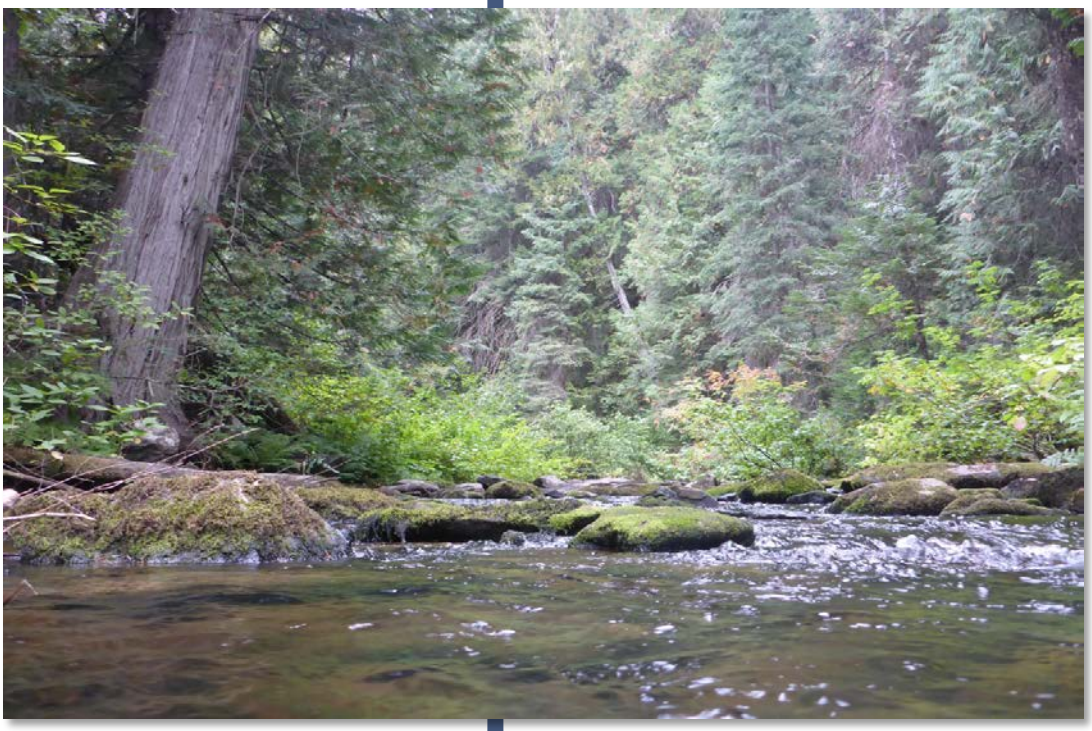
Lolo Creek Tributaries Watershed

2017 Temperature TMDL

Hydrologic Unit Code 17060306



State of Idaho
Department of Environmental Quality
July 2020

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Printed on recycled paper, DEQ, February 2020, PID 9003, CA code 22066. Costs associated with this publication are available from the State of Idaho Department of Environmental Quality in accordance with Section 60-202, Idaho Code.

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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
§	section (usually a section of federal or state rules or statutes)
AU	assessment unit
BLM	United States Bureau of Land Management
BMP	best management practice
BURP	Beneficial Use Reconnaissance Program
C	Celsius
CFR	Code of Federal Regulations (refers to citations in the federal administrative rules)
CGP	Construction General Permit
CNF	Clearwater National Forest
COLD	cold water aquatic life
CWA	Clean Water Act
DEQ	Idaho Department of Environmental Quality
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
GIS	geographic information system
HUC	hydrologic unit code
IDAPA	refers to citations of Idaho administrative rules
IDL	Idaho Department of Lands
IDWR	Idaho Department of Water Resources
kWh	kilowatt-hour
LA	load allocation
LC	load capacity
m	meter
mg/L	milligrams per liter
mL	milliliter
MOS	margin of safety
NB	natural background
NPDES	National Pollutant Discharge Elimination System
NREL	National Renewable Energy Laboratory
PNV	potential natural vegetation
SFI	DEQ's Stream Fish Index
SHI	DEQ's Stream Habitat Index
SMI	DEQ's Stream Macroinvertebrate Index
SS	salmonid spawning
SWPPP	Stormwater Pollution Prevention Plan
TDS	total dissolved solids

TMDL	total maximum daily load
US	United States
USC	United States Code
WAG	watershed advisory group
WBAG	*Water Body Assessment Guidance*
WLA	wasteload allocation

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 the CWA §303, 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. The CWA §303(d) 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 (a "§303(d) list") of impaired waters. Currently, this list is published every 2 years as the list of Category 5 water bodies in Idaho's Integrated Report. 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. A TMDL analysis establishes water quality targets and load capacities, estimates existing pollutant loads, and allocates responsibility for load reductions needed to return listed waters to a condition meeting water quality standards. It also identifies implementation strategies—including reasonable time frames, approach, responsible parties, and monitoring strategies—necessary to achieve load reductions and meet water quality standards.

Revising the existing temperature TMDL, *Lolo Creek Tributaries Subbasin Assessment and Total Maximum Daily Load* (DEQ 2011), this 2017 TMDL focuses on five assessment units (AUs) contained within Category 4a of the 2016 Integrated Report (DEQ 2018). The 2011 TMDL focused on main-stem segments of the water bodies. This 2017 TMDL, compared to the 2011 TMDL, includes additional analysis of all 1st- and 2nd-order stream segments for each AU in Category 4a but does not include an analysis of the 3rd-order segment of Eldorado Creek. This TMDL further aligns AU designations within the 2016 Integrated Report and assists in establishing future assessment and analysis time frames. In compliance with Idaho Code §39-3611(7), the review describes current water quality status, pollutant sources, and recent pollution control efforts relating to temperature impairments in the Lolo Creek watershed.

This TMDL describes key physical and biological characteristics of the watershed; water quality concerns and status; pollutant sources; and recent pollution control actions in the Clearwater River subbasin, located in central Idaho. Detailed information about the watershed and previous TMDLs is found in the *Lolo Creek Tributaries Subbasin Assessment and Total Maximum Daily Load* (DEQ 2011).

Watershed at a Glance

Lolo Creek is a 6th-order tributary of the Clearwater River (hydrologic unit code 17060306), forming the boundary between Idaho and Clearwater Counties in north-central Idaho. The creek flows primarily southwest, from an elevation of 5,240 feet, just below the summit of Hemlock Butte, to 1,118 feet at the mouth where it enters the Clearwater River.

The Lolo Creek watershed is a sparsely populated area with no incorporated cities. Dominant land uses are and were historically forestry, road building, grazing, placer mining, and recreational activities. Landownership varies throughout the watershed from public and state

endowment land to privately owned nonindustrial land. The lower 4 miles of Lolo Creek are located within the current boundary of the Nez Perce tribal reservation (Figure A).

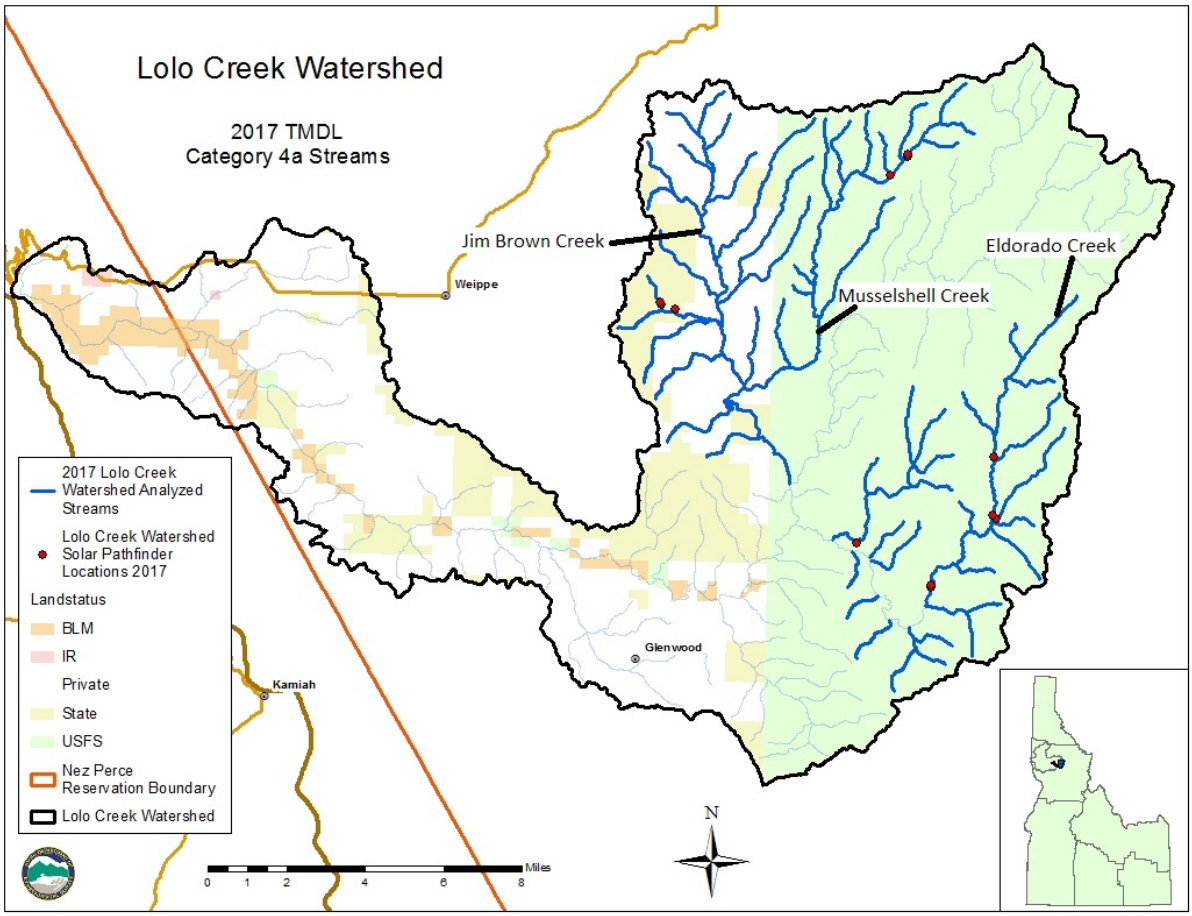


Figure A. Lolo Creek watershed.

Key Findings

Five temperature TMDLs were approved in 2011 for Eldorado, Jim Brown, and Musselshell Creeks (Table A). In 2017, the AUs included in the 2011 analysis within the Lolo Creek watershed were analyzed (Figure A) and are not yet meeting their shade targets. Eldorado, Jim Brown, Musselshell Creeks were placed on the §303(d) list of impaired waters (DEQ 2018), or subsequent lists, for temperature criteria violations, and the Idaho Department of Environmental Quality (DEQ) developed temperature TMDLs for these waters (Table B).

Effective target shade levels were established for five AUs based on the concept of maximum shading under potential natural vegetation resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation that was partially field verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02).

The AUs with TMDLs reviewed in this document should remain in Category 4a for temperature impairments until excess loads improve. Assessment outcomes, including recommended changes to listing status in the next Integrated Report and recommended actions to improve stream temperature, are presented in Tables B and C.

Table A. Existing TMDLs and general status.

Assessment Unit Name	Assessment Unit Number	Pollutant	Implementation Plan	Implementation Activities	Water Quality Trend
Eldorado Creek	ID17060306CL029_02	Temperature	Yes	Culvert upgrades, stream restoration, road improvement, upland and riparian management	Improving
Jim Brown Creek	ID17060306CL031_02	Temperature	Yes	Culvert upgrades, stream restoration, road improvement, upland and riparian management	Static
Jim Brown Creek	ID17060306CL031_03	Temperature	Yes	Culvert upgrades, stream restoration, road improvement, upland and riparian management	Degrading
Musselshell Creek	ID17060306CL032_02	Temperature	Yes	Culvert upgrades, stream restoration, road improvement, upland and riparian management	Improving
Musselshell Creek	ID17060306CL032_03	Temperature	Yes	Culvert upgrades, stream restoration, road improvement, upland and riparian management	Improving

Table B. Lolo Creek watershed 2017 status.

Approved TMDLs	Pollutants	Assessment Units Moving from Category 4a to 2
Eldorado Creek—Temperature Jim Brown Creek—Temperature Musselshell Creek—Temperature	Temperature	All AUs with TMDLs will remain in Category 4a
Implementation Plans	**Implementation Actions**	**Estimated percent of watershed in Category 4a**
2011 Idaho Soil Conservation Commission Agriculture Implementation Plan	Culvert upgrades, stream restoration, road improvement, upland and riparian management	39%

Table C. Summary of recommended actions.

Recommended Action	Schedule	Responsibility	Justification
Continue intensive riparian management	Next 5 years	Land management	Has decreased solar load based on 2017 data
Continue to restore riparian areas and fish habitat as much as possible	Next 5 years	Land management	Will improve riparian habitat, increase stream habitat variability, and lower temperature impairments.

Public Participation

This TMDL was developed with participation from the Lolo Creek Watershed Advisory Group (WAG). The Lolo Creek WAG met on July 12, 2018, to discuss the Lolo Creek watershed temperature TMDL.

Introduction

This document identifies water bodies in the Lolo Creek watershed of the Clearwater River watershed that were addressed by the *Lolo Creek Tributaries Subbasin Assessment and Total Maximum Daily Load* (DEQ 2011). This total maximum daily load (TMDL) evaluates current water quality data, the appropriateness of the TMDL to current watershed conditions, and any available implementation plans. Based on this TMDL, no changes have been recommended for Idaho's next Integrated Report (DEQ 2018).

Regulatory Requirements

This document was prepared in compliance with both federal and state regulatory requirements. The federal government, through the United States 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 Clean Water Act (CWA) in Idaho, while EPA oversees Idaho and certifies the fulfillment of CWA requirements and responsibilities.

Congress passed the Federal Water Pollution Control Act, or CWA, in 1972. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 USC §1251). 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 ensure "swimmable and fishable" conditions. These goals relate water quality to more than just chemistry.

The 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 CWA §303, 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. DEQ must review those standards every 3 years, and EPA must approve Idaho's water quality standards. Idaho adopts water quality standards to protect public health and welfare, enhance water quality, 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.

CWA §303(d) 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 (a "§303(d) list") of impaired waters. Currently, this list is published every 2 years as the list of Category 5 waters in Idaho's Integrated Report. For waters identified on this list, states and tribes must develop a TMDL for the pollutants, set at a level to achieve water quality standards.

DEQ monitors waters, and for those not meeting water quality standards, DEQ must establish a TMDL for each pollutant impairing the waters. However, some conditions that impair water quality do not require TMDLs. EPA considers certain unnatural conditions—such as flow alteration, human-caused lack of flow, or habitat alteration—that are not the result of discharging

a specific pollutant as "pollution." TMDLs are not required for water bodies impaired by pollution, rather than a specific pollutant. A TMDL is only required when a pollutant can be identified and in some way quantified.

This report identifies the 2011 TMDL (DEQ 2011), considers the most current and applicable information in conformance with Idaho Code §39-3607, evaluates the appropriateness of the TMDL to current watershed conditions, evaluates the *Lolo Creek Watershed Total Maximum Daily Load Implementation Plan for Agriculture* (ISWCC 2011), and consults with the watershed advisory group (WAG). An evaluation of the recommendations presented is provided. Final decisions for TMDL modifications are decided by DEQ's director. Approval of TMDL modifications is decided by EPA with consultation by DEQ.

Water bodies are tracked and assessed by assessment unit (AU). AUs are groups of similar streams that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining AUs. Using AUs to describe water bodies offers many benefits; primarily, that all waters of the state are defined consistently. AUs are a subset of water body identification numbers, which allows them to relate directly to the water quality standards.

