet of similar stream type	3400	ft
Eroding Bank Extrapolation	863.724907	ft
Total Streambank Erosion	1.71017532	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
2.292972491	1.7101753	4.18176	3.118896	-82.37288136

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	189.376	ft^2
Erosion over sampled reach (with load reduction (20%)	0.426096	tons/yr/sample
Erosion Rate	4.18176	tons/mile/year
Feet of Similar Stream Type	3400	ft
Eroding Bank Extrapoltation (with reduction)	1575.2	ft
Total Streambank Erosion	3.118896	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	1
Bank Condition (0-3)	0
Vegetative/cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	1
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	4
Recession Rate	**0.05**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Bunnel Creek		**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Reach 3		*Upstream:*	47.117623,-116.726941	
Date Collected:		4/28/2005	*Downstream:*	47.116866,-116.725639	
Field Crew:	Zaroban & Valverde		**Landuse and Notes:**	intact forest	
Data Reduced By:	Mark Shumar		represents 950m of Bunnel, 1500m of upper Hangman,		

Streambank Erosion Calculations

Average Bank Height	0.99	ft
Total Inventoried Bank Length	643	ft
Inventoried Bank to Bank Length	1286	ft
Erosive Bank Length	46	ft
Bank to Bank Eroding Segment Length	92	ft
Percent Eroding Bank	0.07153966	%
Eroding Area	91.08	ft^2
Recession Rate	0.05	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	0.20493	tons/year/sample reach
Erosion Rate (Er)	1.68278445	tons/mile/year
Feet of similar stream type	16581	ft
Eroding Bank Extrapolation	2464.39813	ft
Total Streambank Erosion	5.48944684	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
1.682784448	5.4894468	4.70448	15.346584	-179.5652174

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	254.628	ft^2
Erosion over sampled reach (with load reduction (20%)	0.572913	tons/yr/sample
Erosion Rate	4.70448	tons/mile/year
Feet of Similar Stream Type	16581	ft
Eroding Bank Extrapoltation (with reduction)	6889.6	ft
Total Streambank Erosion	15.34658	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	1
Bank Condition (0-3)	0
Vegetative/cover on Banks (0-3)	0
Bank/Channel Shape - downcutting (0-3)	1
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	4
Recession Rate	**0.05**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Martin Creek		**Stream Segment Location (DD)**		**Elevation (ft)**
Section:	Reach 1		*Upstream:*	47.07372,-116.7662	
Date Collected:		4/27/2005	*Downstream:*	47.07339,-116.7640	
Field Crew:	Zaroban et al.		**Landuse and Notes:**	forest-shrub mix	
Data Reduced By:	Mark Shumar		represents 2000m of Martin and 2700m of Conrad		

Streambank Erosion Calculations

Average Bank Height	1.7	ft
Total Inventoried Bank Length	785	ft
Inventoried Bank to Bank Length	1570	ft
Erosive Bank Length	181	ft
Bank to Bank Eroding Segment Length	362	ft
Percent Eroding Bank	0.23057325	%
Eroding Area	615.4	ft^2
Recession Rate	0.12	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	3.32316	tons/year/sample reach
Erosion Rate (Er)	22.3519552	tons/mile/year
Feet of similar stream type	8073	ft
Eroding Bank Extrapolation	4084.83567	ft
Total Streambank Erosion	37.4987914	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
22.35195516	37.498791	19.38816	32.526576	13.25966851

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	533.8	ft^2
Erosion over sampled reach (with load reduction (20%)	2.88252	tons/yr/sample
Erosion Rate	19.38816	tons/mile/year
Feet of Similar Stream Type	8073	ft
Eroding Bank Extrapoltation (with reduction)	3543.2	ft
Total Streambank Erosion	32.52658	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	1
Bank Condition (0-3)	0
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	1
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	7
Recession Rate	**0.12**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream:	Martin Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section:	Reach 2		*Upstream:* 47.07683,-116.7688	
Date Collected:		4/27/2005	*Downstream:* 47.07455,-116.7676	
Field Crew:	Zaroban & Valverde		**Landuse and Notes:** grazed shrub	
Data Reduced By:	Mark Shumar		represents 600m of lower Martin	

Streambank Erosion Calculations

Average Bank Height	1.44	ft
Total Inventoried Bank Length	1375	ft
Inventoried Bank to Bank Length	2750	ft
Erosive Bank Length	507	ft
Bank to Bank Eroding Segment Length	1014	ft
Percent Eroding Bank	0.36872727	%
Eroding Area	1460.16	ft^2
Recession Rate	0.38	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	24.968736	tons/year/sample reach
Erosion Rate (Er)	95.8799462	tons/mile/year
Feet of similar stream type	594	ft
Eroding Bank Extrapolation	1452.048	ft
Total Streambank Erosion	35.75523	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
95.87994624	35.75523	52.005888	19.3938624	45.75936884

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	792	ft^2
Erosion over sampled reach (with load reduction (20%)	13.5432	tons/yr/sample
Erosion Rate	52.00589	tons/mile/year
Feet of Similar Stream Type	594	ft
Eroding Bank Extrapoltation (with reduction)	787.6	ft
Total Streambank Erosion	19.39386	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	3
Bank Condition (0-3)	1
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	3
Channel Bottom (0-2)	2
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	11
Recession Rate	**0.38**

STREAMBANK EROSION INVENTORY WORKSHEET

Stream: Tenas Creek		**Stream Segment Location (DD)**	**Elevation (ft)**
Section: Reach 6		*Upstream:* 47.06791,-116.76263	
Date Collected:	4/29/2005	*Downstream:* 47.06869,-116.76279	
Field Crew: Zaroban et al.		**Landuse and Notes:** harvested forest	
Data Reduced By: Mark Shumar		represents 950m of Tenas Creek	

Streambank Erosion Calculations

Average Bank Height	1.5	ft
Total Inventoried Bank Length	743	ft
Inventoried Bank to Bank Length	1486	ft
Erosive Bank Length	174	ft
Bank to Bank Eroding Segment Length	348	ft
Percent Eroding Bank	0.23418573	%
Eroding Area	522	ft^2
Recession Rate	0.09	
Bulk Density	90	lb/ft^2
Bank Erosion over Sampled Reach (E)	2.1141	tons/year/sample reach
Erosion Rate (Er)	15.0234832	tons/mile/year
Feet of similar stream type	2374	ft
Eroding Bank Extrapolation	1459.91386	ft
Total Streambank Erosion	8.86897672	tons/year

Summary for Load Reductions

Existing		Proposed		
Erosion Rate (t/mi/yr)	Total Erosion (t/y)	Erosion Rate (ton/mi/yr)	Total Erosion (t/yr)	% reduction
15.02348318	8.8689767	12.8304	7.57431	14.59770115

Streambank Erosion Reduction Calculations

Eroding Area With Load Reductions	445.8	ft^2
Erosion over sampled reach (with load reduction (20%)	1.80549	tons/yr/sample
Erosion Rate	12.8304	tons/mile/year
Feet of Similar Stream Type	2374	ft
Eroding Bank Extrapoltation (with reduction)	1246.8	ft
Total Streambank Erosion	7.57431	tons/year

Recession Rate Calculation Worksheet

Slope Factor	Rating
Bank Stability (0-3)	2
Bank Condition (0-3)	1
Vegetative/cover on Banks (0-3)	1
Bank/Channel Shape - downcutting (0-3)	1
Channel Bottom (0-2)	0
Deposition (0-1)	1
Total = Slight (0-4); Moderate (5-8); Severe (9+)	6
Recession Rate	**0.09**

Appendix E. Solar Pathfinder Data

Tables below summarize information collected during solar pathfinder investigation completed in March 2005 and conducted by Idaho DEQ.

Shade Calculator - Reach 1 Martin Creek, percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average	
Jan-Shade	84	68	16	100	93	100	100	100	95	100	85.6	67.2
Jan-Open	16	32	84	0	7	0	0	0	5	0	14.4	32.8
Feb-Shade	82	69	26	82	92	100	92	100	95	100	83.8	63.1
Feb-Open	18	31	74	18	8	0	8	0	5	0	16.2	36.9
Mar-Shade	73	89	59	69	93	100	93	100	89	100	86.5	59.9
Mar-Open	27	11	41	31	7	0	7	0	11	0	13.5	40.1
Apr-Shade	78	100	62	58	93	91	80	100	91	95	84.8	60.9
Apr-Open	22	0	38	42	7	9	20	0	9	5	15.2	39.1
May-Shade	78	100	77	54	71	75	61	100	77	72	76.5	58.2
May-Open	22	0	23	46	29	25	39	0	23	28	23.5	41.8
Jun-Shade	86	102	85	51	56	73	58	102	75	80	76.8	58
Jun-Open	16	0	17	51	46	29	44	0	27	22	25.2	44
Jul-Shade	78	100	77	49	62	75	61	100	73	78	75.3	57.6
Jul-Open	22	0	23	51	38	25	39	0	27	22	24.7	42.4
Aug-Shade	72	100	63	54	94	84	70	100	82	89	80.8	60.7
Aug-Open	28	0	37	46	6	16	30	0	18	11	19.2	39.3
Sep-Shade	72	93	60	62	93	100	93	100	94	100	86.7	58.6
Sep-Open	28	7	40	38	7	0	7	0	6	0	13.3	41.4
Oct-Shade	82	70	39	82	93	100	92	100	89	100	84.7	62.2
Oct-Open	18	30	61	18	7	0	8	0	11	0	15.3	37.8
Nov-Shade	84	68	24	100	93	100	100	100	95	100	86.4	68.3
Nov-Open	16	32	76	0	7	0	0	0	5	0	13.6	31.7
Dec-Shade	87	68	13	100	92	100	100	100	98	100	85.8	67.3
Dec-Open	13	32	87	0	8	0	0	0	2	0	14.2	32.7

Ave Shade	82.80833	R1+R2	72.32083
Ave Open	17.35833		
Summer Shade	80.15		
Summer Open	20.18333		

Shade Calculator - Reach 2 Martin Creek, percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	66	95	98	52	0	82	69	48	62	100	67.2
Jan-Open	34	5	2	48	100	18	31	52	38	0	32.8
Feb-Shade	65	83	92	37	0	62	67	56	69	100	63.1
Feb-Open	35	17	8	63	100	38	33	44	31	0	36.9
Mar-Shade	70	78	83	6	0	69	74	54	72	93	59.9
Mar-Open	30	22	17	94	100	31	26	46	28	7	40.1
Apr-Shade	69	100	92	2	0	59	73	72	57	85	60.9
Apr-Open	31	0	8	98	100	41	27	28	43	15	39.1
May-Shade	60	84	100	2	0	63	72	91	37	73	58.2
May-Open	40	16	0	98	100	37	28	9	63	27	41.8
Jun-Shade	52	75	102	2	0	63	73	102	36	75	58
Jun-Open	50	27	0	100	102	39	29	0	66	27	44
Jul-Shade	60	73	100	2	0	63	72	96	37	73	57.6
Jul-Open	40	27	0	98	100	37	28	4	63	27	42.4
Aug-Shade	58	100	100	2	0	59	73	76	59	80	60.7
Aug-Open	42	0	0	98	100	41	27	24	41	20	39.3
Sep-Shade	62	78	86	2	0	60	74	63	72	89	58.6
Sep-Open	38	22	14	98	100	40	26	37	28	11	41.4
Oct-Shade	58	82	91	36	0	63	66	55	71	100	62.2
Oct-Open	42	18	9	64	100	37	34	45	29	0	37.8
Nov-Shade	66	97	97	53	0	82	69	57	62	100	68.3
Nov-Open	34	3	3	47	100	18	31	43	38	0	31.7
Dec-Shade	69	97	99	51	0	86	70	43	58	100	67.3
Dec-Open	31	3	1	49	100	14	30	57	42	0	32.7

Ave Shade	61.83333
Ave Open	38.33333
Summer Shade	59
Summer Open	41.33333

Shade Calculator - Reach 3 Bunnel Creek,
percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	100	100	100	100	100	100	100	100	100	100	100
Jan-Open	0	0	0	0	0	0	0	0	0	0	0
Feb-Shade	100	92	100	100	100	100	100	96	100	100	98.8
Feb-Open	0	8	0	0	0	0	0	4	0	0	1.2
Mar-Shade	86	88	100	98	100	86	100	79	86	100	92.3
Mar-Open	14	12	0	2	0	14	0	21	14	0	7.7
Apr-Shade	100	79	83	92	97	100	94	57	80	100	88.2
Apr-Open	0	21	17	8	3	0	6	43	20	0	11.8
May-Shade	100	88	80	91	83	94	97	60	78	100	87.1
May-Open	0	12	20	9	17	6	3	40	22	0	12.9
Jun-Shade	102	90	82	93	85	102	99	62	75	102	89.2
Jun-Open	0	12	20	9	17	0	3	40	27	0	12.8
Jul-Shade	100	88	80	91	83	94	97	60	78	100	87.1
Jul-Open	0	12	20	9	17	6	3	40	22	0	12.9
Aug-Shade	100	79	77	92	93	94	100	59	88	100	88.2
Aug-Open	0	21	23	8	7	6	0	41	12	0	11.8
Sep-Shade	93	90	100	95	100	86	93	73	86	100	91.6
Sep-Open	7	10	0	5	0	14	7	27	14	0	8.4
Oct-Shade	92	92	100	100	100	100	100	93	100	100	97.7
Oct-Open	8	8	0	0	0	0	0	7	0	0	2.3
Nov-Shade	100	100	100	100	100	100	100	100	100	100	100
Nov-Open	0	0	0	0	0	0	0	0	0	0	0
Dec-Shade	100	100	100	100	100	100	100	100	100	100	100
Dec-Open	0	0	0	0	0	0	0	0	0	0	0

Ave Shade	93.35
Ave Open	6.816667
Summer Shade	88.56667
Summer Open	11.76667

Shade Calculator - Reach 4 South Fork Hangman Creek, percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	100	100	100	100	100	100	100	100	100	91	99.1
Jan-Open	0	0	0	0	0	0	0	0	0	9	0.9
Feb-Shade	100	92	100	92	92	100	100	100	100	100	97.6
Feb-Open	0	8	0	8	8	0	0	0	0	0	2.4
Mar-Shade	81	93	100	81	100	93	93	100	94	89	92.4
Mar-Open	19	7	0	19	0	7	7	0	6	11	7.6
Apr-Shade	82	88	88	95	88	93	84	94	95	95	90.2
Apr-Open	18	12	12	5	12	7	16	6	5	5	9.8
May-Shade	71	82	88	84	70	90	100	88	100	100	87.3
May-Open	29	18	12	16	30	10	0	12	0	0	12.7
Jun-Shade	67	84	90	76	72	96	102	90	102	102	88.1
Jun-Open	35	18	12	26	30	6	0	12	0	0	13.9
Jul-Shade	65	82	88	79	70	94	95	88	100	100	86.1
Jul-Open	35	18	12	21	30	6	5	12	0	0	13.9
Aug-Shade	76	100	82	95	76	90	95	94	90	95	89.3
Aug-Open	24	0	18	5	24	10	5	6	10	5	10.7
Sep-Shade	81	93	100	87	100	93	89	93	94	89	91.9
Sep-Open	19	7	0	13	0	7	11	7	6	11	8.1
Oct-Shade	100	93	100	93	85	92	100	100	100	100	96.3
Oct-Open	0	7	0	7	15	8	0	0	0	0	3.7
Nov-Shade	100	100	100	92	100	100	100	100	100	100	99.2
Nov-Open	0	0	0	8	0	0	0	0	0	0	0.8
Dec-Shade	100	100	100	100	100	100	100	100	100	80	98
Dec-Open	0	0	0	0	0	0	0	0	0	20	2

Ave Shade	92.95833
Ave Open	7.208333
Summer Shade	88.81667
Summer Open	11.51667

Shade Calculator - Reach 5 Hangman Creek, percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	0	0	0	0	10	0	0	0	0	2	1.2
Jan-Open	100	100	100	100	90	100	100	100	100	98	98.8
Feb-Shade	0	0	0	0	9	0	0	0	0	1	1
Feb-Open	100	100	100	100	91	100	100	100	100	99	99
Mar-Shade	0	0	0	0	0	0	0	0	0	0	0
Mar-Open	100	100	100	100	100	100	100	100	100	100	100
Apr-Shade	0	0	0	0	0	0	0	0	0	0	0
Apr-Open	100	100	100	100	100	100	100	100	100	100	100
May-Shade	0	0	0	0	0	0	0	0	0	0	0
May-Open	100	100	100	100	100	100	100	100	100	100	100
Jun-Shade	0	0	0	0	0	0	0	0	0	0	0
Jun-Open	102	102	102	102	102	102	102	102	102	102	102
Jul-Shade	0	0	0	0	0	0	0	0	0	0	0
Jul-Open	100	100	100	100	100	100	100	100	100	100	100
Aug-Shade	0	0	0	0	0	0	0	0	0	0	0
Aug-Open	100	100	100	100	100	100	100	100	100	100	100
Sep-Shade	0	0	0	0	0	0	0	0	0	0	0
Sep-Open	100	100	100	100	100	100	100	100	100	100	100
Oct-Shade	0	0	0	0	5	0	0	0	0	2	0.7
Oct-Open	100	100	100	100	95	100	100	100	100	98	99.3
Nov-Shade	0	0	0	0	11	0	0	0	0	4	1.5
Nov-Open	100	100	100	100	89	100	100	100	100	96	98.5
Dec-Shade	0	0	0	0	7	0	0	0	0	4	1.1
Dec-Open	100	100	100	100	93	100	100	100	100	96	98.9