1 Watershed Characterization

Lolo Creek is a 6th-order tributary of the Clearwater River (hydrologic unit code 17060306), and forms the boundary between Idaho and Clearwater Counties in north-central Idaho. The creek flows primarily southwest, from an elevation of 5,240 feet, just below the summit of Hemlock Butte, to 1,118 feet at the mouth where it enters the Clearwater River at river mile 54, near the town of Greer. It drains a watershed of approximately 156,000 acres (244 square miles). A 24-mile stretch of Lolo Creek, from the mouth to the Nez Perce-Clearwater National Forest (CNF) boundary, flows through a steep, V-shaped canyon. The canyon is 1,500 feet deep in the lower portion and approximately half this depth at the Nez Perce-CNF boundary. Most of the canyon is dominated by conifer forest, cliffs, rock outcrops, and talus slopes. Riparian vegetation is primarily limited to the mouth and the upper half of the canyon. The watershed above the canyon is comprised of open meadows interspersed with gently sloping, mostly forested upland.

In the western portion of the watershed, major tributary drainages include Jim Brown Creek, which flows into Musselshell Creek; eastern portion tributary drainages include Yoosa and Eldorado Creeks; and the major tributaries of the southern portion are Yakus and Crocker Creeks.

The Lolo Creek watershed is a sparsely populated area with no incorporated cities. The dominant land uses are and were historically forestry, road building, grazing, placer mining, and recreational activities. Landownership varies throughout the watershed. The upper watershed is public land, managed by the Nez Perce-CNF. The middle portion of the watershed is comprised of state endowment land managed by the Idaho Department of Lands (IDL) and private land owned and managed by the PotlatchDeltic Corporation. Various parcels of privately owned, nonindustrial lands reside in the middle section of the watershed as well. The lower watershed is primarily managed by the United States Bureau of Land Management (BLM), while smaller

portions are owned by various private individuals (nonindustry). The lower 4 miles of Lolo Creek is located within the current boundary of the Nez Perce tribal reservation (Figure 1).

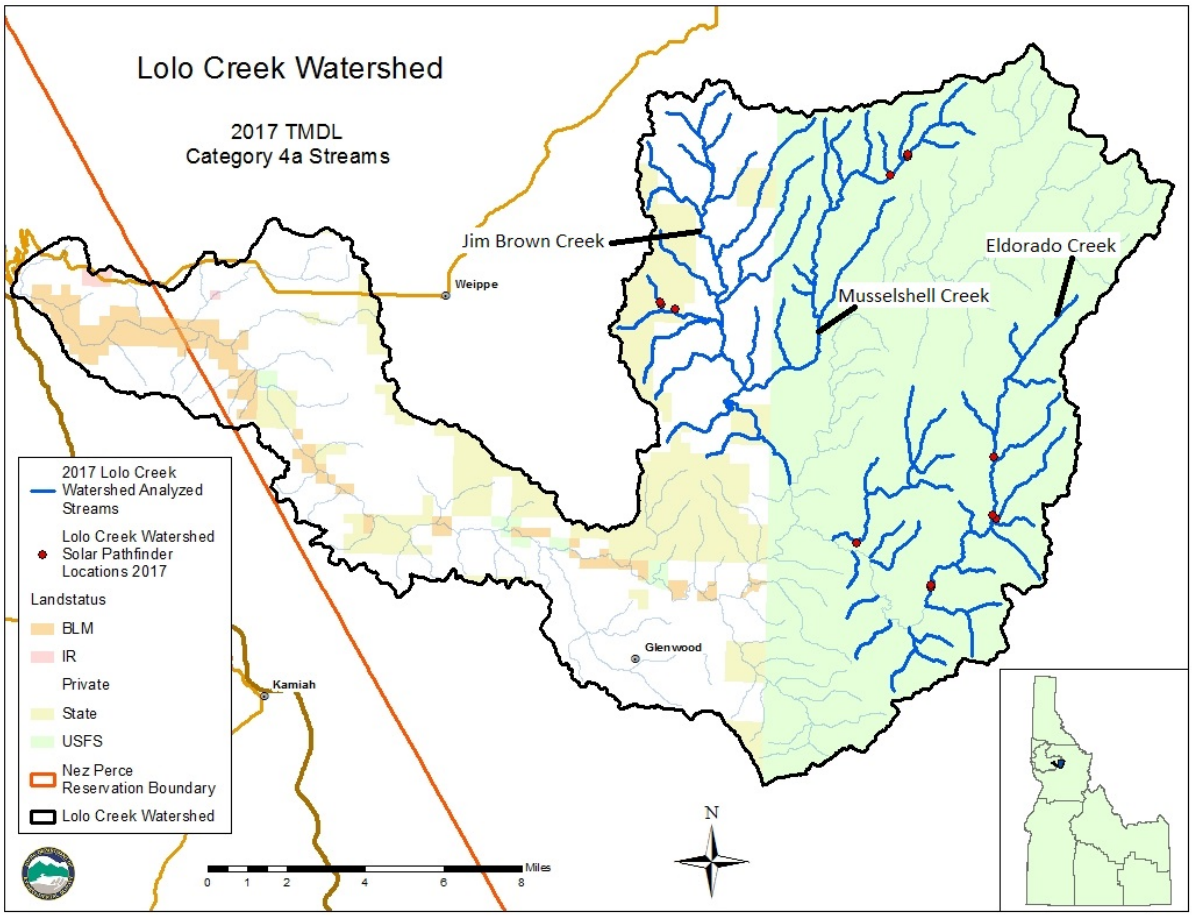


Figure 1. Lolo Creek watershed.

2 Water Quality Concerns and Status

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

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

This TMDL focuses only on those AUs contained within Category 4a of the 2016 Integrated Report (DEQ 2018). The 2011 TMDL focused on main-stem segments of the water bodies reanalyzed as part of this TMDL. The 2017 TMDL, compared to the 2011 TMDL, includes the additional analysis of all 1st- and 2nd-order stream segments for each AU in Category 4a but does not include an analysis of the 3rd-order segment of Eldorado Creek because this AU is not currently identified as having a temperature impairment. This TMDL further aligns with AU

designations within the Integrated Report and assists in establishing future assessment and analysis time frames. Using the 2011 TMDL data, the 2017 TMDL makes direct comparisons where possible and presents TMDLs based on AU designations rather than stream segments.

2.1.1 Assessment Units

AUs are groups of similar streams with similar land use practices, ownership, or land management. Stream order is the main basis for determining AUs—even if ownership and land use change significantly, the AU usually remains the same for the same stream order.

Using AUs to describe water bodies offers many benefits; primarily, that all waters of the state are defined consistently. AUs are a subset of water body identification numbers, which allows them to relate directly to the water quality standards.

2.1.2 Listed Waters

Table 1 shows AUs and pollutant in the Lolo Creek watershed with an approved TMDL (i.e., AUs in Category 4a of the most recent Integrated Report).

Table 1. Lolo Creek AU/pollutant with approved TMDL (2016 Integrated Report Category 4a [DEQ 2018]).

Assessment Unit Name	Assessment Unit Number	Pollutant with Approved TMDL
Eldorado Creek—1st and 2nd order	ID17060306CL029_02	Temperature
Jim Brown Creek—1st and 2nd order	ID17060306CL031_02	Temperature
Jim Brown Creek—3rd order	ID17060306CL031_03	Temperature
Musselshell Creek—1st and 2nd order	ID17060306CL032_02	Temperature
Musselshell Creek—3rd order	ID17060306CL032_03	Temperature

2.2 Applicable Water Quality Standards and Beneficial Uses

Idaho water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. 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 described briefly in Appendix A. The *Water Body Assessment Guidance* (DEQ 2016a) provides a more detailed description of beneficial use identification for use assessment purposes.

Beneficial uses include the following:

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

2.2.1 Beneficial Uses in the Subbasin

In the Lolo Creek watershed, no beneficial uses have been designated; existing uses are listed in Table 2.

Table 2. Lolo Creek watershed beneficial uses of §303(d)-listed streams.

Assessment Unit Name	Assessment Unit Number	Beneficial Uses[a]	Type of Use
Eldorado Creek	ID17060306CL029_02	COLD, SCR, SS	Presumed (SCR) Existing (COLD,SS)
Jim Brown Creek	ID17060306CL031_02	COLD, SCR, SS	Presumed (SCR) Existing (COLD,SS)
Jim Brown Creek	ID17060306CL031_03	COLD, SCR, SS	Presumed (SCR) Existing (COLD,SS)
Musselshell Creek	ID17060306CL032_02	COLD, SCR, SS	Presumed (SCR) Existing (COLD,SS)
Musselshell Creek	ID17060306CL032_03	COLD, SCR, SS	Presumed (SCR) Existing (COLD,SS)

a. Cold water aquatic life (COLD), secondary contact recreation (SCR), salmonid spawning (SS).

2.2.2 Water Quality Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of water quality criteria, which include *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity (Appendix B) and *narrative* criteria for pollutants such as sediment and nutrients (IDAPA 58.01.02.250–251). Temperature criteria supportive of the cold water aquatic life, including Bull Trout, and salmonid spawning beneficial uses are applicable in this watershed. For more about temperature criteria and natural background provisions relevant to the potential natural vegetation (PNV) approach, see Appendix B.

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.050.02. The procedure relies heavily upon biological parameters and is presented in detail in the *Water Body Assessment Guidance* (DEQ 2016a). This guidance requires DEQ to use the most complete data available to make beneficial use support status determinations.

2.3 Summary and Analysis of Existing Water Quality Data

Data collections in the Lolo Creek watershed since the 2011 TMDL have included periodic Beneficial Use Reconnaissance Program (BURP) assessment-level sampling and specific temperature sampling for TMDL purposes. Collected data include bankfull width measurements and estimations, Solar Pathfinder vegetation canopy cover, solar heat load tables, and land-type shade curve evaluation. Data sources for this section are provided in Appendix C.

2.3.1 Beneficial Use Reconnaissance Program Data

DEQ uses BURP-compatible data to calculate MMI scores of macroinvertebrate community - SMI2, and, fish community SFI2, and habitat integrity SHI2. The results of these indices are

assigned index ratings, and the combined index ratings are used to evaluate support of cold water aquatic life. DEQ may also use physicochemical data to identify numeric criteria exceedances of water quality standards and/or other available data to support or modify assessment interpretations.

The stream indices are a direct biological measure of cold water aquatic life. The details of index development and supporting analysis may be found in Jessup (2011). DEQ uses a scoring approach similar to methods recommended in the Rapid Bioassessment Protocols (Barbour et al. 1999) and similar to the scoring approach used in the previous edition of this guidance. Metric values are plugged into corresponding equations to produce individual metric scores. The average of the component metric scores is the individual index score. Each index is assigned an index rating based on comparison to reference condition. Then, for any given site, the index ratings are averaged. The average of index ratings for a given site is the site condition rating. The site condition rating is then used to determine support status, so that an average site condition rating ≥ 2 indicates full support of cold water aquatic life. Sites are only compared to the reference condition within their own respective site class.

Certain streams are difficult to assess for water quality trends over time using BURP data due to infrequent visits, as several streams have only been visited once or have yet to be visited since the outset of the program. Additionally, specific BURP sites are not repeated, so it is difficult to distinguish whether differing scores for the same AU are due to changing watershed conditions or site-specific attributes. Proper site selection that is characteristic of the AU is important in providing a representative assessment of water quality. Table 3 provides the BURP data for cold water aquatic beneficial use collected for the 2017 review using. Scores were calculated using either WBAG II or WBAG III methodology and indicated in the notes for Table 3.

Table 3. BURP data for the Lolo Creek subbasin

Assessment Unit Name	Assessment Unit Number	SMI	SFI	SHI	Average	Current Integrated Report Category
Eldorado Creek—1st-and 2nd-order tributaries	ID17060306CL029_02[a]	1	1	1	1.00	4a
Eva Creek	ID17060306CL029_02[b]	3	3	2	2.67	4a
Swede Creek	ID17060306CL031_02[a]	1	1	1	1.00	4a, 4c
Weaver Creek	ID17060306CL031_02[b]	1	1	1	1.00	4a, 4c
Slate Creek	ID17060306CL031_02[b]	1	1	1	1.00	4a, 4c
Jim Brown Creek	ID17060306CL031_03[b]	1	2	2	1.67	4a, 4c
Musselshell Creek—1st- and 2nd-order tributaries	ID17060306CL032_02[b]	3	2	2	2.33	4a
Gold Creek	ID17060306CL032_02[b]	1	2	1	1.33	4a
Musselshell Creek—3rd order tributary	ID17060306CL032_03[b]	2	2	2	2	4a

Notes: Stream fish index (SFI); stream habitat index (SHI); stream macroinvertebrate index (SMI); [a] calculated using WBAGII; [b] calculated using WBAGIII

2.3.2 Potential Natural Vegetation Temperature Analysis

EPA-approved temperature TMDLs (DEQ 2011) analyzed shade using PNV on three main-stem segments of water bodies in the Lolo Creek watershed: Eldorado, Jim Brown, and Musselshell Creeks. DEQ determined that all streams in the TMDL analysis lacked shade to some degree and required reductions in excess heat from solar load.

For this TMDL analysis, DEQ performed additional field verification of shade for AUs included in the 2011 Lolo Creek TMDL, and currently in Category 4a, within the Lolo Creek watershed to add to existing knowledge about shade levels on the streams and to determine if shade levels have been improving. Twelve sites were visited in 2017 where shade was measured with a Solar Pathfinder following protocols described in the PNV manual (Shumar and de Varona 2009) and the 2011 TMDL. The accuracy of shade values based on the aerial photo interpretation was verified with the measurements of shade at the 12 Solar Pathfinder locations. The results of the Solar Pathfinder measurements were used to adjust shade estimates by reexamining the original aerial interpretations. Existing shade values for the AUs analyzed as part of this TMDL are presented in Appendix D.

2.3.3 Status of Beneficial Uses

No changes to the beneficial uses were found within the watershed. PNV temperature analysis of analogous stream segments shows that excess solar load has been reduced in most AUs with temperature TMDLs. Stream temperature improvements will be more difficult to discern until more ambient water temperature data are collected over a longer time period.

2.3.4 Assessment Unit Summary

A summary of the data analysis, literature review, and field investigations and a list of conclusions for AUs included in Category 4a and 4c of the 2016 Integrated Report (DEQ 2018) follows. No changes for the AUs included in this TMDL are recommended in the next Integrated Report.

2.3.4.1 Assessment Units Addressed in TMDLs

ID17060306CL029_02, **Eldorado Creek—1st- and 2nd-Order Tributaries**

- Listed for water temperature.
- 2017 PNV analysis indicates riparian shade conditions are not met.

ID17060306CL031_02, **Jim Brown Creek—1st- and 2nd-Order Tributaries**

- Listed for water temperature.
- 2017 PNV analysis indicates riparian shade conditions are not met.

ID17060306CL031_03, **Jim Brown Creek—3rd Order**

- Listed for water temperature.
- 2017 PNV analysis indicates riparian shade conditions are not met.

ID17060306CL032_02, **Musselshell Creek—1st- and 2nd-Order Tributaries**

- Listed for water temperature.

- 2017 PNV analysis indicates riparian shade conditions are not met.

ID17060306CL032_03, **Musselshell Creek—3rd Order**

- Listed for water temperature.
- 2017 PNV analysis indicates riparian shade conditions are not met.

3 Pollutant Source Inventory

Pollution within the Lolo Creek watershed is primarily from temperature. Load allocations were established in the *Lolo Creek Tributaries Subbasin Assessment and Total Maximum Daily Load* approved by EPA in 2011 (DEQ 2011).

3.1 Point Sources

No known point sources discharge directly to the Lolo Creek watershed tributaries addressed in this report. Suction dredge operators who wish to mine these streams must apply for and receive an EPA permit that requires specific management practices designed to lessen impacts to the stream and riparian area. Permit provisions for endangered anadromous salmonid species and Bull Trout critical habitat waters should restrict suction dredging in the Lolo Creek watershed. Restrictions to suction dredging in the Lolo Creek watershed are related to limiting excess stream sedimentation and to limiting operations during fish spawning time periods. Only Lolo Creek from Eldorado Creek to Dutchman Creek, including Dutchman Creek itself, is open for permitted recreational suction dredging (IDWR 2018). No waste load allocations are given for suction dredge operations. These operations are not expected to disturb riparian vegetation and use water from within the channel so no significant additions of heat to the system would be made.