Ave Shade	0.458333
Ave Open	99.70833
Summer Shade	0
Summer Open	100.3333

Shade Calculator - Reach 6 Tenas Creek,
percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	71	37	81	100	100	92	100	97	100	20	79.8
Jan-Open	29	63	19	0	0	8	0	3	0	80	20.2
Feb-Shade	67	28	68	93	100	78	79	97	100	28	73.8
Feb-Open	33	72	32	7	0	22	21	3	0	72	26.2
Mar-Shade	65	20	40	88	80	60	79	85	67	50	63.4
Mar-Open	35	80	60	12	20	40	21	15	33	50	36.6
Apr-Shade	51	8	35	70	55	45	57	78	59	33	49.1
Apr-Open	49	92	65	30	45	55	43	22	41	67	50.9
May-Shade	28	12	34	40	21	50	32	53	63	51	38.4
May-Open	72	88	66	60	79	50	68	47	37	49	61.6
Jun-Shade	35	17	9	38	14	51	23	43	61	47	33.8
Jun-Open	67	85	93	64	88	51	79	59	41	55	68.2
Jul-Shade	33	15	23	40	21	45	23	49	59	51	35.9
Jul-Open	67	85	77	60	79	55	77	51	41	49	64.1
Aug-Shade	39	10	43	65	49	53	46	78	56	47	48.6
Aug-Open	61	90	57	35	51	47	54	22	44	53	51.4
Sep-Shade	65	8	34	88	74	53	69	72	61	49	57.3
Sep-Open	35	92	66	12	26	47	31	28	39	51	42.7
Oct-Shade	68	24	61	93	96	71	75	98	97	30	71.3
Oct-Open	32	76	39	7	4	29	25	2	3	70	28.7
Nov-Shade	70	36	82	100	100	92	85	97	100	22	78.4
Nov-Open	30	64	18	0	0	8	15	3	0	78	21.6
Dec-Shade	72	34	70	100	100	91	100	100	100	10	77.7
Dec-Open	28	66	30	0	0	9	0	0	0	90	22.3

Ave Shade	58.95833
Ave Open	41.20833
Summer Shade	43.85
Summer Open	56.48333

Shade Calculator - Reach 7 Bunnel Creek, percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	66	100	75	100	87	92	100	81	100	100	90.1
Jan-Open	34	0	25	0	13	8	0	19	0	0	9.9
Feb-Shade	76	94	72	100	79	92	100	84	100	84	88.1
Feb-Open	24	6	28	0	21	8	0	16	0	16	11.9
Mar-Shade	100	93	89	90	74	74	100	74	100	86	88
Mar-Open	0	7	11	10	26	26	0	26	0	14	12
Apr-Shade	100	87	92	89	89	68	100	77	81	100	88.3
Apr-Open	0	13	8	11	11	32	0	23	19	0	11.7
May-Shade	100	100	92	92	95	83	100	88	77	88	91.5
May-Open	0	0	8	8	5	17	0	12	23	12	8.5
Jun-Shade	102	102	89	93	102	85	102	84	79	90	92.8
Jun-Open	0	0	13	9	0	17	0	18	23	12	9.2
Jul-Shade	100	100	92	92	95	83	100	88	77	88	91.5
Jul-Open	0	0	8	8	5	17	0	12	23	12	8.5
Aug-Shade	100	88	89	87	94	68	100	82	88	88	88.4
Aug-Open	0	12	11	13	6	32	0	18	12	12	11.6
Sep-Shade	100	86	93	86	76	74	100	81	100	86	88.2
Sep-Open	0	14	7	14	24	26	0	19	0	14	11.8
Oct-Shade	77	94	71	89	80	86	100	84	100	76	85.7
Oct-Open	23	6	29	11	20	14	0	16	0	24	14.3
Nov-Shade	66	100	70	100	87	92	100	82	100	100	89.7
Nov-Open	34	0	30	0	13	8	0	18	0	0	10.3
Dec-Shade	72	100	100	100	86	100	100	80	100	100	93.8
Dec-Open	28	0	0	0	14	0	0	20	0	0	6.2

Ave Shade	89.675
Ave Open	10.49167
Summer Shade	90.11667
Summer Open	10.21667

Shade Calculator - Reach 8 South Fork Hangman Creek, percent shade by month

Site	1	2	3	4	5	6	7	8	9	10	Average
Jan-Shade	95	100	100	92	73	100	100	100	100	100	96
Jan-Open	5	0	0	8	27	0	0	0	0	0	4
Feb-Shade	95	100	92	63	60	100	89	100	92	94	88.5
Feb-Open	5	0	8	37	40	0	11	0	8	6	11.5
Mar-Shade	94	95	60	59	40	79	52	99	61	62	70.1
Mar-Open	6	5	40	41	60	21	48	1	39	38	29.9
Apr-Shade	90	86	68	35	56	86	35	100	27	47	63
Apr-Open	10	14	32	65	44	14	65	0	73	53	37
May-Shade	95	78	60	31	65	94	36	83	26	29	59.7
May-Open	5	22	40	69	35	6	64	17	74	71	40.3
Jun-Shade	97	79	62	28	73	90	38	68	27	30	59.2
Jun-Open	5	23	40	74	29	12	64	34	75	72	42.8
Jul-Shade	95	78	60	31	71	94	36	83	26	29	60.3
Jul-Open	5	22	40	69	29	6	64	17	74	71	39.7
Aug-Shade	95	86	70	37	64	88	34	94	29	39	63.6
Aug-Open	5	14	30	63	36	12	66	6	71	61	36.4
Sep-Shade	89	92	53	52	46	72	39	99	33	61	63.6
Sep-Open	11	8	47	48	54	28	61	1	67	39	36.4
Oct-Shade	95	100	79	56	54	100	100	100	80	87	85.1
Oct-Open	5	0	21	44	46	0	0	0	20	13	14.9
Nov-Shade	95	100	100	83	74	100	89	100	92	100	93.3
Nov-Open	5	0	0	17	26	0	11	0	8	0	6.7
Dec-Shade	100	100	100	100	71	100	100	100	100	100	97.1
Dec-Open	0	0	0	0	29	0	0	0	0	0	2.9

Ave Shade	74.95833
Ave Open	25.20833
Summer Shade	61.56667
Summer Open	38.76667

Appendix F. Bacteria Loading Analysis

Table below illustrates the estimated flows and *E. coli* concentrations for Hangman and South Fork Hangman Creek.

Date	Hangman Creek *E. coli* (cfu/100ml)	5-day geomean	Estimated Flow (cfs)	# cfu at flow	# cfu at geomean ave. flow	South Fork Hangman Creek *E. coli* (cfu/100ml)	5-day geomean	Estimated Flow (cfs)	# cfu at flow	# cfu at geomean ave. flow
7/8/2002	1100		0.64	199351		730		0.57	117826	
7/22/2002	1300		0.33	121479		68		0.29	5584	
7/26/2002	730		0.31	64081		64		0.28	5074	
7/29/2002	2400		0.27	183493		26		0.24	1767	
8/2/2002	99	756.6605	0.2	5607	74992	1000	152.5447	0.18	50970	13477
8/5/2002	20	339.4912	0.22	1246	25571	1200	168.4879	0.2	67960	11355
8/9/2002	59	182.8985	0.23	3843	12741	21	133.202	0.21	1249	8374
8/13/2002	31	97.23397	0.24	2107	6388	370	189.1974	0.22	23050	11251

Appendix G. Distribution List

Copies of the final document will be provided to the Idaho Department of Environmental Quality State Office, U.S. Environmental Protection Agency, and the Upper Hangman Creek Watershed Advisory Group participants including:

Concerned Citizen	Bob Cordell
Concerned Citizen	Deborah Olson
United States Forest Service	Meg Foltz
Washington Department of Ecology	Elaine Snouwaert
Potlatch Forest Holdings	Neil Smith
Potlatch Forest Holdings	Terry Cundy
Bennett Lumber Products	Mike Kerttu
Coeur d’Alene Tribe of Idaho	Dee Bailey
Coeur d’Alene Tribe of Idaho	Bruce Kinkead
Benewah Soil and Water Conservation District	Sherry Klaus
Benewah Soil and Water Conservation District	Mark Cottrell
Benewah County Commissioner District II	Terry Doupè
Kootenai Environmental Alliance	Mike Mihelich
Idaho Department of Lands	Steve Cuvala

Copies of the final document can be obtained by contacting the Idaho Department of Environmental Quality, Coeur d’ Alene Regional Office at:

2110 Ironwood Parkway
Coeur d’ Alene Idaho, 83814

Phone: (208) 769-1422

Fax: (208) 769-1404

Appendix H. Public Comments

Document Section	Commenter	Comments	Response	Page
Executive Summary Subbasin at a Glance	Kootenai Environmental Alliance	The final document should provide information that will indicate the number of acres of industrial forestlands that are located within the 10,000-acre analysis area. The owner(s) of the industrial forestlands should be listed in the final document.	Comment has been noted and modifications will be included in the final document. Any information regarding the current land ownership is subject to change. Information identifying private landowners by name will not be included in the final document. Identification of landowners by name is difficult to achieve and may not accurately represent future land ownership. Any attempt by DEQ to classify land use activities and landownership will need to be re-evaluated during management actions taken as a result of this document.	xvii
Executive Summary Key Findings	Kootenai Environmental Alliance	The Final document should indicate there are a number of April 2006 FPA stream protection regulations that apply to the forestlands in the 10,000 acres analysis area. There should also be information in the Final document that will indicate whether any variances from the standing tree and shade requirements	Comment has been noted and text has been added to the document. Personal communication with Idaho Department of Lands, March 23, 2007. No variances from the standing tree and shade requirements set by the FPA have been issued in the upper Hangman Creek watershed.	42

Document Section	Commenter	Comments	Response	Page
		have been submitted to the Idaho Department of Lands (IDL) after April 12, 2006. If any variance has been submitted to IDL, the Final document should include information that describes the reasons why a variance was needed.		
Executive Summary Key Findings	Kootenai Environmental Alliance	The Final document should include information that will indicate whether culvert surveys are included as part of the CWE process. If culvert surveys were not conducted as part of the CWE process, did the BURP process or other DEQ inspections reveal any failed culverts and/or fish passage problems in the streams and Creeks in the analysis area? If there are any culvert failures in the analysis area, are these culverts contributing to the sediment problems noted in the document?	Comment has been noted and modification will be included in final document. DEQ did conduct a field visit on September 27, 2006 to Tenas Creek as requested by the Upper Hangman Creek WAG. One (1) culvert was inspected and determined to be a possible barrier to fish passage. The site was not evaluated as a possible sediment source. IDL CWE report did indicate two management problems associated with culverts. Problem culverts are located on Bunnel Creek and South Fork Hangman Creek. Further evaluation of the CWE identified problem culverts should be conducted. While fish passage is important to the fisheries of the upper Hangman Creek watershed and the beneficial uses DEQ is trying to protect, fish	31

Document Section	Commenter	Comments	Response	Page
			passage and distribution is beyond the scope of the pollutant reduction efforts outlined in this document.	
1.3 Cultural Characteristics	Coeur d'Alene Tribe	On Pg 12, section 1.3 Cultural Characteristics, the Tribe request that this section also recognize that the Tribe and its members still use upper Hangman creek and its tributaries for fishing, hunting, gathering and ceremonial uses and that this area always has been and will continue to be an important tribal trust resource.	Comment has been noted and modification will be included in final document. Final document will include text describing the Coeur d' Alene tribes' involvement and the current and historical cultural significance of the upper Hangman Creek watershed.	12
2.4 Summary and Analysis of Existing Water Quality Data, Water Column Data	Coeur d'Alene Tribe	As you are aware the Tribe will be completing a TMDL for those portions of Hangman Creek within the exterior boundaries of the Coeur d'Alene Reservation in the near future. We appreciate DEQ's acknowledgment of this other impending TMDL and DEQ's commitment to working with the Tribe to coordinate both these TMDL's once finished.	DEQ looks forward to coordinating future water quality projects in the Hangman Creek watershed with the Coeur d' Alene Tribe.	NA
5.1 In-stream Water Quality Targets	Coeur d'Alene Tribe	In regards to sediment, the document does not clearly define how	Comment has been noted and modification will be included in final document. In	47-48

Document Section	Commenter	Comments	Response	Page
		sediment from forested areas was derived nor how background sediment levels were obtained. The use of McGreer (1998) which is cited in the reference section as a "personal communication" is not sufficient to describe how load calculations for sediment were obtained and/or justified. The discussion of sediment load calculations needs a much more detailed description to be acceptable. The Program also suggest that a multiple lines of evidence approach be used to show how or if the CWE-McGreer sediment loading calculation method is at least comparable to other approaches in similar forested areas.	researching the use of the McGreer (1998) citation, the citation first appears in the Priest River TMDL. The correct citation of McGreer's work will be made to final document. Additional lines of evidence will be evaluated and compared to the values obtained from using the McGreer equation and descriptions of comparisons will be added to the final document.	

Appendix I. Daily Sediment Loads

Daily Sediment Load Targets

Recently the Idaho Department of Environmental Quality has had to reevaluate TMDL targets and adjust targets to reflect daily loads. Historically the DEQ has assigned loads and load reductions on a yearly basis, but recent guidance from the EPA has focused on assigning daily loads.

It is well understood that pulses of pollutants, in this case sediment, occur during high discharge events. To better relate target sediment loads to this phenomenon daily sediment loads were developed using stream flow data obtained from the United States Geological Survey (USGS). Stream flow information has been collected by the USGS on Hangman Creek near Tensed, Idaho. USGS gauging station 12422950 has been collecting Hangman Creek stream flow information since 1981. The Hangman Creek hydrograph will be used to represent stream flows for streams in the upper Hangman Creek watershed for which sediment TMDL was developed.

After determining the monthly flow average, the percentage of flow occurring during each month was calculated. The flow percentage for the months was then multiplied by the sediment load target and divided by the number of days in the month. The end result was a flow based daily sediment load target for streams in the upper Hangman Creek watershed.

Flows from January through April are the highest as are the target sediment loads. Flows from July through November are the lowest as are the target sediment loads. Table I-1 outlines the daily sediment load targets by month. By reducing the existing sediment load to the below listed amounts, sediment will be reduced in sufficient quantities to support beneficial uses.

Table I-1. Target Sediment Load (tons/day)

	Hangman Creek watershed	Upper Martin Creek	Lower Martin Creek	Lower Bunnel Creek	Upper South Fork Hangman Creek	Hangman Creek	Tenas Creek	Upper Bunnel Creek	Lower South Fork Hangman Creek
Jan	1.6789	0.1449	0.0866	0.0683	0.2513	0.5783	0.0336	0.0139	0.5021
Feb	3.7553	0.3242	0.1936	0.1527	0.5621	1.2934	0.0752	0.0310	1.1230
Mar	2.4957	0.2154	0.1287	0.1015	0.3735	0.8596	0.0500	0.0206	0.7463
Apr	1.4418	0.1245	0.0743	0.0586	0.2158	0.4966	0.0289	0.0119	0.4312
May	0.7260	0.0627	0.0374	0.0295	0.1087	0.2501	0.0145	0.0060	0.2171
June	0.8323	0.0718	0.0429	0.0338	0.1246	0.2867	0.0167	0.0069	0.2489
July	0.0250	0.0022	0.0013	0.0010	0.0037	0.0086	0.0005	0.0002	0.0075
Aug	0.0295	0.0025	0.0015	0.0012	0.0044	0.0102	0.0006	0.0002	0.0088
Sept	0.0074	0.0006	0.0004	0.0003	0.0011	0.0025	0.0001	0.0001	0.0022
Oct	0.0147	0.0013	0.0008	0.0006	0.0022	0.0051	0.0003	0.0001	0.0044
Nov	0.0633	0.0055	0.0033	0.0026	0.0095	0.0218	0.0013	0.0005	0.0189
Dec	0.3176	0.0274	0.0164	0.0129	0.0475	0.1094	0.0064	0.0026	0.0950

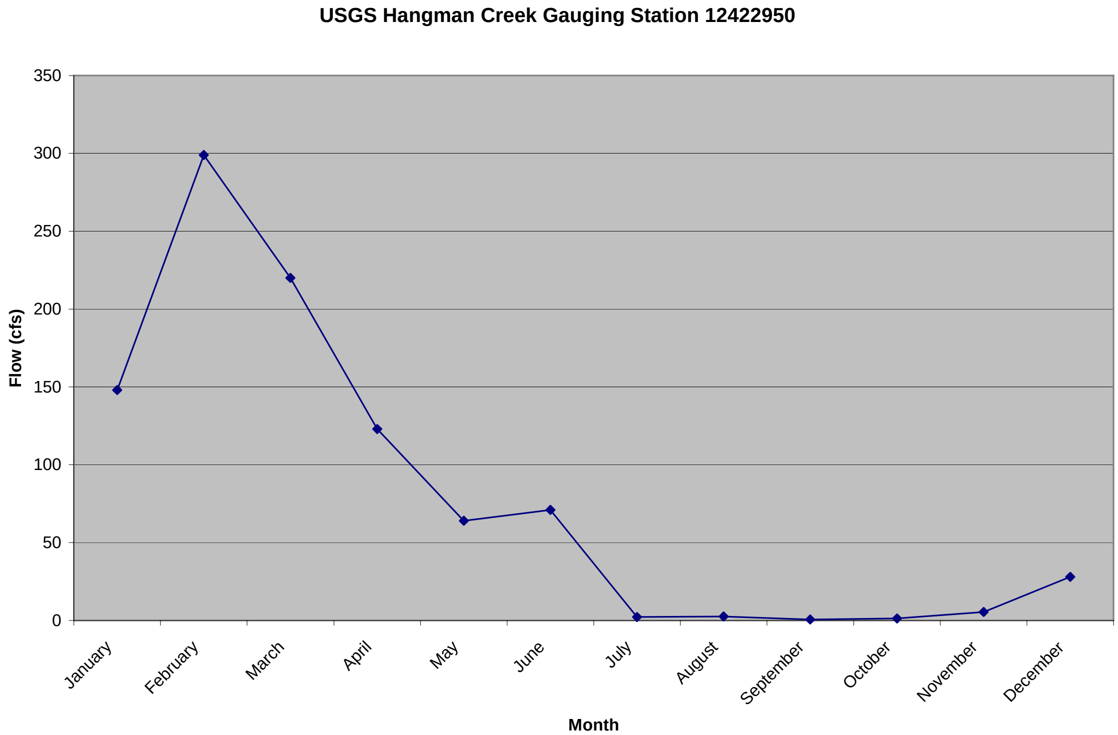


Figure I-1. USGS Hangman Creek gauging station 12422950 near Tensed, Idaho.