3.2 Nonpoint Sources

Nonpoint sources of pollution in the Lolo Creek watershed include timber harvest activities, roads, grazing, agriculture, mining, recreational off-road vehicle use, and septic tanks. Timber harvest on CNF lands has been reduced, and road maintenance and obliteration have helped control sediment transport. The PotlatchDeltic Corporation and IDL continue to extract timber from their lands in the subbasin, using best management practices (BMPs) prescribed by Forest Practices Act guidelines. Grazing continues on CNF, BLM, IDL, and PotlatchDeltic Corporation lands, as well as on private lands. Implementation projects like riparian fencing and off-site watering of cattle have improved streambanks and habitat on Jim Brown and Musselshell Creeks.

Because this TMDL is based on PNV-style riparian shade calculations, which are equivalent to background load, the load allocation is essentially the desire to achieve background conditions. To reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Load allocations are stream segment specific and depend on the target load for a given segment. This target load (i.e., load capacity) is necessary to achieve background conditions. No opportunity exists to further remove

shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL depends on background conditions for achieving water quality standards, all tributaries to the waters examined must reflect natural conditions to prevent excess heat loads to the system.

3.3 Pollutant Transport

Pollutant transport refers to the pathway by which pollutants move from the pollutant source to cause a problem or water quality violation in the receiving water body. For temperature, most pollutant transport is in the form of solar radiation directly to the stream as a result of exposure. DEQ estimates PNV (i.e., target shade) from models of plant community structure (shade curves for specific riparian plant communities) and measures or estimates existing canopy cover or shade. Comparing target and existing shade determines how much excess solar load the stream is receiving and what potential exists to decrease solar gain. Streams disturbed by wildfire, flood, or some other natural disturbance will be at less than PNV and require time to recover. Streams disturbed by human activity may require additional restoration above and beyond natural recovery.

4 Summary of Past and Present Pollution Control Efforts, Monitoring and Implementation

Table 4 provides the activities, structures, and management strategies within the TMDL implementation plan, including BMPs appropriate for reducing agricultural impacts to water quality in the Lolo Creek watershed. Not all of these projects address the temperature impairment directly but do address other sources of pollutants and are expected to improve water quality overall (E. Rowan, Idaho Soil and Water Conservation Commission, correspondence with DEQ, 2017). The implementation plan only recommended BMP actions for private lands primarily within the Jim Brown Creek drainage and in some lower segments of Musselshell Creek (ISWCC 2011). Planned restoration activities for forested or other public lands may include many of the same activities as those presented here and would have similar benefits to stream condition.

Table 4. Completed BMPs for the Lolo Creek watershed.

Water Body or Location	Activity or Strategy	Schedule	Completion Status
Lolo Creek watershed	Channel stabilization	1995 / 1997	Completed
	Road stabilization	2016 / 2017	Completed
	Fencing	1992 / 1997 / 1999	Completed
	Heavy use protection	1992 / 1999	Completed
	Prescribed grazing	1992 / 1999	Completed
	Riparian forest buffer	2018	Completed
	Streambank protection	1995 / 1997	Completed
	Pipeline	1992 / 1999	Completed
	Watering facility	1992 - 1999	Completed

The TMDL implementation plan indicates annual status reviews should be done to assess stated time frames and BMPs installed according to standards and specifications. The implementation plan states that BMP effectiveness monitoring should be conducted on completed installations to ensure the installation was adequate, is consistently operated with the correct maintenance schedules, and the BMPs are relatively effective in reducing water quality impacts.

The Idaho Soil and Water Conservation Commission provided the following BMP accomplishments in support of this TMDL:

- Carrot Ridge Road improvements and culvert replacements on 3 miles of road.
- Lolo Cutoff Road improvements and culvert replacements on 3 miles of road.
- Approximately 400 feet of roadside hill stabilization was completed.

The Nez Perce Tribe completed several projects to enhance water quality and riparian conditions within the watershed. Projects considered or completed by the tribe related to the listed streams assessed in this TMDL include fence maintenance, road realignment, floodplain connectivity, and invasive weed management.

4.1 Water Quality Monitoring and Implementation

Effectiveness monitoring programs for implementing BMPs and other restoration projects will be key for the adaptive management strategies employed as part of the implementation plan and projects administered by the Nez Perce Tribe and other federal and state agencies. DEQ will monitor water quality through their stream monitoring program to collect and measure important stream ecology variables that aid in determining beneficial use support status. In addition to monitoring on-going and past projects, new projects within the watershed may expand the installation of BMPs to new streams and may include activities such as instream habitat features, culvert replacement, fence line maintenance, floodplain connectivity, and riparian and upland plantings.

DEQ plans to collect instream numeric temperature data for future assessments and TMDL 5-year reviews. The Nez Perce Tribe Water Resources program plans to collect instream numeric temperature data for upcoming Lolo Creek assessments (A. Helfrick, Nez Perce Tribe, communication to Lolo Creek WAG, July 12, 2018).

Implementing activities within this TMDL relies on riparian area management practices that will provide a mature canopy cover to shade the stream and prevent excess solar loads. Because implementation depends on mature riparian communities to substantially improve stream temperatures, DEQ believes 10–20 years may be a reasonable amount of time for achieving water quality standards. Shade targets will not be achieved all at once. Given their smaller bankfull widths, targets for smaller streams may be reached sooner than those for larger streams.

DEQ and the designated WAG will continue to reevaluate TMDLs on a 5-year cycle. During the 5-year review, implementation actions completed, in progress, and planned will be reviewed, and pollutant load allocations will be reassessed accordingly.

The federal, state, and local governments; individuals; or entities involved in or responsible for implementing the TMDL are presented below.

4.2 Federal and Tribal Efforts

4.1.1 Bureau of Land Management

BLM considers the lands they manage in the lower Lolo Creek watershed a high-priority restoration watershed. BLM applies management strategies aimed at protection, active and passive restoration, and rehabilitation of aquatic and riparian ecological functions. Recent activities focused on road closures and securing conservation easements along the lower 8 miles of Lolo Creek.

4.1.2 Clearwater Focus Group

The Clearwater Group coordinates staff and funding resources for projects to enhance and restore fish and wildlife habitats in the Clearwater River Basin. The Office of Species Conservation and the Nez Perce Tribal Watershed Division co-coordinate the program on behalf of the State of Idaho and Nez Perce Tribe.

Projects have been conducted on private, state, federal, and tribal lands, and partnerships have been developed for all projects in the Clearwater Basin. In addition to the Idaho Soil and Water Conservation Commission and the tribe, frequent project partners include the United States Forest Service, Natural Resources Conservation Service, soil and water conservation districts, private landowners, Idaho Department of Fish and Game, and BLM. Projects have focused on riparian fencing, plantings, road obliterations, revegetation, grassed waterways, culvert replacement, and agricultural ponds.

4.1.3 Natural Resources Conservation Service

The Natural Resources Conservation Service provides technical assistance to the Clearwater Soil and Water Conservation District and its landowners and administers cost-sharing programs on private lands. These programs are largely voluntary on the part of private landowners, and include the following:

- Environmental Quality Incentive Program
- Wildlife Habitat Incentive Program
- Wetland Reserve Program

- Conservation Reserve Program
- Continuous Conservation Reserve Program

4.1.4 United States Forest Service, Nez Perce Clearwater National Forest

The Nez Perce-CNF manages its lands within the watershed using guidelines and policies specified in the Nez Perce-CNF Plan. The plan uses strategies designed to protect habitats and populations of fish. The plan contains a monitoring requirement designed to ensure Idaho's water quality standards are met on the forest. On-site monitoring will be conducted to establish a baseline, guide implementation, and track the effectiveness compliance of BMPs. Instream monitoring will be conducted to address the effect of land disturbance activities on water quality and fish habitat.

The Nez Perce-CNF, along with the Nez Perce Tribe, an integral partner in the funding and implementation of various projects, has implemented projects to improve watershed conditions. Today, the focus of the watershed restoration efforts involves two main components: road decommissioning projects and aquatic passage improvement projects. Meadow restoration projects are currently scheduled to occur in the Musselshell Creek subwatershed.

4.1.5 United States Fish and Wildlife Service

The United States Fish and Wildlife Service administers two grant programs: Partners for Wildlife Program and Private Stewardship Grant Program. The Partners for Wildlife Program provides cost-share opportunities for projects aimed at enhancing fish and wildlife habitat, with an emphasis on the restoration of riparian areas, wetlands, and native plant communities. The Private Stewardship Grant Program provides grants and assistance to groups engaged in private, voluntary conservation efforts targeted at benefitting endangered/threatened species.

4.1.6 Nez Perce Tribe

The Nez Perce Tribe is responsible for protecting, enhancing, and restoring tribal resources. The tribe developed the Watershed Assessment and Watershed Restoration Priorities plan, which identifies watersheds containing tribal fee and trust lands and tribal usual and accustomed fishing places. The plan prioritizes restoration projects. The Tribe Water Resources Division implements restoration work in watersheds within the reservation after completing TMDLs developed under a triparty agreement with the tribe, EPA, and DEQ. In addition, the 1996 Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes updated 2014 (CRIFC 2014)., sets adult anadromous return targets for each watershed in the Columbia Basin and recommends restoration activities and fish release and production programs.

The Nez Perce Tribe Department of Fisheries Resource Management, Watershed Division has led a cooperative effort to enhance fish habitat, reduce sediment delivery, and protect riparian areas from excessive grazing. The tribe has partnered with the Nez Perce-CNF on national forest lands and with PotlatchDeltic on their privately owned lands.

4.3 State Agency Efforts

4.1.7 Idaho Department of Fish and Game

The Idaho Department of Fish and Game works to preserve, protect, perpetuate, and manage all wildlife. The agency has created several management plans and policies relevant to fish and wildlife and their habitat in the Clearwater River subbasin. The staff works with landowners who volunteer to improve habitat through incentive programs.

4.1.8 Idaho Soil and Water Conservation Commission

The Idaho Soil and Water Conservation Commission provides technical and administrative support to the 51 conservation districts in Idaho. The commission provides funding with grants and loans through the Resource Conservation and Rangeland Development Program and financial incentives through the Water Quality Program for Agriculture. The programs are intended to improve rangeland and riparian areas and contribute to water quality protection and enhancement. The commission also administers the Idaho Agricultural Pollution Abatement Plan, which is the implementing action for all nonpoint source agricultural sector activities in the state.

4.1.9 Idaho Department of Lands

The Idaho Department of Lands administers the following laws and acts: Idaho Forestry Act Fire Hazard Reduction programs, Idaho Forestry Practices Act, Idaho Lake Protection Act, surface mining laws, placer mining laws, and navigable waters provisions. The IDL also administers the state's Stewardship Program, which provides cost-share dollars to perform forestry practices and assists private landowners in developing timber management plans with site-specific BMPs designed to protect riparian areas and water quality.

4.1.10 Idaho Department of Water Resources

The Idaho Department of Water Resources enforces the Stream Channel Protection Act, requiring permits for in-channel work or developments, including suction dredging activities, and manages Idaho's water rights program, reserving the authority to establish minimum stream flows to protect a variety of instream uses.

4.1.11 University of Idaho

Faculty and students from the University of Idaho's College of Agricultural and Life Sciences, College of Natural Resources, and College of Science have been directly involved in activities related to fish, wildlife, and water quality issues. The Cooperative Extension Service provides assistance in public outreach and education.

4.4 Local and Community Efforts

4.1.12 Clearwater Soil and Water Conservation District

The Clearwater Soil and Water Conservation District provides guidance and assistance to citizens with land use and natural resource needs. The Resource Conservation Plan facilitates sustainable management of natural resources by outlining procedures and methods, prioritizing current needs, and identifying expectations. The district's goal is to ensure that the land, water, and wildlife resources under its care will remain viable and sustainable in the future.

The district's staff successfully recruited private landowner cooperation to install BMPs such as riparian fencing, armored stream access ramps, and woody vegetation plantings along degraded stream segments of Jim Brown Creek. BMP effectiveness monitoring undertaken by the district indicated improvements in habitat and bank and channel stability where BMPs were installed.

4.1.13 Highway Districts

Both the Clearwater and Idaho County Highway Districts administer BMPs to control erosion and sediment transport from county road construction projects.

4.1.14 PotlatchDeltic Corporation

PotlatchDeltic Corporation uses comprehensive methods to control sediment transport from their harvesting, planting, and road building activities in the Lolo Creek subbasin. The corporation follows Idaho Forest Practices Act guidelines for BMPs and uses their own refined procedures to ensure their impact on water quality is minimal and their forests remain sustainable.

5 Total Maximum Daily Loads

A TMDL prescribes an upper limit (i.e., load capacity) on discharge of a pollutant from all sources to ensure water quality standards are met. It further allocates this load capacity among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation, and nonpoint sources, each of which receives a load allocation. Natural background contributions, when present, are considered part of the load allocation but are often treated separately because they represent a part of the load not subject to control. Because of uncertainties about quantifying loads and the relation of specific loads to attaining water quality standards, the rules regarding TMDLs (40 CFR 130) require a margin of safety (MOS) be included in the TMDL. Practically, the MOS and natural background are both reductions in the load capacity available for allocation to pollutant sources.

Load capacity can be summarized by the following equation:

$$LC = MOS + NB + LA + WLA = TMDL$$

Where:

LC = load capacity
MOS = margin of safety
NB = natural background

LA = load allocation
WLA = wasteload allocation

The equation is written in this order because it represents the logical order in which a load analysis is conducted. First, the load capacity is determined. Then the load capacity is broken down into its components. After the necessary MOS and natural background, if relevant, are quantified, the remainder is allocated among pollutant sources (i.e., the load allocation and wasteload allocation). When the breakdown and allocation are complete, the result is a TMDL, which must equal the load capacity.

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, determining critical conditions can be more complicated than it may initially appear.

Another step in a load analysis is quantifying current pollutant loads by source. This step allows for the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary for pollutant trading to occur. A load is fundamentally a quantity of 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 (40 CFR 130.2). These other measures must still be quantifiable and relate to water quality standards, but they allow flexibility to deal with pollutant load 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 Instream Water Quality Targets

For the Lolo Creek temperature TMDLs, we used a PNV approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and for temperature TMDLs, the natural level of shade and channel width become the TMDL target. The instream temperature that results from attaining these conditions is consistent with the water quality standards, even if it exceeds numeric temperature criteria. Appendix B provides further discussion of water quality standards and natural background provisions.

The PNV approach is described briefly below. The procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in detail in *The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar and de Varona 2009). The manual also provides a more complete discussion of shade and its effects on stream water temperature.

5.1.1 Factors Controlling Water Temperature in Streams

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 controllable. The parameters that affect 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 (i.e., structure) affects riparian vegetation density and water storage in the alluvial aquifer. Riparian vegetation and channel morphology are the factors influencing shade that are most likely to have been influenced by anthropogenic activities and can be most readily corrected and addressed by a TMDL.

Riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. However, depending on how much vertical elevation surrounds the stream, vegetation further away from the riparian corridor can also provide shade. The amount of shade a stream receives can be measured in a number of ways. Effective shade (i.e., shade provided by all objects that intercept the sun as it makes its way across the sky) can be measured in a given location with a Solar Pathfinder or with other 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 stream 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 using aerial photography. All of these methods provide information about how much of the stream is covered and how much is exposed to direct solar radiation.

5.1.2 Potential Natural Vegetation for Temperature TMDLs

PNV along a stream is that riparian plant community that could grow to an overall mature state, although some level of natural disturbance is usually included in the development and use of shade targets. Vegetation can be removed by disturbance either naturally (e.g., wildfire, disease/old age, wind damage, and wildlife grazing) or anthropogenically (e.g., domestic livestock grazing, vegetation removal, and erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar load to the stream without any anthropogenic removal of shade-producing vegetation. Vegetation levels less than PNV (except for natural levels of disturbance and age distribution) result in the stream heating up from anthropogenically created additional solar inputs.

We can estimate PNV (and target shade) from models of plant community structure (shade curves for specific riparian plant communities), and we can measure or estimate existing canopy cover or shade. Comparing the two (target and existing shade) tells us how much excess solar load the stream is receiving and what potential exists to decrease solar gain. Streams disturbed by wildfire, flood, or some other natural disturbance will be at less than PNV and require time to recover. Streams that have been disturbed by human activity may require additional restoration above and beyond natural recovery.