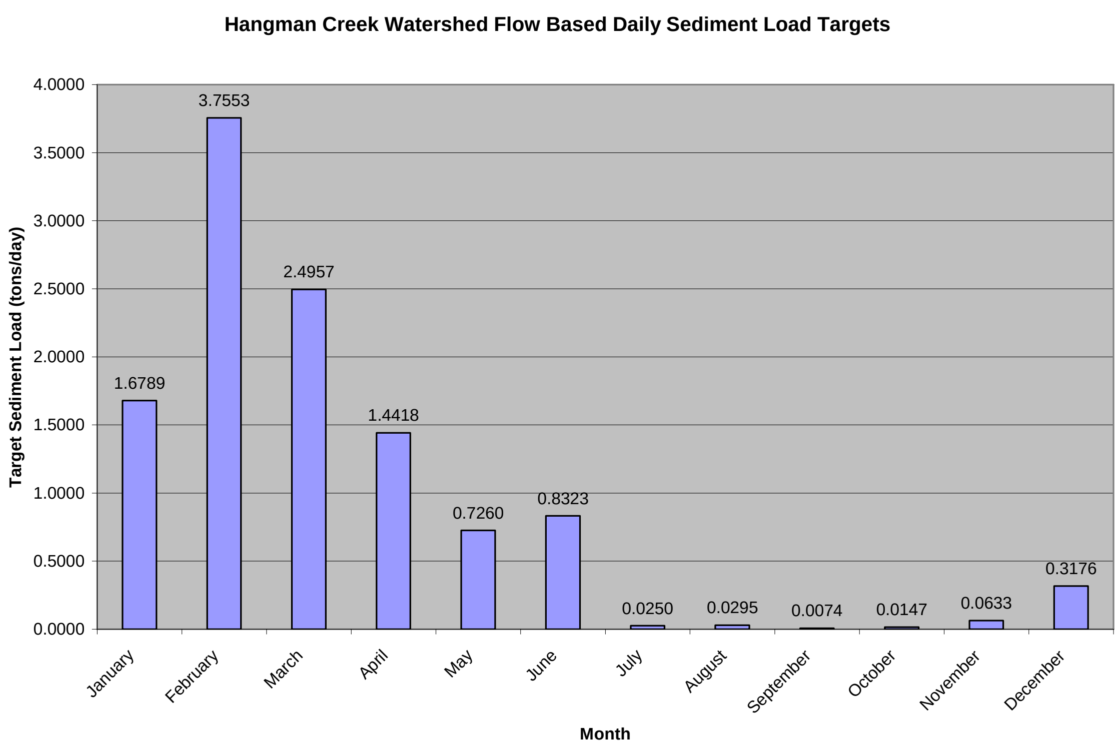


Figure I-2. Upper Hangman Creek watershed target sediment loads (tons/day).

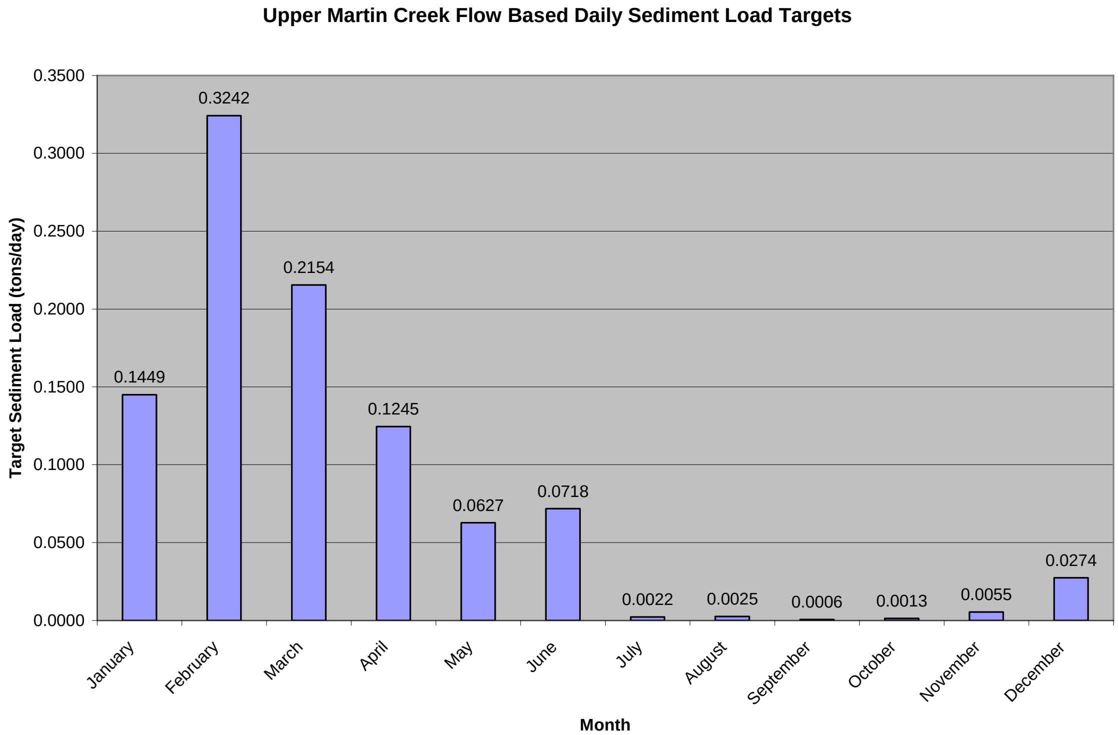


Figure I-3. Upper Martin Creek watershed target sediment loads (tons/day).

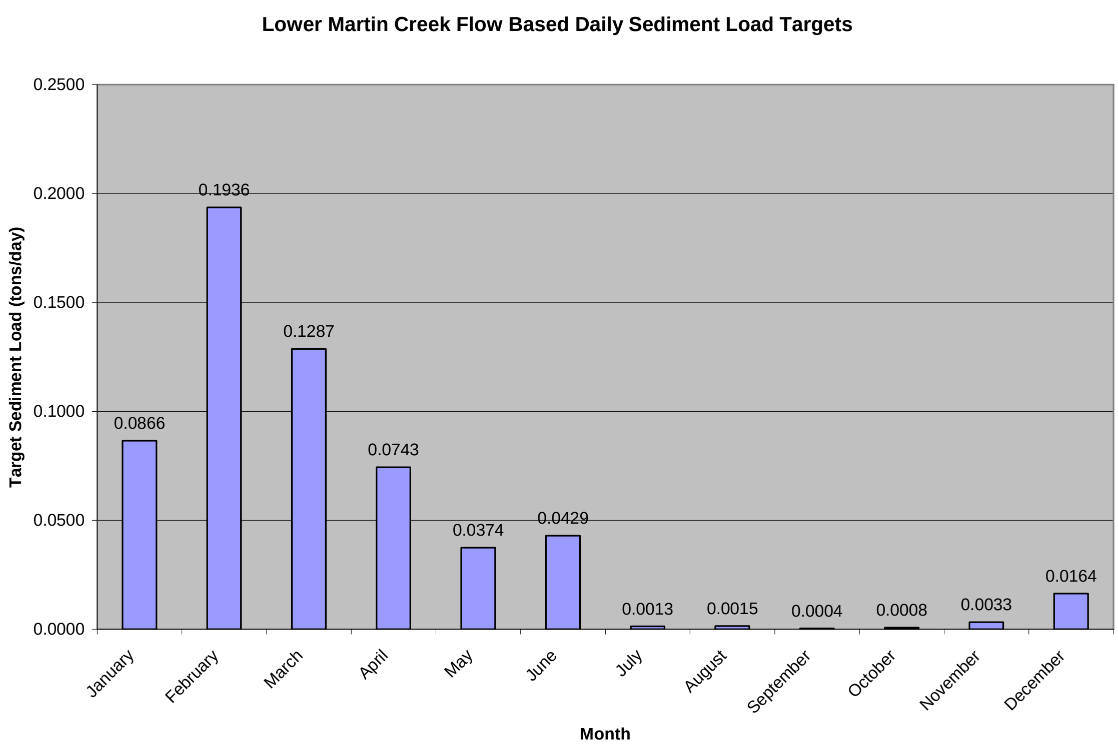


Figure I-4. Lower Martin Creek watershed target sediment loads (tons/day).

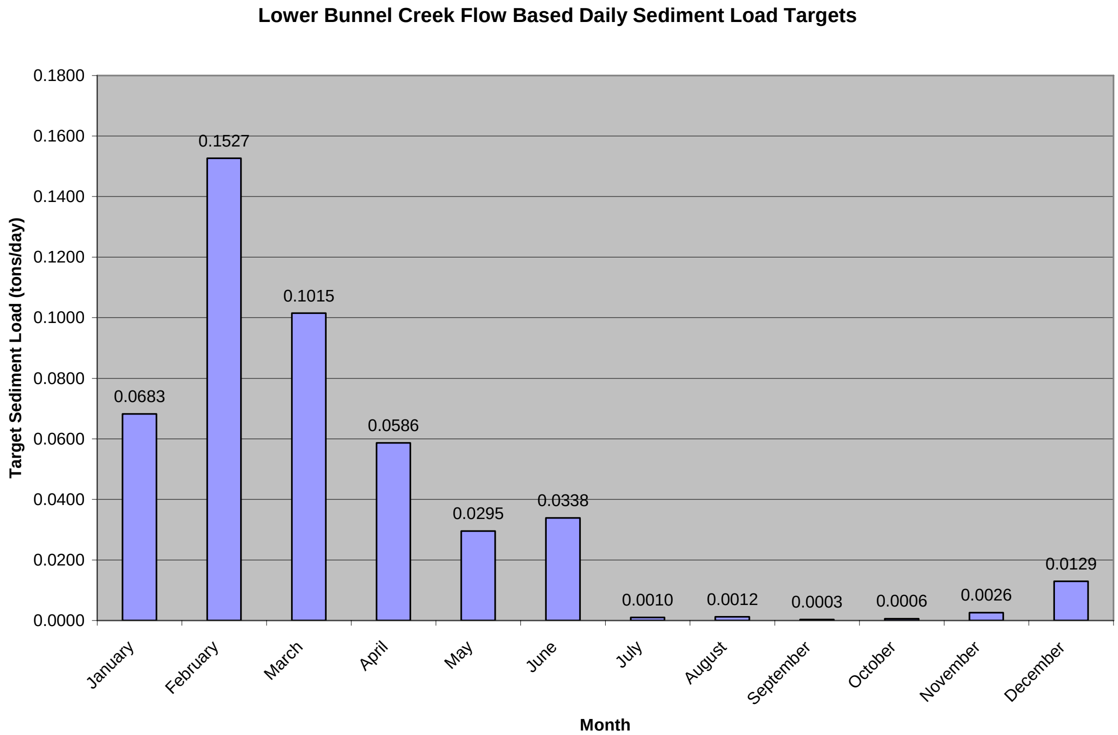


Figure I-5. Lower Bunnel Creek watershed target sediment loads (tons/day).

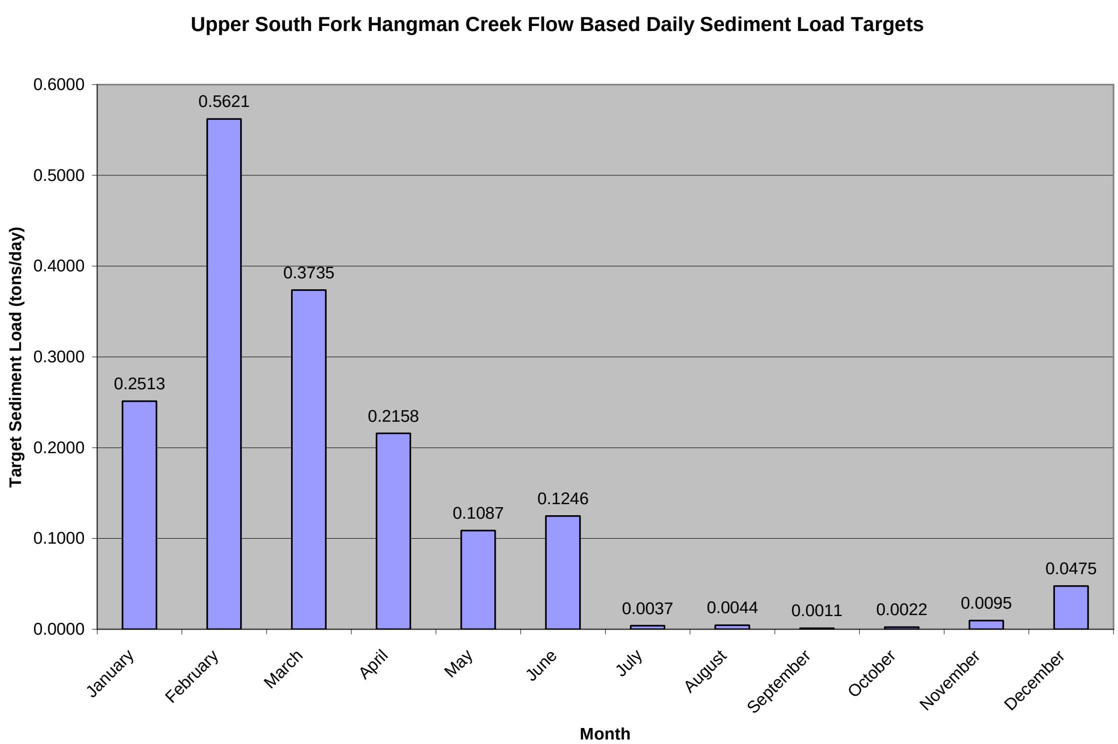


Figure I-6. Upper S.F. Hangman Creek watershed target sediment loads (tons/day).

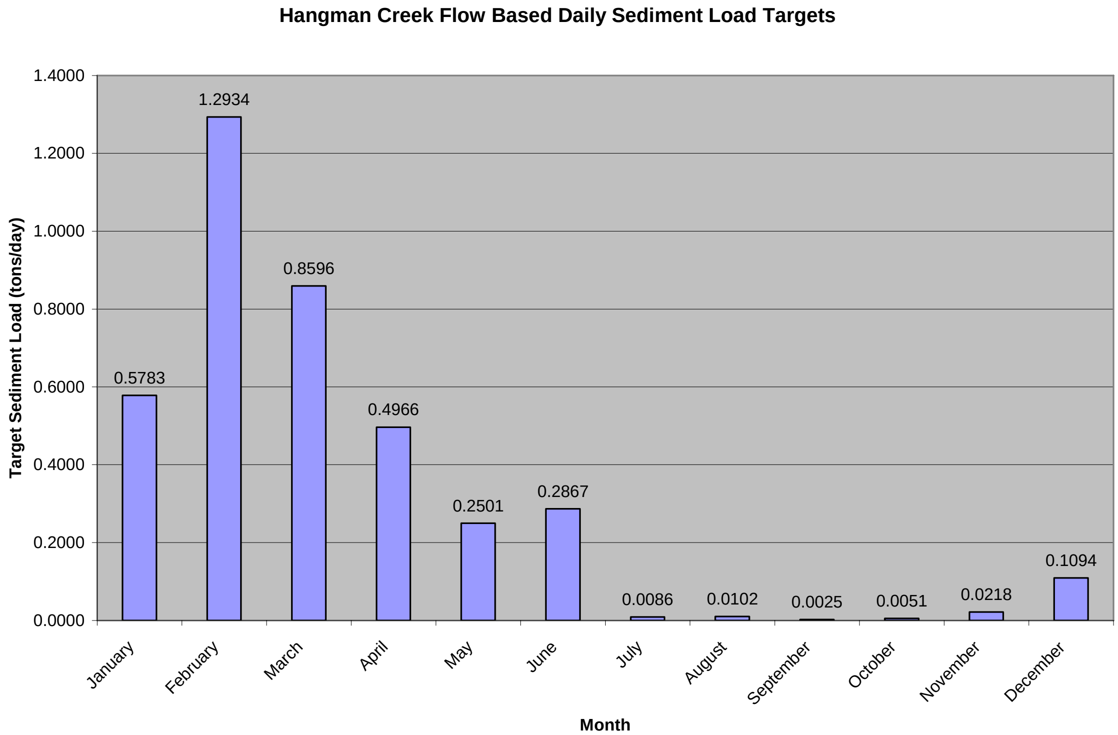


Figure I-7. Hangman Creek watershed target sediment loads (tons/day).

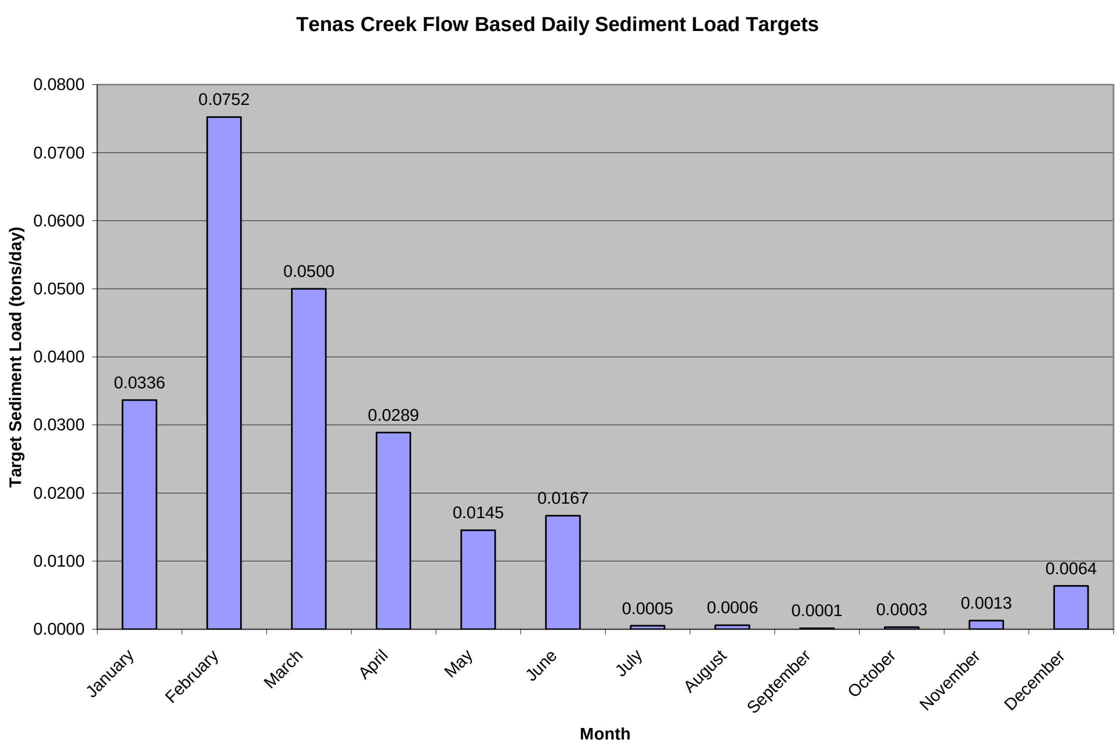


Figure I-8. Tenas Creek watershed target sediment loads (tons/day).