Existing and PNV shade was converted to solar loads from data collected on flat-plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather stations collecting these data. In this case, we used the Missoula, Montana station. The difference between existing and target solar loads, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (Appendix B).

PNV shade and the associated solar loads are assumed to be the natural condition; thus, stream temperatures under PNV conditions are assumed to be natural (as long as no point sources or other anthropogenic sources of heat exist in the watershed) and are considered to be consistent with the Idaho water quality standards, even if they exceed numeric criteria by more than 0.3 °C (IDAPA 58.01.02 061. – 069. 07).

5.1.2.1 Existing Shade Estimates

Existing shade was estimated for five AUs and to include analysis of tributary streams within the associated AUs from visual interpretation of aerial photos. Estimates of existing shade based on plant type and density were marked out as stream segments on a 1:100,000 or 1:250,000 hydrography, taking into account natural breaks in vegetation density. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. Each segment was assigned a single value representing the bottom of a 10% shade class (adapted from the cumulative watershed effects process, IDL 2000). For example, if shade for a particular stream segment was estimated somewhere between 50% and 59%, we assigned a 50% shade class to that segment. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and stream width. Streams where the banks and water are clearly visible are usually in low shade classes (10%, 20%, or 30%). Streams with dense forest or heavy brush where no portion of the stream is visible are usually in high shade classes (70%, 80%, or 90%). More open canopies where portions of the stream may be visible usually fall into moderate shade classes (40%, 50%, or 60%).

Visual estimates made from aerial photos are strongly influenced by canopy cover and do not always account for topography or any shading that may occur from physical features other than vegetation. It is not always possible to visualize or anticipate shade characteristics resulting from topography and landform. However, research has shown that shade and canopy cover measurements are remarkably similar (OWEB 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade. The visual estimates of shade in this TMDL were partially field verified with a Solar Pathfinder, which measures effective shade and considers other physical features that block the sun from hitting the stream surface (e.g., hillsides, canyon walls, terraces, and man-made structures).

Solar Pathfinder Field Verification

The accuracy of the aerial photo interpretations was field verified with a Solar Pathfinder at 12 sites (Table 5). The Solar Pathfinder traces 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 location where the tracing is made. To adequately characterize the effective shade on a stream segment, 20 traces are taken at systematic or random intervals along the length of the stream in question.

At each sampling location, the Solar Pathfinder was placed in the middle of the stream at about the bankfull water level. Twenty traces were taken following the manufacturer's instructions (i.e., orient to south and level). Systematic sampling was used because it is easiest to accomplish without biasing the sampling location. For each sampled segment, the sampler started at a unique location, such as 25 to 50 meters from a bridge or fence line, and proceeded upstream or downstream taking additional traces at fixed intervals (e.g., every 25 meters, 25 paces, etc.). Alternatively, one can randomly locate points of measurement by generating random numbers to be used as interval distances.

When possible, the sampler also measured bankfull widths, took notes, and photographed the landscape of the stream at several unique locations while taking traces. Special attention was given to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade-producing ones) were present. One can also take densiometer readings at the same location as Solar Pathfinder traces. These readings provide the potential to develop relationships between canopy cover and effective shade for a given stream.

Table 5. Solar Pathfinder results within Lolo Creek subbasin.

Assessment Unit Name	Solar Pathfinder Location	Aerial Classification	Solar Pathfinder Measurement	Solar Pathfinder Shade Classification	Classification Difference[a]
Cedar Creek	CedCre_01	60	67	60	0
Dollar Creek	DolCre_01	30	60	60	-3
Eldorado Creek	EldCre_01	60	74	70	-1
Eldorado Creek	EldCre_02	50	75	70	-2
Eldorado Creek	EldCre_03	40	47	40	0
Eldorado Creek	EldCre_04	10	54	50	-4
Mosquito Creek	MosCre_01	20	15	10	1
Mosquito Creek Tributary	MosTri_01	50	54	50	0
Mosquito Creek Tributary	MosTri_02	30	28	20	1
Musselshell Creek	MusCre_01	70	85	80	-1
Musselshell Creek	MusCre_02	80	80	80	0
Musselshell Creek	MusCre_03	90	90	90	0

a. Mean: -0.75; Standard Deviation: 1.54; Confidence Interval (95%): 0.98

5.1.2.2 Target Shade Determination

PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in Idaho (Shumar and de Varona 2009). A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, shade decreases as 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.

Natural Bankfull Widths

Stream width must be known to calculate target shade since the width of a stream affects the amount of shade the stream receives. Bankfull width is used because it best approximates the width between the points on either side of the stream where riparian vegetation starts. Measures of current bankfull width may not reflect widths present under PNV (i.e., natural widths). As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase so streams become wider and shallower. Shade produced by vegetation covers a lower percentage of the water surface in wider streams, and widened streams can also have less vegetative cover if shoreline vegetation has eroded away.

For each stream evaluated in the load analysis existing bankfull width may not be discernible from aerial photo interpretation and may not reflect natural bankfull widths, this parameter must be estimated from available information. We used regional curves for the major basins in Idaho—developed from data compiled by Diane Hopster of the Idaho Department of Lands—to estimate natural bankfull width Figure 2. Existing widths and natural widths are the same in load tables when no data exist to support making them different. Measured stream width values collected as part of DEQ's BURP were evaluated to determine the relative accuracy of the Clearwater Basin regression. As no BURP values are obvious outliers, the calculated stream bankfull widths from the regression were used for solar heat load values. A full accounting of bankfull widths used in the solar heat load analysis is presented in Table 6.

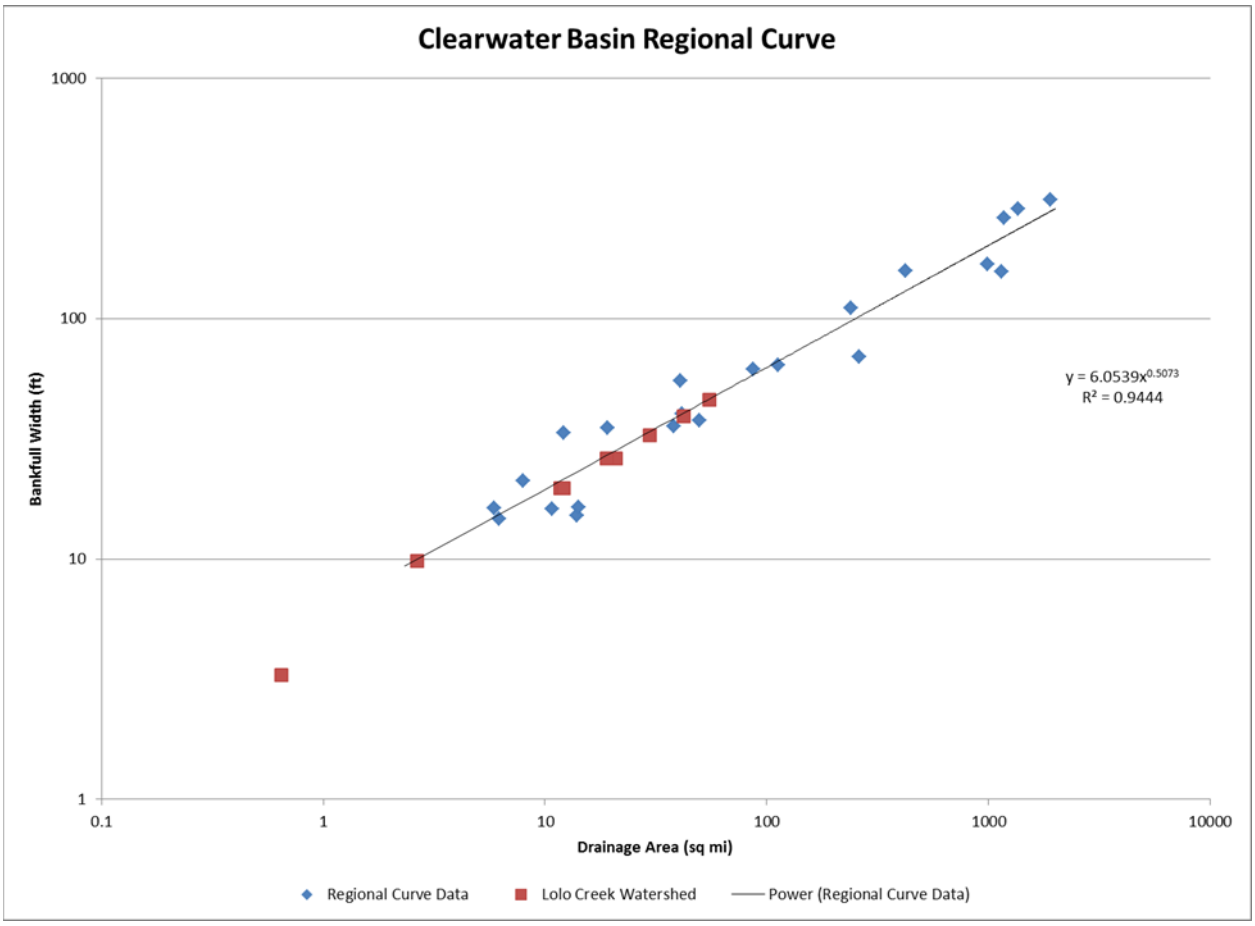


Figure 2. Bankfull width as a function of drainage area for the Clearwater Basin.

Table 6. Estimated stream bankfull widths as related to drainage area.

Stream	StreamStats Drainage Area (square mile)	Clearwater Basin Regional Curve Estimate (meter)	BURP Measurements (meter)
Eldorado Creek AU (ID17060306CL029_02)			
April Creek	0.7	1.5	—
Austin Creek	1.1	1.8	—
Brick Creek	0.8	1.6	—
Cedar Creek	8.5	5.2	—
Dollar Creek at NF Road 500	0.7	1.4	2.0
Dollar Creek	2.7	2.9	—
Dora Creek	0.7	1.4	—
Eldorado Creek	42.4	12.1	—
Eldorado Creek at Dollar Creek	11.7	6.2	9.5
Eva Creek	1.0	1.8	—
Fan Creek	2.8	2.9	—
Four-bit Creek	1.8	2.3	—
Lunch Creek	1.0	1.7	—
May Creek	1.1	1.8	—
Opal Creek	0.2	0.8	—
Panther Creek	0.7	1.4	—
Six-bit Creek	1.7	2.3	—
Trout Creek	2.3	2.6	—
Two-bit Creek	0.6	1.4	—
Wapiti Creek	0.9	1.6	—
Jim Brown Creek AU (ID17060306CL031_02 and ID17060306CL031_03)			
Bat Creek	5.1	4.0	—
Blonde Creek	2.1	2.5	—
Burnt Creek	1.8	2.4	—
Burcham Creek	2.6	2.8	—
Dan Lee Creek	2.0	2.4	—
Jim Brown Creek at Burcham Creek	6.7	4.6	—
Jim Brown Creek at Mosquito Creek	20.8	8.3	—
Jim Brown Creek	29.6	10.0	8.9
Lost Creek	0.4	1.1	—
Mosquito Creek	2.9	3.0	—
Pierson Creek	1.5	2.1	—
Slate Creek	0.8	1.6	—
Sourdough Creek	0.9	1.6	—
Swede Creek	4.3	3.7	—
Weaver Creek	3.5	3.3	—
Musselshell Creek AU (ID17060306CL032_02 and ID17060306CLCL032_03)			
Alder Creek	0.9	1.6	—
Cole Creek	1.5	2.1	—
Deer Creek	1.4	2.0	—

Stream	StreamStats Drainage Area (square mile)	Clearwater Basin Regional Curve Estimate (meter)	BURP Measurements (meter)
Dewey Creek	0.7	1.5	—
Gold Creek	3.0	3.0	—
Greer Gulch	0.8	1.6	—
Johnson Draw	0.3	0.9	—
Musselshell Creek at Gold Creek	12.1	6.3	8.0
Musselshell Creek at Jim Brown Creek	19.0	7.9	7.4
Musselshell Creek	55.2	13.8	16.6
Nelson Creek	0.43	1.1	—
Winter Draw	0.19	0.7	—

5.1.3 Design Conditions

The percent shade targets used in this analysis were developed by applying the appropriate shade curve based on land type. This TMDL used the same shade curves as the 2011 TMDL. A comparison of percent shade targets between stream segments analyzed for the 2011 TMDL and matching stream segments from 2017 TMDL sampling was completed to the extent practical. Some stream segments analyzed in 2011 did not match AU boundaries or did not include all tributary streams within the AU. Due to the differences in AU boundaries and additional assessments of the tributaries the percent shade target vary between the 2011 TMDL and the current TMDL.

The 2011 temperature TMDL was based on average summer loads. All loads in both analyses were calculated to be inclusive of the 6-month period from April through September. This time period was chosen because it represented when the combination of increasing air and water temperatures coincides with increasing solar inputs and increasing vegetative shade. The critical time period begins in April when spring salmonid spawning occurs, the second half of July when maximum temperatures typically exceed cold water aquatic life criteria, and then through the fall and winter when salmonid species known to occur in the watershed are spawning. Water temperatures are not likely to be a problem for beneficial uses outside of these time periods due to cooler weather and a lower sun angle.

Data from the 2017 analysis were modified and compared to the 2011 data to determine stream shade-level trends. Shade targets and percent shade deficits presented in the 2011 TMDL and 2017 TMDL provide sufficient information to make broad comparisons to assess the TMDL. The 2011 TMDL contains a full description of the forest types and nonforest land-type associations used to determine existing and targeted shade values. These associations have been related to stream width to create shade curves (Table 6). The shade curves consider the effect of stream-side vegetation density, height, and relative position within the riparian corridor and detail what an expected shade value would be at a defined stream width.

The 2011 TMDL identifies three broad groups of forest type based on their land type associations classification system: breaklands, uplands, and subalpine. The 2017 analysis identified the Lolo Creek watershed in the same general groups with more specific forest types:

1. Breakland—forests on steep slopes at lower elevations, with warmer temperature regimes
2. Upland Alder Mix—riparian areas in the upper watershed containing thinleaf alder, ninebark, red osier dogwood, and Rocky Mountain maple.
3. Upland—forests generally above the breaklands in elevation and with more rolling topography; cooler and more mesic than breaklands

Since this original classification was developed, DEQ defined uplands with more specific riparian plant types identified to more closely describe the forest habitat of the region (Nez Perce-CNF)

5.1.4 Shade Curve Selection

To determine PNV shade targets for Lolo Creek, effective shade curves from Clearwater Basin region (i.e., breakland, upland alder mix, and upland) were examined (Shumar and de Varona 2009). These curves were produced using vegetation community modeling of Idaho plant communities. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. For Lolo Creek, curves for the most similar vegetation type were selected for shade target determinations.

First, an overlay of CNF land types grouped as breakland, upland alder mix, and upland was placed over the stream being examined. The upper portions of Jim Brown and Eldorado Creeks were predominantly in the upland and upland alder mix types with occasional sections of stream in the breakland type, possibly due to change of geology and steepness resulting in shallow soils and lack of vegetation. As streams progress downstream, they leave the forest groups and enter a region where other nonforest land types occur. Visual observations of these regions reveal that stream valleys were widening, alder communities tended to dominate the streamside vegetation, and the forest was further away from the stream.

5.2 Load Capacity

The load capacity for a stream under PNV is essentially the solar load allowed under the shade targets specified for the segments within that stream. These loads are determined by multiplying the solar load measured by a flat-plate collector (under full sun) for a given period of time by the fraction of the solar radiation that is not blocked by shade (i.e., the percent open or 100% minus percent shade). In other words, if a shade target is 60% (or 0.6), the solar load hitting the stream under that target is 40% of the load hitting the flat-plate collector under full sun.

We obtained solar load data from flat-plate collectors at the NREL weather station in Missoula, Montana. The solar load data used in this TMDL analysis are spring/summer averages (i.e., an average load for the 6-month period from April through September). The load capacity calculations are also based on this 6-month period, which coincides with the time of year when stream temperatures are increasing, deciduous vegetation is in leaf, and fall spawning is occurring. During this period, temperatures may affect beneficial uses such as spring and fall salmonid spawning, and cold water aquatic life criteria may be exceeded during summer months. Late July and early August typically represent the period of highest stream temperatures.

However, solar gains can begin early in the spring and affect not only the highest temperatures reached later in the summer but also salmonid spawning temperatures in spring and fall.

Appendix D (Tables D1–D5 and Figure D1) provides the PNV shade targets. The tables show corresponding target summer loads (in kilowatt-hours per square meter per day [kWh/m^2/day] and kWh/day) that serve as the load capacities for the streams. Existing and target loads in kWh/day can be summed for the entire stream or portion of stream examined in a single load analysis table. These total loads are shown at the bottom of their respective columns in each table. Because load calculations involve stream segment area calculations, the segments channel width which typically only has one or two significant figures dictates the level of significance of the corresponding loads. One significant figure in the resulting load can create rounding errors when existing and target loads are subtracted. The totals row of each load table represents total loads with two significant figures in an attempt to reduce apparent rounding errors.

The AU with the largest target load (i.e., load capacity) was Eldorado Creek (ID17060306CL029_02) with 350,000 kWh/day (Table D1). The smallest target load was in the Jim Brown Creek AU (ID17060306CL031_02) with 110,000 kWh/day (Table D2).

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" (40 CFR 130.2(g)).

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. Currently, no permitted point sources exist in the affected AUs. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat-plate collector at the NREL weather station. Existing shade data are presented in Appendix D. Like load capacities (target loads), existing loads in the tables are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day). Existing loads in kWh/day are also summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target and existing load is also summed for the entire table. If existing load exceeds target load, this difference becomes the excess load (i.e., lack of shade) discussed section 5.4 and depicted in the lack-of-shade figures in Appendix D (Figure D3).

The AU with the largest existing load was Eldorado Creek (ID17060306CL029_02) with 490,000 kWh/day (Table D2). The smallest existing load was in the Musselshell Creek AU (ID17060306CL032_03) with 280,000 kWh/day (Table D5).

5.4 Load and Wasteload Allocation

No permitted point sources discharge into the affected AUs, so no wasteload allocations are apportioned in this TMDL.

Because this TMDL is based on PNV, which is equivalent to background load, the load allocation is essentially the desire to achieve background conditions. To reach that objective,

load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Load allocations are stream segment specific and depend upon the target load for a given segment. The tables in Appendix D show the total existing, target, and excess loads and the average lack of shade for each water body examined. The size of a stream influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths. This target load (i.e., load capacity) is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL depends upon background conditions for achieving water quality standards, all tributaries to the waters examined here need to be in natural conditions to prevent excess heat loads to the system.

This TMDL analysis focuses on total solar loads, but it is important to note that differences between existing and target shade, as depicted in the shade deficit figure (Figure D3), are the key to successfully restoring these waters to achieving water quality standards. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts. Each load analysis table contains a column that lists the lack of shade on the stream segment. This value is derived from subtracting target shade from existing shade for each segment. Stream segments with the largest lack of shade are in the worst shape. The average lack of shade derived from the last column in each load analysis table is listed in Table 7 and provides a general level of comparison among streams. Table 8 provides the same information from 2011.

Table 7. Lolo Creek watershed 2017 excess solar loads and percent reduction estimates.

Assessment Unit Name	Assessment Unit Number	Total Existing Load	Total Target Load	Excess Load (% Reduction)	Average Lack of Shade (%)
		(kWh/day)			
Eldorado Creek	ID17060306CL029_02	490,000	350,000	150,000 30	-17
Jim Brown Creek	ID17060306CL031_02	360,000	110,000	250,000 67	-32
Jim Brown Creek	ID17060306CL031_03	370,000	250,000	120,000 29	-26
Musselshell Creek	ID17060306CL032_02	340,000	230,000	120,000 34	-18
Musselshell Creek	ID17060306CL032_03	280,000	210,000	73,000 20	-16

Table 8. Lolo Creek watershed 2011 excess solar loads and percent reduction estimates.

Assessment Unit Name	Assessment Unit Number	Total Existing Load	Total Target Load	Excess Load (% Reduction)	Average Lack of Shade (%)
		(kWh/day)			
Eldorado Creek	ID17060306CL029_02	351,346	217,444	133,901 62	-15
Jim Brown Creek	ID17060306CL031_02	59,703	30,476	29,227 49	-23
Jim Brown Creek	ID17060306CL031_03	332,189	227,078	105,111 32	-27
Musselshell Creek	ID17060306CL032_02	349,525	251,432	98,093 28	-14
Musselshell Creek	ID17060306CL032_03	351,588	265,575	86,012 24	-14

Note: Load data are rounded to two significant figures, which may present rounding errors.

In the Eldorado Creek AU, target loads have increased. An adjustment to the amount of the AU categorized within the upland forest type was made to more closely match delineations of forest type made by the Nez Perce-CNF in their land-type association classification system. With the increase in target shade, the AU has a lower excess shade value percentage when compared to 2011 data.

In the Musselshell Creek AU, lower values for existing, target, and excess solar loads were observed. Some of this difference could be associated with refinements to land-type association classifications and also due to significant figure rounding discrepancies. Changes to land-type associations accounted for approximately 10% more of the AU classified as within the upland forest type resulting in an estimated 7% increase in average target shade values. Within this AU, it appears that many small changes have led to noticeable changes in solar load value percentage. Using land-type associations that more closely match the delineations made by the Nez Perce-CNF should allow for more accurate and repeatable analysis results in future efforts. Figure D1 presents target shade value percentage for the Lolo Creek subbasin.

Notable within the 2017 analysis of solar loads is the 2nd-order segment of the Jim Brown Creek AU. This AU shows the greatest excess solar loads compared to the other AUs analyzed with solar loads approximately two times greater than other AUs in the Lolo Creek subbasin. As an AU with predominately small tributary streams, target shade values are relatively high, which creates a relatively low value for expected solar loads. While a large difference between existing and target shade has currently been measured, the size of the streams within the drainage and the easy access make segments of Jim Brown Creek prime targets for stream restoration. In the lower, 3rd-order segment of Musselshell Creek, DEQ observed this reach of stream requires the smallest reduction in solar loads to meet target value percentages. Figure D3 presents the shade deficit calculated for the Lolo Creek subbasin.

A certain amount of excess load is potentially created by the existing shade/target shade difference inherent in the load analysis. Because existing shade is reported as a 10% shade class and target shade a unique integer between 0 and 100%, there is usually a difference between the

two. For example, say a particular stream segment has a target shade of 86% based on its vegetation type and natural bankfull width. If existing shade on that segment were at target level, it would be recorded as 80% in the load analysis because it falls into the 80% existing shade class. There is an automatic difference of 6%, which could be attributed to the MOS.

5.4.1 Water Diversion

Stream temperature may be affected by diversions of water for water rights purposes. Diversion of flow reduces the amount of water exposed to a given level of solar radiation in the stream channel, which can result in increased water temperature in that channel. Loss of flow in the channel also affects the ability of the near-stream environment to support shade-producing vegetation, resulting in an increase in solar load to the channel.

Although these water temperature effects may occur, nothing in this TMDL supersedes any water appropriation in the affected watershed. Section 101(g), the Wallop Amendment, was added to the CWA as part of the 1977 amendments to address water rights.

> It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this chapter. It is the further policy of Congress that nothing in this chapter shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall co-operate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.

Additionally, Idaho water quality standards indicate the following:

> The adoption of water quality standards and the enforcement of such standards is not intended to…interfere with the rights of Idaho appropriators, either now or in the future, in the utilization of the water appropriations which have been granted to them under the statutory procedure. (IDAPA 58.01.02.050.01)

In this TMDL, we have not quantified what impact, if any, diversions have on stream temperature. Water diversions are allowed for in state statute, and it is possible for a water body to be 100% allocated. Diversions notwithstanding, reaching shade targets as discussed in the TMDL will protect what water remains in the channel and allow the stream to meet water quality standards for temperature. This TMDL will lead to cooler water by achieving shade that would be expected under natural conditions and water temperatures resulting from that shade. DEQ encourages local landowners and holders of water rights to voluntarily do whatever they can to help instream flow for the purpose of keeping channel water cooler for aquatic life.

5.4.2 Margin of Safety

The MOS in this TMDL is considered implicit in the design. Because the target is essentially background conditions, loads (shade levels) are allocated to lands adjacent to these streams at natural background levels. Because shade levels are established at natural background or system potential levels, it is unrealistic to set shade targets at higher, or more conservative, levels. Additionally, existing shade levels are reduced to the next lower 10% shade class, which likely underestimates actual shade in the load analysis. Although the load analysis used in this TMDL involves gross estimations that are likely to have large variances, load allocations are applied to the stream and its riparian vegetation rather than specific nonpoint source activities and can be adjusted as more information is gathered from the stream environment.

5.4.3 Seasonal Variation

This TMDL is based on average seasonal loads. All loads have been calculated to be inclusive of the 6-month period from April through September. This time period is when the combination of increasing air and water temperatures coincide with increasing solar inputs and vegetative shade. The critical time periods are April through June when spring salmonid spawning occurs, July and August when maximum temperatures may exceed cold water aquatic life criteria, and September when fall salmonid spawning is most likely to be affected by higher temperatures. Water temperature is not likely to be a problem for beneficial uses outside of this time period because of cooler weather and lower sun angle. If natural shade and temperature are achieved during these warmer spring, summer and early fall months when beneficial uses are most likely to be affected, DEQ expects that natural shade will be achieved throughout the year and water temperature will not exceed applicable criteria during cooler portions of the year.

5.4.4 Reasonable Assurance

CWA §319 requires each state to develop and submit a nonpoint source management plan. The *Idaho Nonpoint Source Management Plan* was approved by EPA in March 2015 (DEQ 2015). The plan identifies programs to achieve implementation of nonpoint source BMPs, includes a schedule for program milestones, outlines key agencies and agency roles, is certified by the state attorney general to ensure that adequate authorities exist to implement the plan, and identifies available funding sources.

Idaho's nonpoint source management program describes many of the voluntary and regulatory approaches the state will take to abate nonpoint pollution sources. One of the prominent programs described in the plan is the provision for public involvement, including basin advisory groups and WAGs. The Lolo Creek WAG is the designated watershed advisory group for the Lolo Creek watershed.

The Idaho water quality standards refer to existing authorities to control nonpoint pollution sources in Idaho. Some of these authorities and responsible agencies are listed in Table 9.

Table 9. State of Idaho's regulatory authority for nonpoint pollution sources.

Authority	Water Quality Standard	Responsible Agency
Rules Pertaining to the Idaho Forest Practices Act (IDAPA 20.02.01)	58.01.02.350.03(a)	Idaho Department of Lands
Solid Waste Management Rules and Standards (IDAPA 58.01.06)	58.01.02.350.03(b)	Idaho Department of Environmental Quality
Individual/Subsurface Sewage Disposal Rules (IDAPA 58.01.03)	58.01.02.350.03(c)	Idaho Department of Environmental Quality
Stream channel Alteration Rules (IDAPA 37.03.07)	58.01.02.350.03(d)	Idaho Department of Water Resources
Rathdrum Prairie Sewage Disposal Regulations (Panhandle District Health Department)	58.01.02.350.03(e)	Idaho Department of Environmental Quality/Panhandle District Health Department
Rules Governing Exploration, Surface Mining and Closure of Cyanidation Facilities (IDAPA 20.03.02)	58.01.02.350.03(f)	Idaho Department of Lands
Dredge and Placer Mining Operations in Idaho	58.01.02.350.03(g)	Idaho Department of Lands

(IDAPA 20.03.01)
Rules Governing Dairy Waste (IDAPA 02.04.14) 58.01.02.350.03(h) Idaho State Department of Agriculture

Idaho uses a voluntary approach to address agricultural nonpoint sources; however, regulatory authority is found in the water quality standards (IDAPA 58.01.02.350.01–03). IDAPA 58.01.02.055.07 refers to the *Idaho Agricultural Pollution Abatement Plan* (Ag Plan) (ISWCC 2015), which provides direction to the agricultural community regarding approved BMPs. A portion of the Ag Plan outlines responsible agencies or elected groups (soil conservation districts) that will take the lead if nonpoint source pollution problems need to be addressed. For agricultural activity, the Ag Plan assigns the local soil conservation districts to assist the landowner/operator with developing and implementing BMPs to abate nonpoint source pollution associated with the land use. If a voluntary approach does not succeed in abating the pollutant problem, the state may seek injunctive relief for those situations determined to be an imminent and substantial danger to public health or the environment (IDAPA 58.01.02.350.02(a)).

Idaho's water quality standards and wastewater treatment requirements specify that if water quality monitoring indicates water quality standards are not being met, even with the use of BMPs or knowledgeable and reasonable practices, the state may request the designated agency evaluate and/or modify the BMPs to protect beneficial uses. If necessary, the state may seek injunctive or other judicial relief against the operator of a nonpoint source activity according to the DEQ director's authority provided in Idaho Code §39-108 (IDAPA 58.01.02.350). The water quality standards list designated agencies responsible for reviewing and revising nonpoint source BMPs: the Idaho Department of Lands for timber harvest activities, oil and gas exploration and development, and mining activities; Idaho Soil and Water Conservation Commission for grazing and agricultural activities, Idaho Transportation Department for public road construction, Idaho State Department of Agriculture for aquaculture, and DEQ for all other activities (IDAPA 58.01.02.010.24).

5.4.5 Construction Stormwater and TMDL Wasteload Allocations

There are no known National Pollutant Discharge Elimination System permitted point sources in the affected watersheds and thus no wasteload allocations. If a point source is proposed that would have thermal consequences on these waters, background provisions in Idaho's water quality standards addressing such discharges (IDAPA 58.01.02.200.09; IDAPA 58.01.02.401.01) should be involved (Appendix B).

Stormwater runoff is water from rain or snowmelt that does not immediately infiltrate into the ground and flows over or through natural or man-made storage or conveyance systems. When undeveloped areas are converted to land uses with impervious surfaces—such as buildings, parking lots, and roads—the natural hydrology of the land is altered and can result in increased surface runoff rates, volumes, and pollutant loads. Certain types of stormwater runoff are considered point source discharges for CWA purposes, including stormwater associated with municipal separate storm sewer systems, industrial stormwater covered under the Multi-Sector General Permit, and construction stormwater covered under the Construction General Permit. For more information about these permits and managing stormwater, see Appendix E.

5.4.6 Reserve for Growth

A growth reserve has not been included in this TMDL. The load capacity has been allocated to the existing sources in the watershed. Any new sources will need to obtain an allocation from the existing load allocation, which would require a TMDL revision.

5.5 Downstream Waters

Consistent with IDAPA 58.01.02.054.04, "there is no impairment of beneficial uses or violations of water quality standards where natural conditions exceed applicable water quality criteria." This TMDL's load capacity estimates and load allocations are based on the concept of Potential Natural Vegetation. The goal of PNV TMDLs is to attain shade conditions equivalent to natural conditions and achieve a temperature regime expected under "natural background conditions." Since this TMDL does not estimate "natural background temperatures" but uses shade as a surrogate, no numeric temperature target is established. Since natural background standards apply only "when natural background conditions exceed any applicable water quality criteria" (IDAPA 58.01.02.200.09), if stream temperatures are below numeric temperature criteria when natural conditions are achieved (i.e. TMDL is fully implemented), natural background standards would not apply; however, if stream temperatures do not exceed numeric criteria when PNV is achieved, there is no longer an impairment of beneficial uses due to temperature.

Idaho's water quality standards require that all waters "shall maintain a level of water quality at their pour point into downstream waters that provides for the attainment and maintenance of the water quality standards of those downstream waters, including waters of another state or tribe" (IDAPA 58.01.02.070.08). The TMDLs in the document are developed to achieve stream temperature equivalent to natural background conditions. If stream temperatures exceed numeric temperature criteria when PNV targets are achieved and there are no other anthropogenic sources of heat load, the stream temperature is equivalent to natural background temperature or natural conditions, consistent with IDAPA 58.01.02.200.09. The Clearwater River, which is currently in Category 3 of Idaho's 2016 Integrated Report as unassessed for the designated beneficial uses of cold water aquatic life, salmonid spawning, contact recreation, and domestic water supply, is the only water downstream from Lolo Creek. The allocations in this TMDL are developed to achieve natural background temperatures which are considered to be protective of beneficial uses and would not contribute to downstream temperature impairments to the Clearwater River.