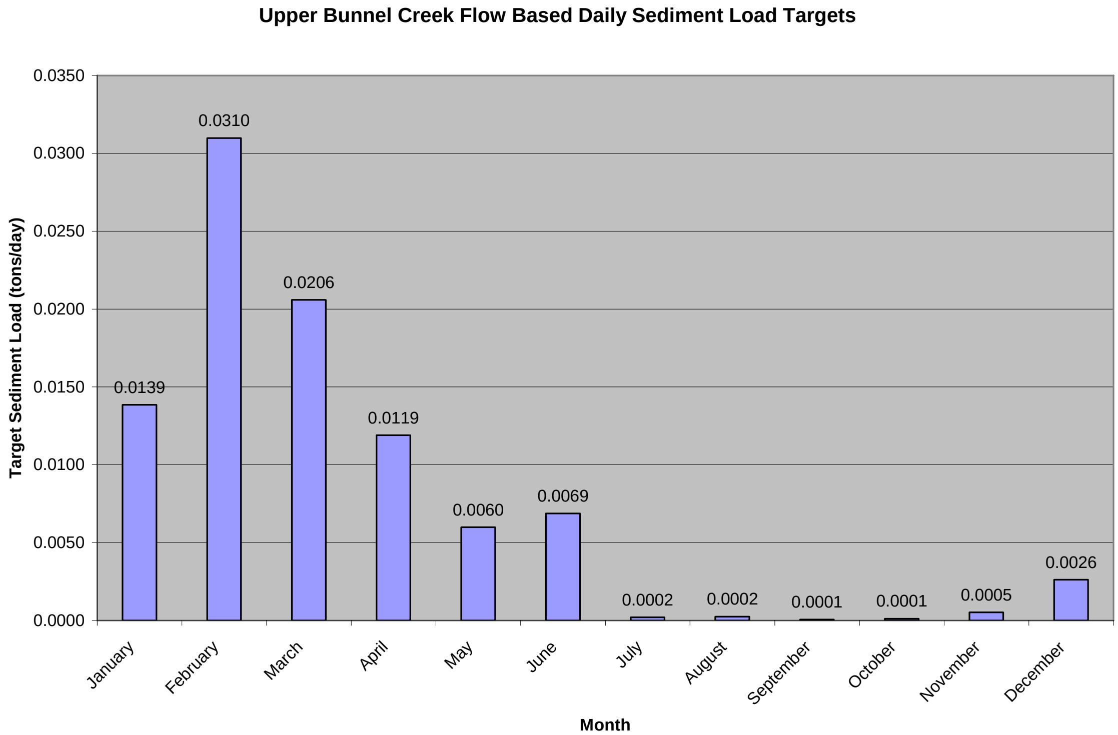


Figure I-9. Upper Bunnel Creek watershed target sediment loads (tons/day).

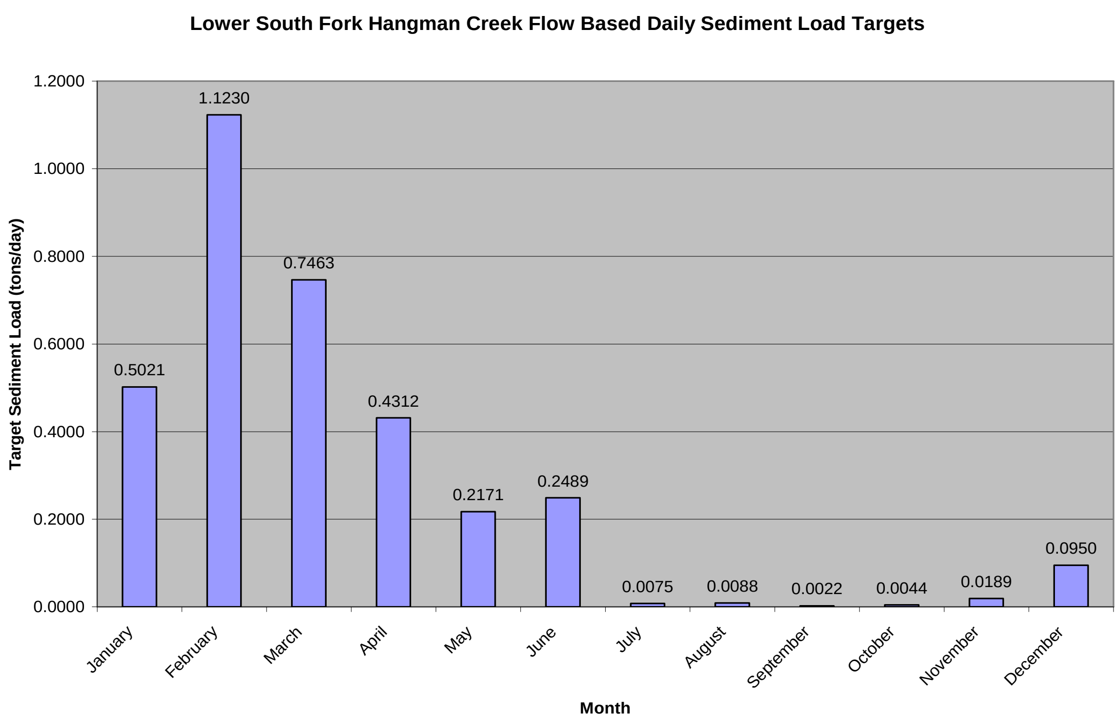


Figure I-10. Lower South Fork Hangman Creek watershed target sediment loads (tons/day).

Appendix J. Daily Bacteria Loads

Daily Bacteria Load Targets

Recently the Idaho Department of Environmental Quality (DEQ) has had to reevaluate TMDL targets and adjust targets to reflect daily loads. Historically the DEQ has assigned loads and load reductions on a yearly basis, but recent guidance from the EPA has focused on assigning daily loads.

Estimated *E. coli* at load capacities, the amount of *E. coli* (cfu) allowable in a stream as to assure water quality standards are met, were calculated for Hangman Creek and South Fork Hangman Creek outside of the Coeur d'Alene Tribal Reservation. Flow data for this portion of the watershed was limited to information collected during BURP surveys. To estimate the *E. coli* at load capacity flow information from USGS gaging station 12422950, located downstream near the confluence of Hangman and Little Hangman Creek was used to extrapolate flows for Hangman and South Fork Hangman Creek. Flow was estimated using the same approach used in section 5.1 *In-Stream Water Quality Targets, Design Conditions*, page 46.

Estimated stream flows resemble the flow measurements made during BURP surveys. Flow is highly variable and can change greatly from year to year and season to season. During future evaluation of bacteria contamination in Hangman and South Fork Hangman Creek flow measurements should be taken during sample collection.

To determine the approximate daily bacteria load the Idaho water quality standard (IDAPA 58.01.02.251.01a) of 126 *E. coli* cfu/100ml was first converted to cubic feet. After calculating the amount of *E. coli* allowed per cubic foot of water (35,679 *E. coli* cfu/1 cubic foot as per IDAPA 58.01.02.251.01a) the estimated flow (cfs) was then multiplied by this amount. Because flow is recorded in seconds, the number calculated from the previous calculation was then multiplied by 86,400 seconds. See below for calculation details.

<u>Converting Idaho Water Quality Standard to a daily load.</u>

1 cubic foot = 28,316.85 milliliters

1 day = 86,400 seconds

28,316.85 milliliters / 100 milliliters = 283.1685 milliliters

126 E. coli (cfu) x 283.1685 milliliters = 35,679.231 E. coli (cfu)/1 cubic foot of water

<u>Example January calculation for Hangman Creek</u>

35,679.231 E. coli (cfu) x 40.09 cfs x 86,400 seconds = 126,115,002,458.8 E. coli/day

Tables J-1 and J-2 contain the estimated flow (cfs) and *E. coli* (cfu) at load capacity for Hangman and South Fork Hangman Creek.

Table J-1. Hangman Creek estimated flow and *E. coli* at load capacity (*E. coli* (cfu)/day).