5.6 Implementation Strategies

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows the TMDL goals are not being met or significant progress is not being made toward achieving the goals. Reasonable assurance (section 5.4.4) for the TMDL to meet water quality standards is based on the implementation strategy.

Implementation strategies for TMDLs produced using PNV-based shade and solar loads should incorporate the load analysis tables presented in this TMDL (Appendix D). These tables need to be updated, first to field verify the remaining existing shade levels and second to monitor progress toward achieving reductions and TMDL goals. Using the Solar Pathfinder to measure existing shade levels in the field is important to achieving both objectives. It is likely that further

field verification will find discrepancies with reported existing shade levels in the load analysis tables. Due to the inexact nature of the aerial photo interpretation technique, these tables should not be viewed as complete until verified. Implementation strategies should include Solar Pathfinder monitoring to simultaneously field verify the TMDL and mark progress toward achieving desired load reductions.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or significant progress is not being made toward achieving the goals. Reasonable assurance (section 5.4.4) for the TMDL to meet water quality standards is based on the implementation strategy. There may be a variety of reasons that individual stream segments do not meet shade targets, including natural phenomena (e.g., beaver ponds, springs, wet meadows, and past natural disturbances) and/or historic land-use activities (e.g., logging, grazing, and mining). It is important that existing shade for each stream segment be field verified to determine if shade differences are real and result from activities that are controllable. Information within this TMDL (maps and load analysis tables) should be used to guide and prioritize implementation investigations. The information in this TMDL may need further adjustment to reflect new information and conditions in the future.

5.6.1 Time Frame

Implementing the temperature TMDL relies on riparian area management practices that will provide a mature canopy cover to shade the stream and prevent excess solar load. Because implementation depends on mature riparian communities to substantially improve stream temperatures, DEQ believes 10–20 years may be a reasonable amount time for achieving water quality standards. Shade targets will not be achieved all at once. Given their smaller bankfull widths, smaller streams may reach targets sooner than larger streams.

DEQ and the Lolo Creek WAG will continue to reevaluate TMDLs and implementation plans on a 5-year cycle. During the next review, implementation actions completed, in progress, and planned will be reviewed, and pollutant load allocations will be reassessed accordingly.

5.6.2 Approach

The Clearwater Soil and Water Conservation District will work with landowners to identify appropriate BMPs to establish healthy riparian plant communities to increase shading to the streams that have been identified as temperature impaired. Given the expanded scope of this TMDL, this may require evaluation and revision of the existing agricultural implementation plan (ISWCC 2011). Funding provided under the CWA§319 and other funds will be used to encourage voluntary projects to reduce nonpoint source pollution.

Table 10 provides DEQ's recommendations for projects to improve shade and lower stream temperatures.

Table 10. Summary of recommended actions.

Recommended Action	Schedule	Responsibility	Justification
Continue intensive riparian management	Next 5 years	Land management	Has decreased solar load based on 2017 data
Continue to restore riparian areas and fish habitat as	Next 5 years	Land management	Will improve riparian habitat, increase stream habitat variability, and lower

much as possible temperature impairments.

5.6.3 Responsible Parties

DEQ and the designated management agencies in Idaho have primary responsibility for overseeing implementation in cooperation with landowners and managers. In Idaho, these agencies, and their federal and state partners, are charged by the CWA to lend available technical assistance and other appropriate support to local efforts for water quality improvements. Designated state agencies are responsible for assisting with preparation of specific implementation plans, particularly for those resources for which they have regulatory authority or programmatic responsibilities:

- Idaho Department of Lands for timber harvest, oil and gas exploration and development, and mining
- Idaho Soil and Water Conservation Commission for grazing and agricultural activities
- Idaho Transportation Department for public road construction
- Idaho State Department of Agriculture for aquaculture
- DEQ for all other activities

In addition to the designated management agencies, the public—through the WAG and other equivalent organizations or processes—will have opportunities to be involved in developing the implementation plan to the maximum extent practical. Public participation will significantly affect public acceptance of the document and the proposed control actions. Stakeholders (e.g., landowners, local governing authorities, taxpayers, industries, and land managers) are the most educated regarding the pollutant sources and will be called upon to help identify the most appropriate control actions for each area. Experience has shown that the best and most effective implementation plans are those developed with substantial public cooperation and involvement.

5.6.4 Implementation Monitoring Strategy

The objectives of a monitoring strategy are to demonstrate long-term recovery, better understand natural variability, track project and BMP implementation, and track the effectiveness of TMDL implementation. This monitoring and feedback mechanism is a major component of the reasonable assurance component of the TMDL implementation plan.

Monitoring will provide information on progress being made toward achieving TMDL allocations and water quality standards and will help in the interim evaluation of progress, including in the development of 5-year reviews and future TMDLs.

The implementation plan will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. Implementation plan monitoring will include watershed monitoring and BMP monitoring.

Effective shade monitoring can take place on any segment throughout the Lolo Creek watershed and be compared to existing shade estimates seen in Appendix D (Figure D2). Those areas with the largest disparity between existing and target shade should be monitored with Solar Pathfinders to verify existing shade levels and determine progress toward meeting shade targets. Since many existing shade estimates have not been field verified, they may require adjustment during the implementation process. Stream segment length for each estimate of existing shade

varies depending on the land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade toward target levels. Ten equally spaced Solar Pathfinder measurements averaged together within that segment should suffice to determine new shade levels in the future.

5.6.5 Pollutant Trading

Pollutant trading (also known as water quality trading) is a contractual agreement to exchange pollution reductions between two parties. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost-effective, local solutions to problems caused by pollutant discharges to surface waters. Pollutant trading is one of the tools available to meet reductions called for in a TMDL where point and nonpoint sources both exist in a watershed. For additional information, see Appendix F.

6 Conclusions

In compliance with Idaho Code §39-3611, this TMDL reevaluated the *Lolo Creek Tributaries Subbasin Assessment and Total Maximum Daily Load* (DEQ 2011) approved by EPA in 2011. DEQ data were the primary source of information. DEQ reviewed the activities of federal land management agencies, Nez Perce Tribe, other state agencies, and private landowners in the watershed since the 2011 TMDL was approved. To DEQ's knowledge, no significant changes have occurred in the watershed with regard to population and land use. Instream target and pollutant allocation assessments and 2017 TMDL analysis were conducted with input and support from the WAG and basin advisory group.

PNV methodology for temperature impairment has not changed since the 2011 TMDL. This 2017 TMDL analyzed all tributary streams within the associated AUs. No point sources were identified in the watershed and nonpoint sources that could affect stream temperature were considered when evaluating implementation planning and projects.

No changes to the list of beneficial uses were found within the watershed. PNV temperature analysis of analogous stream segments shows that excess solar load has been reduced in most AUs with temperature TMDLs. Stream temperature improvements will be more difficult to discern until more ambient water temperature data are collected over a longer time period.

Important projects have restored fish habitat and reduced impacts on riparian areas. Activities relating to BMP refinement and improvement are likely improving conditions within the streams included in this TMDL. These improvements have resulted from restoration projects and good resource management. DEQ recommends these activities continue within the Lolo Creek subbasin. Table 10 summarizes types of improvement projects that would have a large impact on further lowering stream temperatures. Over time, these projects and changes in land management will lead to overall water quality improvements.

Effective shade targets were established for the main stem portions of two Jim Brown Creek AUs (ID17060306CL031_02 and ID17060306CL03_03) and two Musselshell Creek AUs (ID17060306CL032_02 and ID17060305CL032_03), based on the concept of maximum shading under PNV resulting in natural background temperature levels. Shade targets were derived from

effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation and partially field verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02). A summary of assessment outcomes, including recommended changes to listing status in the next Integrated Report, is presented in Table 11.

Target shade levels for individual stream segments should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts.

Table 11. Summary of assessment outcomes.

Assessment Unit Name	Assessment Unit Number	Pollutant	TMDL Completed	Recommended Changes to Next Integrated Report	Justification
Eldorado Creek	ID17060306CL029_02	Temperature	Yes	Remain in Category 4a	2017 PNV analysis indicates temperature impairment
Jim Brown Creek	ID17060306CL031_02	Temperature	Yes	Remain in Category 4a	2017 PNV analysis indicates temperature impairment
Jim Brown Creek	ID17060306CL031_03	Temperature	Yes	Remain in Category 4a	2017 PNV analysis indicates temperature impairment
Musselshell Creek	ID17060306CL032_02	Temperature	Yes	Remain in Category 4a	2017 PNV analysis indicates temperature impairment
Musselshell Creek	ID17060306CL032_03	Temperature	Yes	Remain in Category 4a	2017 PNV analysis indicates temperature impairment

This document was prepared with input from the public, as described in Appendix G. Following the public comment period, comments and DEQ responses will also be included in this appendix, and a distribution list will be included in Appendix H.

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GIS Coverages

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Glossary

§303(d)

Refers to section 303 subsection "d" of the Clean Water Act. Section 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 United States Environmental Protection Agency approval.

Assessment Unit (AU)

A group of similar streams that have similar land use practices, ownership, or land management. However, stream order is the main basis for determining AUs. All the waters of the state are defined using AUs, and because AUs are a subset of water body identification numbers, they tie directly to the water quality standards so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

Beneficial Use

Any of the various uses of water that are recognized in water quality standards, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics.

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.

Exceedance

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

Fully Supporting

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

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

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

Load Capacity (LC)

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, a margin of safety, and natural background contributions, it becomes a total maximum daily load.

Margin of Safety (MOS)

An implicit or explicit portion of a water body's load capacity set aside to allow for uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. The margin of safety 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 margin of safety is not allocated to any sources of pollution.

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 nonirrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.
Not Assessed (NA)	A concept and an assessment category describing water bodies that have been studied but are missing critical information needed to complete an assessment.
Not Fully Supporting	Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).
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 plants.
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 that alter the functioning of natural processes and produce undesirable environmental and health effects. Pollution includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.
Potential Natural Vegetation (PNV)	A.U. Küchler (1964) defined potential natural vegetation as vegetation that would exist without human interference and if the resulting plant succession were projected to its climax condition while allowing for natural disturbance processes such as fire. Our use of the term reflects Küchler's definition in that riparian vegetation at PNV would produce a system potential level of shade on streams and includes recognition of some level of natural disturbance.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A 1st-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.
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 basis. 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.

Wasteload Allocation (WLA)	The portion of receiving water's load 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 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, aquatic habitat, or industrial processes.
Water Quality Standards	State-adopted and United States 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.

Appendix A. Beneficial Uses

Idaho water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. 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.

Existing Uses

Existing uses under the Clean Water Act 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" (40 CFR 131.3). The existing instream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.051.01). Existing uses need to be protected, whether or not the level of water quality to fully support the uses currently exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water that supported salmonid spawning since November 28, 1975, but does not now due to other factors, such as blockage of migration, channelization, sedimentation, or excess heat.

Designated Uses

Designated uses under the Clean Water Act are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained" (40 CFR 131.3). 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. Multiple uses often apply to the same water; in this case, water quality must be sufficiently maintained to meet the most sensitive use (designated or existing). 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 described in the Idaho water quality standards (IDAPA 58.01.02.100) and specifically listed by water body in sections 110–160.

Undesignated Surface Waters and Presumed Use Protection

In Idaho, due to a change in scale of cataloging waters in 2000, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations (IDAPA 58.01.02.110–160). The water quality standards have three sections that address nondesignated waters. Sections 101.02 and 101.03 specifically address nondesignated man-made waterways and private waters. Man-made waterways and private waters have no presumed use protections. Man-made waters are protected for the use for which they were constructed unless otherwise designated in the water quality standards. Private waters are not protected for any beneficial uses unless specifically designated in the water quality standards.

All other undesignated waters are addressed by section 101.01. Under this section, absent information on existing uses, DEQ presumes that most Idaho waters 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 applies the numeric cold water and recreation criteria to undesignated waters. If in addition to presumed uses, an additional existing use (e.g., salmonid spawning) exists, then the additional numeric criteria for salmonid spawning would also apply (e.g., intergravel dissolved oxygen, temperature) because of the requirement to protect water quality for that existing use. However, if some other use that requires less stringent criteria for protection (such as seasonal cold aquatic life) is found to be an existing use, then a use designation (rulemaking) is needed before that use can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

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

Table B1. Selected numeric criteria supportive of designated beneficial uses in Idaho water quality standards.

Parameter	Primary Contact Recreation	Secondary Contact Recreation	Cold Water Aquatic Life	Salmonid Spawning[a]
Water Quality Standards: IDAPA 58.01.02.250–251				
Bacteria				
• Geometric mean	<126 *E. coli*/100 mL[b]	<126 *E. coli*/100 mL	—	—
• Single sample	≤406 *E. coli*/100 mL	≤576 *E. coli*/100 mL	—	—
pH	—	—	Between 6.5 and 9.0	Between 6.5 and 9.5
Dissolved oxygen (DO)	—	—	DO exceeds 6.0 milligrams/liter (mg/L)	**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 1-day minimum and exceeds 6.0 mg/L for a 7-day average
Temperature[c]	—	—	22 °C or less daily maximum; 19 °C or less daily average **Seasonal Cold Water**: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °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 nephelometric turbidity units (NTU) instantaneously or more than 25 NTU for more than 10 consecutive days.	—
Ammonia	—	—	Ammonia not to exceed calculated concentration based on pH and temperature.	—
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR 131				
Temperature	—	—	—	7-day moving average of 10 °C or less maximum daily temperature for June–September

[a] During spawning and incubation periods for inhabiting species
[b] *Escherichia coli* per 100 milliliters
[c] 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 7-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.

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 by species. For spring-spawning salmonids, the default spawning and incubation period recognized by the Idaho Department of Environmental Quality (DEQ) is generally March 15 to July 15 (DEQ 2016a). Fall spawning can occur as early as September 1 and continue with incubation into the following spring up to June 1. As per IDAPA 58.01.02.250.02.f.ii., the following water quality criteria need to be met during that time period:

- 13 °C as a daily maximum water temperature
- 9 °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 the highest annual maximum weekly maximum air temperatures) is compared to the daily maximum criterion of 13 °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 certain 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:

> 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, there shall be no lowering of water quality from natural background conditions. Provided, however, that temperature may be increased above natural background conditions when allowed under Section 401. (IDAPA 58.01.02.200.09)

Section 401 relates to point source wastewater treatment requirements. In this case, if temperature criteria for any aquatic life use are exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3 °C (IDAPA 58.01.02.401.01.c).

Appendix C. Data Sources

Table C1. Data sources for Lolo Creek watershed assessment.

Water Body/Area	Data Source	Type of Data	Collection Date
Lolo Creek watershed	DEQ State Technical Services Office, DEQ Lewiston Regional Office	Land-type shade curves, bankfull width measurements and estimations, Solar Pathfinder vegetation canopy cover, solar heat load tables	2017

Appendix D. Existing and Target Solar Loads

Table D1. Existing and target solar loads for Eldorado Creek (ID17060306CL029_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	April Creek	1	454	Upland	98%	0.11	1	500	60	90%	0.57	1	500	300	200	0%
029_02	April Creek	2	421	Upland	98%	0.11	1	400	50	60%	2.28	1	400	900	900	-38%
029_02	April Creek	3	158	Upland	98%	0.11	2	300	30	70%	1.71	2	300	500	500	-28%
029_02	April Creek	4	240	Upland-Alder Mix	87%	0.74	2	500	400	70%	1.71	2	500	900	500	-17%
029_02	April Creek	5	418	Upland-Alder Mix	87%	0.74	2	800	600	80%	1.14	2	800	900	300	-7%
029_02	Austin Creek	1	280	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
029_02	Austin Creek	2	673	Upland	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
029_02	Austin Creek	3	241	Upland	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
029_02	Austin Creek	4	612	Upland	98%	0.11	2	1,000	100	80%	1.14	2	1,000	1,000	900	-18%
029_02	Austin Creek	5	595	Upland	98%	0.11	2	1,000	100	70%	1.71	2	1,000	2,000	2,000	-28%
029_02	Brick Creek	1	2329	Upland	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
029_02	Brick Creek	2	39	Upland	98%	0.11	2	80	9	70%	1.71	2	80	100	90	-28%
029_02	Cedar Creek	1	407	Upland	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
029_02	Cedar Creek	2	585	Upland	98%	0.11	1	600	70	90%	0.57	1	600	300	200	-8%
029_02	Cedar Creek	3	515	Upland	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
029_02	Cedar Creek	4	392	Upland	98%	0.11	1	400	50	60%	2.28	1	400	900	900	-38%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Cedar Creek	5	305	Upland	98%	0.11	2	600	70	70%	1.71	2	600	1,000	900	-28%
029_02	Cedar Creek	6	710	Upland	98%	0.11	2	1,000	100	60%	2.28	2	1,000	2,000	2,000	-38%
029_02	Cedar Creek	7	180	Upland	98%	0.11	2	400	50	70%	1.71	2	400	700	700	-28%
029_02	Cedar Creek	8	153	Upland	98%	0.11	2	300	30	60%	2.28	2	300	700	700	-38%
029_02	Cedar Creek	9	117	Upland	98%	0.11	2	200	20	50%	2.85	2	200	600	600	-48%
029_02	Cedar Creek	10	83	Upland	98%	0.11	2	200	20	50%	2.85	2	200	600	600	-48%
029_02	Cedar Creek	11	130	Upland	98%	0.11	2	300	30	50%	2.85	2	300	900	900	-48%
029_02	Cedar Creek	12	354	Upland	98%	0.11	2	700	80	80%	1.14	2	700	800	700	-18%
029_02	Cedar Creek	13	443	Upland	96%	0.23	3	1,000	200	70%	1.71	3	1,000	2,000	2,000	-26%
029_02	Cedar Creek	14	266	Upland	96%	0.23	3	800	200	70%	1.71	3	800	1,000	800	-26%
029_02	Cedar Creek	15	232	Upland	96%	0.23	3	700	200	80%	1.14	3	700	800	600	-16%
029_02	Cedar Creek	16	269	Upland	96%	0.23	3	800	200	60%	2.28	3	800	2,000	2,000	-36%
029_02	Cedar Creek	17	306	Upland	96%	0.23	3	900	200	70%	1.71	3	900	2,000	2,000	-26%
029_02	Cedar Creek	18	280	Upland	96%	0.23	3	800	200	50%	2.85	3	800	2,000	2,000	-46%
029_02	Cedar Creek	19	398	Upland	96%	0.23	3	1,000	200	80%	1.14	3	1,000	1,000	800	-16%
029_02	Cedar Creek	20	434	Upland-Alder Mix	61%	2.22	4	2,000	4,000	70%	1.71	4	2,000	3,000	(1,000)	9%
029_02	Cedar Creek	21	756	Upland-Alder Mix	61%	2.22	4	3,000	7,000	70%	1.71	4	3,000	5,000	(2,000)	9%
029_02	Cedar Creek	22	1182	Upland-Alder Mix	61%	2.22	4	5,000	10,000	80%	1.14	4	5,000	6,000	(4,000)	19%
029_02	Cedar Creek	23	420	Upland-Alder Mix	52%	2.74	5	2,000	5,000	90%	0.57	5	2,000	1,000	(4,000)	38%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Cedar Creek	24	681	Upland-Alder Mix	52%	2.74	5	3,000	8,000	60%	2.28	5	3,000	7,000	(1,000)	8%
029_02	Cedar Creek	25	318	Upland-Alder Mix	52%	2.74	5	2,000	5,000	80%	1.14	5	2,000	2,000	(3,000)	28%
029_02	Cedar Creek	26	373	Upland-Alder Mix	52%	2.74	5	2,000	5,000	70%	1.71	5	2,000	3,000	(2,000)	18%
029_02	Cedar Creek_Trib 01	1	1215	Upland	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
029_02	Cedar Creek_Trib 01	2	887	Upland	98%	0.11	1	900	100	70%	1.71	1	900	2,000	2,000	-28%
029_02	Dollar Creek	1	746	Upland	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
029_02	Dollar Creek	2	256	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
029_02	Dollar Creek	3	400	Upland	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%
029_02	Dollar Creek	4	69	Upland	98%	0.11	1	70	8	70%	1.71	1	70	100	90	-28%
029_02	Dollar Creek	5	91	Upland	98%	0.11	1	90	10	90%	0.57	1	90	50	40	-8%
029_02	Dollar Creek	6	78	Upland	98%	0.11	1	80	9	60%	2.28	1	80	200	200	-38%
029_02	Dollar Creek	7	172	Upland	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
029_02	Dollar Creek	8	93	Upland	98%	0.11	2	200	20	60%	2.28	2	200	500	500	-38%
029_02	Dollar Creek	9	343	Upland	98%	0.11	2	700	80	90%	0.57	2	700	400	300	-8%
029_02	Dollar Creek	10	99	Upland	98%	0.11	2	200	20	60%	2.28	2	200	500	500	-38%
029_02	Dollar Creek	11	236	Upland	98%	0.11	2	500	60	80%	1.14	2	500	600	500	-18%
029_02	Dollar Creek	12	76	Upland	98%	0.11	2	200	20	70%	1.71	2	200	300	300	-28%
029_02	Dollar Creek	13	1072	Upland	98%	0.11	2	2,000	200	80%	1.14	2	2,000	2,000	2,000	-18%
029_02	Dollar Creek	14	563	Upland	96%	0.23	3	2,000	500	90%	0.57	3	2,000	1,000	500	-6%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Dollar Creek	15	179	Upland	96%	0.23	3	500	100	80%	1.14	3	500	600	500	-16%
029_02	Dollar Creek	16	156	Upland-Alder Mix	74%	1.48	3	500	700	70%	1.71	3	500	900	200	-4%
029_02	Dollar Creek	17	120	Upland-Alder Mix	74%	1.48	3	400	600	60%	2.28	3	400	900	300	-14%
029_02	Dollar Creek	18	461	Upland-Alder Mix	74%	1.48	3	1,000	1,000	30%	3.99	3	1,000	4,000	3,000	-44%
029_02	Dora Creek	1	511	Upland	98%	0.11	1	500	60	90%	0.57	1	500	300	200	-8%
029_02	Dora Creek	2	345	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
029_02	Dora Creek	3	355	Upland	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%
029_02	Dora Creek	4	306	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
029_02	Dora Creek	5	138	Upland	98%	0.11	1	100	10	60%	2.28	1	100	200	200	-38%
029_02	Dora Creek	6	509	Upland	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
029_02	Eldorado Creek	1	2756	Breakland	95%	0.29	1	3,000	900	90%	0.57	1	3,000	2,000	1,000	-5%
029_02	Eldorado Creek	2	569	Upland	98%	0.11	2	1,000	100	90%	0.57	2	1,000	600	500	-8%
029_02	Eldorado Creek	3	153	Upland	98%	0.11	2	300	30	70%	1.71	2	300	500	500	-28%
029_02	Eldorado Creek	4	253	Upland	98%	0.11	2	500	60	70%	1.71	2	500	900	800	-28%
029_02	Eldorado Creek	5	377	Upland	98%	0.11	2	800	90	90%	0.57	2	800	500	400	-8%
029_02	Eldorado Creek	6	256	Upland	96%	0.23	3	800	200	70%	1.71	3	800	1,000	800	-26%
029_02	Eldorado Creek	7	97	Upland	96%	0.23	3	300	70	50%	2.85	3	300	900	800	-46%
029_02	Eldorado Creek	8	325	Upland	96%	0.23	3	1,000	200	50%	2.85	3	1,000	3,000	3,000	-46%
029_02	Eldorado Creek	9	348	Upland	96%	0.23	3	1,000	200	20%	4.56	3	1,000	5,000	5,000	-76%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Eldorado Creek	10	919	Upland	94%	0.34	4	4,000	1,000	50%	2.85	4	4,000	10,000	9,000	-44%
029_02	Eldorado Creek	11	122	Upland	94%	0.34	4	500	200	80%	1.14	4	500	600	400	-14%
029_02	Eldorado Creek	12	118	Upland	94%	0.34	4	500	200	10%	5.13	4	500	3,000	3,000	-84%
029_02	Eldorado Creek	13	344	Upland	94%	0.34	4	1,000	300	70%	1.71	4	1,000	2,000	2,000	-24%
029_02	Eldorado Creek	14	288	Upland	92%	0.46	5	1,000	500	80%	1.14	5	1,000	1,000	500	-12%
029_02	Eldorado Creek	15	335	Upland	92%	0.46	5	2,000	900	50%	2.85	5	2,000	6,000	5,000	-42%
029_02	Eldorado Creek	16	42	Upland	92%	0.46	5	200	90	50%	2.85	5	200	600	500	-42%
029_02	Eldorado Creek	17	201	Upland	92%	0.46	5	1,000	500	70%	1.71	5	1,000	2,000	2,000	-22%
029_02	Eldorado Creek	18	849	Upland-Alder Mix	52%	2.74	5	4,000	10,000	10%	5.13	5	4,000	20,000	10,000	-42%
029_02	Eldorado Creek	19	175	Upland-Alder Mix	46%	3.08	6	1,000	3,000	10%	5.13	6	1,000	5,000	2,000	-36%
029_02	Eldorado Creek	20	176	Upland-Alder Mix	46%	3.08	6	1,000	3,000	30%	3.99	6	1,000	4,000	1,000	-16%
029_02	Eldorado Creek	21	107	Upland-Alder Mix	46%	3.08	6	600	2,000	10%	5.13	6	600	3,000	1,000	-36%
029_02	Eldorado Creek	22	116	Upland-Alder Mix	46%	3.08	6	700	2,000	70%	1.71	6	700	1,000	(1,000)	24%
029_02	Eldorado Creek	23	318	Upland-Alder Mix	46%	3.08	6	2,000	6,000	20%	4.56	6	2,000	9,000	3,000	-26%
029_02	Eldorado Creek	24	482	Upland-Alder Mix	46%	3.08	6	3,000	9,000	10%	5.13	6	3,000	20,000	10,000	-36%
029_02	Eldorado Creek	25	554	Upland-Alder Mix	41%	3.36	7	4,000	10,000	60%	2.28	7	4,000	9,000	(1,000)	19%
029_02	Eldorado Creek	26	292	Upland-Alder Mix	41%	3.36	7	2,000	7,000	30%	3.99	7	2,000	8,000	1,000	-11%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Eldorado Creek	27	122	Upland-Alder Mix	41%	3.36	7	900	3,000	40%	3.42	7	900	3,000	0	-1%
029_02	Eldorado Creek	28	60	Upland-Alder Mix	41%	3.36	7	400	1,000	10%	5.13	7	400	2,000	1,000	-31%
029_02	Eldorado Creek	29	269	Upland-Alder Mix	41%	3.36	7	2,000	7,000	40%	3.42	7	2,000	7,000	0	-1%
029_02	Eldorado Creek	30	208	Upland-Alder Mix	37%	3.59	8	2,000	7,000	20%	4.56	8	2,000	9,000	2,000	-17%
029_02	Eldorado Creek	31	41	Upland-Alder Mix	37%	3.59	8	300	1,000	10%	5.13	8	300	2,000	1,000	-27%
029_02	Eldorado Creek	32	206	Upland-Alder Mix	37%	3.59	8	2,000	7,000	10%	5.13	8	2,000	10,000	3,000	-27%
029_02	Eldorado Creek	33	84	Upland-Alder Mix	37%	3.59	8	700	3,000	40%	3.42	8	700	2,000	(1,000)	3%
029_02	Eldorado Creek	34	85	Upland-Alder Mix	37%	3.59	8	700	3,000	40%	3.42	8	700	2,000	(1,000)	3%
029_02	Eldorado Creek	35	450	Upland-Alder Mix	37%	3.59	8	4,000	10,000	30%	3.99	8	4,000	20,000	10,000	-7%
029_02	Eldorado Creek	36	297	Upland-Alder Mix	37%	3.59	8	2,000	7,000	20%	4.56	8	2,000	9,000	2,000	-17%
029_02	Eldorado Creek	37	291	Upland-Alder Mix	33%	3.82	9	3,000	10,000	30%	3.99	9	3,000	10,000	0	-3%
029_02	Eldorado Creek	38	110	Upland-Alder Mix	33%	3.82	9	1,000	4,000	20%	4.56	9	1,000	5,000	1,000	-13%
029_02	Eldorado Creek	39	409	Upland-Alder Mix	33%	3.82	9	4,000	20,000	20%	4.56	9	4,000	20,000	0	-13%
029_02	Eldorado Creek	40	127	Upland-Alder Mix	33%	3.82	9	1,000	4,000	40%	3.42	9	1,000	3,000	(1,000)	7%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Eldorado Creek	41	513	Upland-Alder Mix	31%	3.93	10	5,000	20,000	20%	4.56	10	5,000	20,000	0	-11%
029_02	Eldorado Creek	42	115	Upland-Alder Mix	31%	3.93	10	1,000	4,000	40%	3.42	10	1,000	3,000	(1,000)	9%
029_02	Eldorado Creek	43	189	Upland-Alder Mix	31%	3.93	10	2,000	8,000	20%	4.56	10	2,000	9,000	1,000	-11%
029_02	Eldorado Creek	44	109	Upland-Alder Mix	31%	3.93	10	1,000	4,000	30%	3.99	10	1,000	4,000	0	-1%
029_02	Eldorado Creek	45	165	Upland-Alder Mix	31%	3.93	10	2,000	8,000	20%	4.56	10	2,000	9,000	1,000	-11%
029_02	Eldorado Creek	46	260	Upland-Alder Mix	31%	3.93	10	3,000	10,000	30%	3.99	10	3,000	10,000	0	-1%
029_02	Eldorado Creek	47	149	Upland-Alder Mix	28%	4.10	11	2,000	8,000	30%	3.99	11	2,000	8,000	0	2%
029_02	Eldorado Creek	48	396	Upland-Alder Mix	28%	4.10	11	4,000	20,000	40%	3.42	11	4,000	10,000	(10,000)	12%
029_02	Eldorado Creek	48	473	Upland-Alder Mix	28%	4.10	11	5,000	20,000	30%	3.99	11	5,000	20,000	0	2%
029_02	Eldorado Creek	49	456	Upland	68%	1.82	11	5,000	9,000	70%	1.71	11	5,000	9,000	0	2%
029_02	Eldorado Creek	50	376	Upland	64%	2.05	12	5,000	10,000	50%	2.85	12	5,000	10,000	0	-14%
029_02	Eldorado Creek	51	836	Upland	64%	2.05	12	10,000	20,000	60%	2.28	12	10,000	20,000	0	-4%
029_02	Eldorado Creek	52	74	Upland	64%	2.05	12	900	2,000	50%	2.85	12	900	3,000	1,000	-14%
029_02	Eldorado Creek_Trib 01	1	177	Upland	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
029_02	Eldorado Creek_Trib 01	2	1578	Upland	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
029_02	Eldorado	1	150	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
	Creek_Trib 02															
029_02	Eldorado Creek_Trib 02	2	121	Breakland	95%	0.29	1	100	30	90%	0.57	1	100	60	30	-5%
029_02	Eldorado Creek_Trib 02	3	285	Upland	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
029_02	Eldorado Creek_Trib 02	4	790	Breakland	95%	0.29	1	800	200	70%	1.71	1	800	1,000	800	-25%
029_02	Eldorado Creek_Trib 02	5	568	Breakland	95%	0.29	1	600	200	80%	1.14	1	600	700	500	-15%
029_02	Eldorado Creek_Trib 02	6	214	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
029_02	Eldorado Creek_Trib 03	1	601	Upland	98%	0.11	1	600	70	70%	1.71	1	600	1,000	900	-28%
029_02	Eldorado Creek_Trib 03	2	142	Upland	98%	0.11	1	100	10	60%	2.28	1	100	200	200	-38%
029_02	Eldorado Creek_Trib 03	3	227	Upland	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
029_02	Eldorado Creek_Trib 03	4	441	Upland	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
029_02	Eldorado Creek_Trib 03	5	132	Upland-Alder Mix	92%	0.46	1	100	50	60%	2.28	1	100	200	200	-32%
029_02	Eva Creek	1	582	Upland	98%	0.11	1	600	70	90%	0.57	1	600	300	200	-8%
029_02	Eva Creek	2	334	Upland	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
029_02	Eva Creek	3	306	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
029_02	Eva Creek	4	492	Upland	98%	0.11	1	500	60	70%	1.71	1	500	900	800	-28%
029_02	Eva Creek	5	671	Upland	98%	0.11	2	1,000	100	60%	2.28	2	1,000	2,000	2,000	-38%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Eva Creek	6	610	Upland	98%	0.11	2	1,000	100	90%	0.57	2	1,000	600	500	-8%
029_02	Eva Creek	7	339	Upland	98%	0.11	2	700	80	70%	1.71	2	700	1,000	900	-28%
029_02	Fan Creek	1	268	Upland	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
029_02	Fan Creek	2	633	Upland	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
029_02	Fan Creek	3	511	Upland	98%	0.11	2	1,000	100	90%	0.57	2	1,000	600	500	-8%
029_02	Fan Creek	4	288	Upland	98%	0.11	2	600	70	90%	0.57	2	600	300	200	-8%
029_02	Fan Creek	5	188	Upland	96%	0.23	3	600	100	80%	1.14	3	600	700	600	-16%
029_02	Fan Creek	6	343	Upland	96%	0.23	3	1,000	200	70%	1.71	3	1,000	2,000	2,000	-26%
029_02	Fan Creek	7	163	Upland	96%	0.23	3	500	100	90%	0.57	3	500	300	200	-6%
029_02	Fan Creek_Trib 01	1	510	Upland	98%	0.11	1	500	60	90%	0.57	1	500	300	200	-8%
029_02	Fan Creek_Trib 01	2	348	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
029_02	Fan Creek_Trib 01	3	1327	Upland	98%	0.11	2	3,000	300	90%	0.57	2	3,000	2,000	2,000	-8%
029_02	Fan Creek_Trib 02	1	1164	Upland	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
029_02	Fan Creek_Trib 02	2	200	Upland	98%	0.11	2	400	50	80%	1.14	2	400	500	500	-18%
029_02	Fan Creek_Trib 02	3	320	Upland	98%	0.11	2	600	70	60%	2.28	2	600	1,000	900	-38%
029_02	Fan Creek_Trib 02	4	247	Upland	98%	0.11	2	500	60	80%	1.14	2	500	600	500	-18%
029_02	Four-bit Creek	1	1027	Breakland	95%	0.29	1	1,000	300	90%	0.57	1	1,000	600	300	-5%
029_02	Four-bit Creek	2	300	Breakland	95%	0.29	1	300	90	60%	2.28	1	300	700	600	-35%
029_02	Four-bit Creek	3	1520	Breakland	94%	0.34	2	3,000	1,000	80%	1.14	2	3,000	3,000	2,000	-14%
029_02	Four-bit Creek	4	178	Upland-Alder Mix	87%	0.74	2	400	300	80%	1.14	2	400	500	200	-7%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Lunch Creek	1	689	Breakland	95%	0.29	1	700	200	90%	0.57	1	700	400	200	-5%
029_02	Lunch Creek	2	692	Upland	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
029_02	Lunch Creek	3	141	Upland	98%	0.11	2	300	30	70%	1.71	2	300	500	500	-28%
029_02	Lunch Creek	4	216	Upland	98%	0.11	2	400	50	80%	1.14	2	400	500	500	-18%
029_02	Lunch Creek	5	142	Upland	98%	0.11	2	300	30	90%	0.57	2	300	200	200	-8%
029_02	May Creek	1	161	Upland	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
029_02	May Creek	2	385	Upland	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%
029_02	May Creek	3	240	Upland	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
029_02	May Creek	4	539	Upland	98%	0.11	1	500	60	70%	1.71	1	500	900	800	-28%
029_02	May Creek	5	240	Upland	98%	0.11	2	500	60	80%	1.14	2	500	600	500	-18%
029_02	May Creek	6	473	Upland	98%	0.11	2	900	100	70%	1.71	2	900	2,000	2,000	-28%
029_02	Opal Creek	1	269	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
029_02	Opal Creek	2	1476	Upland	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
029_02	Panther Creek	1	126	Upland	98%	0.11	1	100	10	90%	0.57	1	100	60	50	-8%
029_02	Panther Creek	2	790	Upland	98%	0.11	1	800	90	80%	1.14	1	800	900	800	-18%
029_02	Panther Creek	3	450	Upland	98%	0.11	1	500	60	70%	1.71	1	500	900	800	-28%
029_02	Panther Creek	4	337	Upland	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
029_02	Six-Bit Creek	1	376	Upland	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
029_02	Six-Bit Creek	2	302	Breakland	95%	0.29	1	300	90	80%	1.14	1	300	300	200	-15%
029_02	Six-Bit Creek	3	643	Breakland	95%	0.29	1	600	200	90%	0.57	1	600	300	100	-5%
029_02	Six-Bit Creek	4	196	Breakland	95%	0.29	1	200	60	80%	1.14	1	200	200	100	-15%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Six-Bit Creek	5	335	Breakland	95%	0.29	1	300	90	70%	1.71	1	300	500	400	-25%
029_02	Six-Bit Creek	6	176	Upland	98%	0.11	1	200	20	60%	2.28	1	200	500	500	-38%
029_02	Six-Bit Creek	7	751	Upland	98%	0.11	2	2,000	200	70%	1.71	2	2,000	3,000	3,000	-28%
029_02	Six-Bit Creek	8	460	Upland	98%	0.11	2	900	100	60%	2.28	2	900	2,000	2,000	-38%
029_02	Six-Bit Creek	9	476	Upland	98%	0.11	2	1,000	100	80%	1.14	2	1,000	1,000	900	-18%
029_02	Six-Bit Creek	10	671	Upland	98%	0.11	2	1,000	100	70%	1.71	2	1,000	2,000	2,000	-28%
029_02	Trout Creek	1	195	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
029_02	Trout Creek	2	600	Upland	98%	0.11	1	600	70	90%	0.57	1	600	300	200	-8%
029_02	Trout Creek	3	1068	Upland	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
029_02	Trout Creek	4	657	Upland	98%	0.11	2	1,000	100	90%	0.57	2	1,000	600	500	-8%
029_02	Trout Creek	5	476	Upland	98%	0.11	2	1,000	100	80%	1.14	2	1,000	1,000	900	-18%
029_02	Trout Creek	6	763	Upland	98%	0.11	3	2,000	200	90%	0.57	3	2,000	1,000	800	-8%
029_02	Trout Creek_Trib 01	1	1541	Upland	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	0%
029_02	Two-bit Creek	1	193	Upland	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
029_02	Two-bit Creek	2	456	Upland	98%	0.11	1	500	60	90%	0.57	1	500	300	200	0%
029_02	Two-bit Creek	3	452	Upland	98%	0.11	1	500	60	80%	1.14	1	500	600	500	0%
029_02	Two-bit Creek	4	687	Upland	98%	0.11	1	700	80	70%	1.71	1	700	1,000	900	0%
029_02	Two-bit Creek	5	151	Upland-Alder Mix	92%	0.46	1	200	90	70%	1.71	1	200	300	200	0%
029_02	Two-bit Creek	6	65	Upland-Alder Mix	92%	0.46	1	70	30	10%	5.13	1	70	400	400	-82%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
029_02	Wapiti Creek	1	585	Upland	98%	0.11	1	600	70	90%	0.57	1	600	300	200	0%
029_02	Wapiti Creek	2	586	Upland	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
029_02	Wapiti Creek	3	434	Upland	98%	0.11	1	400	50	90%	0.57	1	400	200	200	0%
029_02	Wapiti Creek	4	266	Upland	98%	0.11	2	500	60	70%	1.71	2	500	900	800	0%
029_02	Wapiti Creek	5	248	Upland	98%	0.11	2	500	60	60%	2.28	2	500	1,000	900	0%
029_02	Wapiti Creek	6	401	Upland	98%	0.11	2	800	90	70%	1.71	2	800	1,000	900	0%
029_02	Wapiti Creek	7	255	Upland	98%	0.11	2	500	60	60%	2.28	2	500	1,000	900	-38%
							Totals		350,000					490,000	150,000	