Month	Estimated Flow (cfs)	*E. coli* (cfu) at load capacity per day
January	40.9	126,115,002,458.8
February	82.7	255,032,876,700.5
March	60.9	187,593,220,602.3
April	34.1	105,150,375,188.6
May	17.6	542,71,849,828.4
June	19.7	60,838,679,632.7
July	0.6	1,863,767,457.9
August	0.7	2,193,496,156.3
September	0.2	535,675,749.4
October	0.3	1,073,058,831.8
November	1.5	4,621,181,498.0
December	7.7	23,720,547,393.9

Table J-2. South Fork Hangman Creek estimated flow and *E. coli* at load capacity (*E. coli* (cfu)/day).

Month	Estimated Flow (cfs)	*E. coli* (cfu) at load capacity per day
January	36.4	112,102,325,611.2
February	73.5	22,696,095,056.5
March	54.1	166,749,679,962.1
April	30.3	93,467,084,547.6
May	15.6	48,241,687,843.4
June	17.5	54,078,875,161.3
July	0.5	1,656,683,680.4
August	0.6	1,949,776,121.3
September	0.2	476,156,651.5
October	0.3	953,830,933.8
November	1.3	4,107,720,595.5
December	6.8	21,084,950,051.8

Figures J-1 and J-2 represent estimated stream flows for Hangman and South Fork Hangman Creek based on flow data collected during BURP surveys and flow data collected at USGS gauging station 12422950.

Figure J-1. Estimated stream flows for Hangman Creek outside the Coeur d'Alene Tribal Reservation.

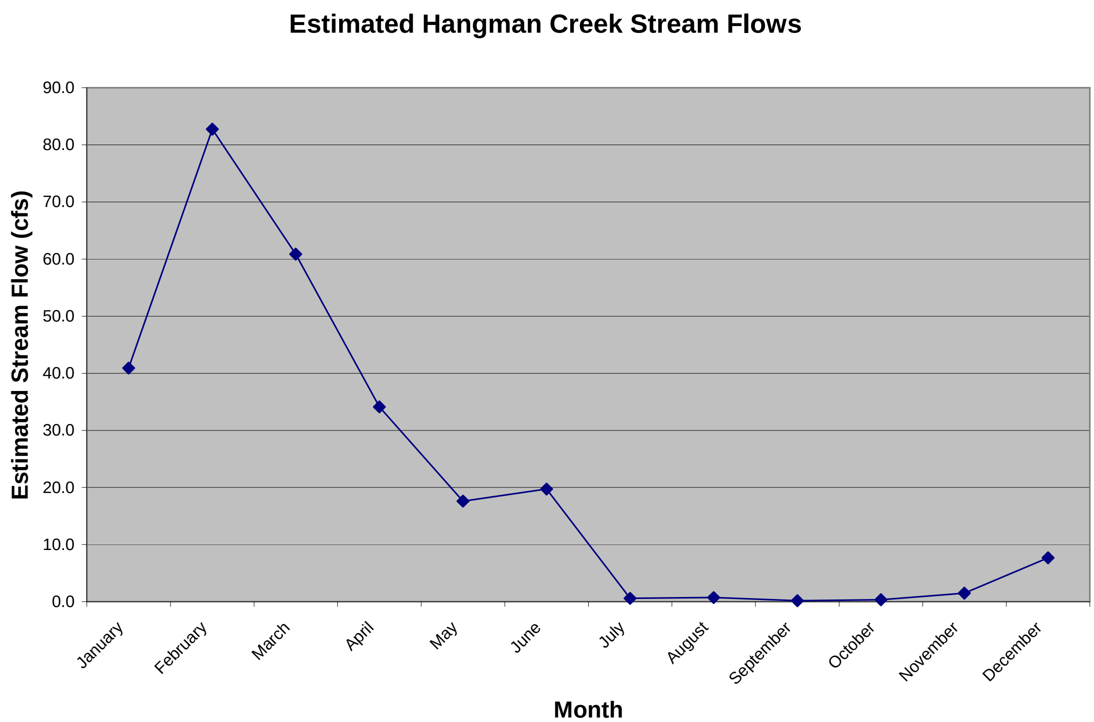


Figure J-2. Estimated stream flows for South Fork Hangman Creek.

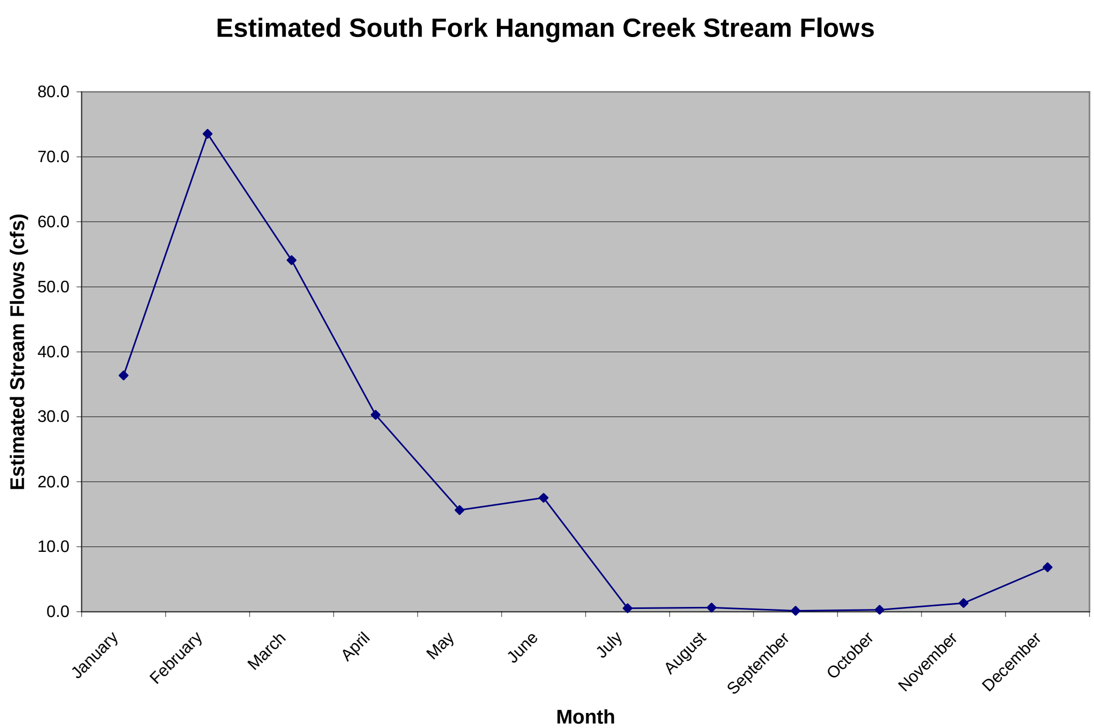


Figure J-3. Estimated *E. coli* (cfu) per day at load capacity for Hangman Creek outside the Coeur d'Alene Tribal Reservation.

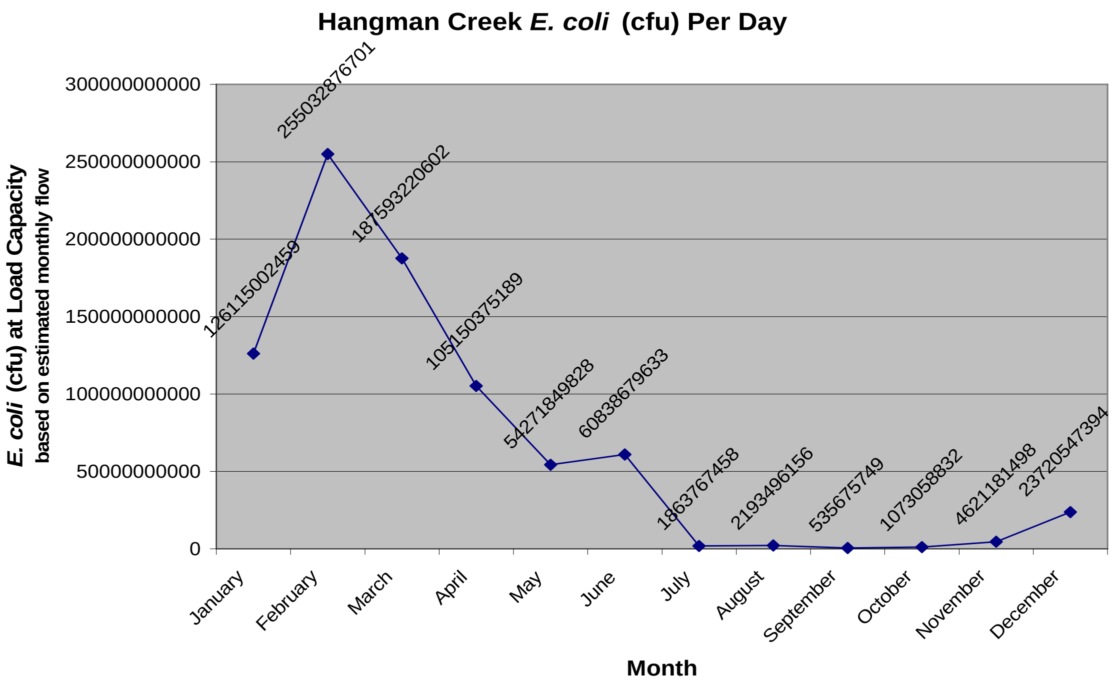


Figure J-4. Estimated *E. coli* (cfu) per day at load capacity for South Fork Hangman Creek.