Table D2. Existing and target solar loads for Jim Brown Creek (ID 17060306CL031_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Bat Creek	1	731	Upland	98%	0.11	1	700	80	70%	1.71	1	700	1,000	900	-28%
031_02	Bat Creek	2	272	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
031_02	Bat Creek	3	435	Upland	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
031_02	Bat Creek	4	240	Upland	98%	0.11	2	500	60	60%	2.28	2	500	1,000	900	-38%
031_02	Bat Creek	5	284	Upland	98%	0.11	2	600	70	80%	1.14	2	600	700	600	-18%
031_02	Bat Creek	6	471	Upland	98%	0.11	2	900	100	70%	1.71	2	900	2,000	2,000	-28%
031_02	Bat Creek	7	280	Upland	98%	0.11	2	600	70	60%	2.28	2	600	1,000	900	-38%
031_02	Bat Creek	8	176	Upland	96%	0.23	3	500	100	40%	3.42	3	500	2,000	2,000	-56%
031_02	Bat Creek	9	243	Upland	96%	0.23	3	700	200	70%	1.71	3	700	1,000	800	-26%
031_02	Bat Creek	10	263	Upland	96%	0.23	3	800	200	60%	2.28	3	800	2,000	2,000	-36%
031_02	Bat Creek	11	645	Upland-Alder Mix	74%	1.48	3	2,000	3,000	10%	5.13	3	2,000	10,000	7,000	-64%
031_02	Bat Creek	12	529	Upland-Alder Mix	61%	2.22	4	2,000	4,000	10%	5.13	4	2,000	10,000	6,000	-51%
031_02	Bat Creek	13	391	Upland-Alder Mix	61%	2.22	4	2,000	4,000	20%	4.56	4	2,000	9,000	5,000	-41%
031_02	Bat Creek	14	332	Upland-Alder Mix	61%	2.22	4	1,000	2,000	0%	5.70	4	1,000	6,000	4,000	-61%
031_02	Blonde Creek	1	344	Upland	98%	0.11	1	300	30	10%	5.13	1	300	2,000	2,000	-88%
031_02	Blonde Creek	2	1132	Upland	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
031_02	Blonde Creek	3	348	Upland-Alder Mix	87%	0.74	2	700	500	60%	2.28	2	700	2,000	2,000	-27%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Blonde Creek	4	399	Upland-Alder Mix	87%	0.74	2	800	600	50%	2.85	2	800	2,000	1,000	-37%
031_02	Blonde Creek	5	479	Upland-Alder Mix	87%	0.74	2	1,000	700	60%	2.28	2	1,000	2,000	1,000	-27%
031_02	Blonde Creek	6	351	Upland	96%	0.23	3	1,000	200	70%	1.71	3	1,000	2,000	2,000	-26%
031_02	Blonde Creek	7	323	Upland	96%	0.23	3	1,000	200	80%	1.14	3	1,000	1,000	800	-16%
031_02	Blonde Creek	8	241	Upland	96%	0.23	3	700	200	70%	1.71	3	700	1,000	800	-26%
031_02	Burnt Creek	1	413	Upland	98%	0.11	1	400	50	40%	3.42	1	400	1,000	1,000	-58%
031_02	Burnt Creek	2	309	Upland	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
031_02	Burnt Creek	3	400	Upland	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
031_02	Burnt Creek	4	621	Upland	98%	0.11	1	600	70	70%	1.71	1	600	1,000	900	-28%
031_02	Burnt Creek	5	299	Upland	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
031_02	Burnt Creek	6	391	Upland	98%	0.11	2	800	90	50%	2.85	2	800	2,000	2,000	-48%
031_02	Burnt Creek	7	526	Upland	98%	0.11	2	1,000	100	60%	2.28	2	1,000	2,000	2,000	-38%
031_02	Burnt Creek	8	347	Upland	98%	0.11	2	700	80	70%	1.71	2	700	1,000	900	-28%
031_02	Burnt Creek	9	210	Upland	98%	0.11	2	400	50	60%	2.28	2	400	900	900	-38%
031_02	Burnt Creek	10	250	Upland	98%	0.11	2	500	60	70%	1.71	2	500	900	800	-28%
031_02	Burnt Creek	11	292	Upland	98%	0.11	2	600	70	80%	1.14	2	600	700	600	-18%
031_02	Burcham Creek	1	599	Upland	98%	0.11	1	600	70	70%	1.71	1	600	1,000	900	-28%
031_02	Burcham Creek	2	265	Upland-Alder Mix	92%	0.46	1	300	100	60%	2.28	1	300	700	600	-32%
031_02	Burcham Creek	3	213	Upland-Alder Mix	92%	0.46	1	200	90	50%	2.85	1	200	600	500	-42%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Burcham Creek	4	279	Upland-Alder Mix	92%	0.46	1	300	100	60%	2.28	1	300	700	600	-32%
031_02	Burcham Creek	5	113	Upland-Alder Mix	92%	0.46	1	100	50	70%	1.71	1	100	200	200	-22%
031_02	Burcham Creek	6	268	Upland-Alder Mix	87%	0.74	2	500	400	60%	2.28	2	500	1,000	600	-27%
031_02	Burcham Creek	7	244	Upland-Alder Mix	87%	0.74	2	500	400	70%	1.71	2	500	900	500	-17%
031_02	Burcham Creek	8	673	Upland-Alder Mix	87%	0.74	2	1,000	700	60%	2.28	2	1,000	2,000	1,000	-27%
031_02	Burcham Creek	9	596	Upland-Alder Mix	87%	0.74	2	1,000	700	50%	2.85	2	1,000	3,000	2,000	-37%
031_02	Burcham Creek	10	347	Upland-Alder Mix	74%	1.48	3	1,000	1,000	60%	2.28	3	1,000	2,000	1,000	-14%
031_02	Burcham Creek	11	308	Upland-Alder Mix	74%	1.48	3	900	1,000	50%	2.85	3	900	3,000	2,000	-24%
031_02	Burcham Creek	12	267	Upland-Alder Mix	74%	1.48	3	800	1,000	60%	2.28	3	800	2,000	1,000	-14%
031_02	Burcham Creek	13	282	Upland-Alder Mix	74%	1.48	3	800	1,000	50%	2.85	3	800	2,000	1,000	-24%
031_02	Burcham Creek_Trib 01	1	99	Upland	98%	0.11	1	100	10	90%	0.57	1	100	60	50	-8%
031_02	Burcham Creek_Trib 01	2	929	Upland	98%	0.11	1	900	100	80%	1.14	1	900	1,000	900	-18%
031_02	Burcham Creek_Trib 01	3	673	Upland-Alder Mix	92%	0.46	1	700	300	70%	1.71	1	700	1,000	700	-22%
031_02	Dan Lee Creek	1	1875	Upland	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
031_02	Dan Lee Creek	2	268	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Dan Lee Creek	3	327	Upland	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
031_02	Dan Lee Creek	4	186	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
031_02	Dan Lee Creek	5	209	Upland	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
031_02	Dan Lee Creek	6	461	Upland	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
031_02	Dan Lee Creek	7	848	Upland	98%	0.11	2	2,000	200	70%	1.71	2	2,000	3,000	3,000	-28%
031_02	Dan Lee Creek	8	644	Upland-Alder Mix	87%	0.74	2	1,000	700	40%	3.42	2	1,000	3,000	2,000	-47%
031_02	Dan Lee Creek	9	630	Upland-Alder Mix	87%	0.74	2	1,000	700	50%	2.85	2	1,000	3,000	2,000	-37%
031_02	Dan Lee Creek	10	186	Upland-Alder Mix	87%	0.74	2	400	300	60%	2.28	2	400	900	600	-27%
031_02	Dan Lee Creek	11	145	Upland-Alder Mix	87%	0.74	2	300	200	50%	2.85	2	300	900	700	-37%
031_02	Dan Lee Creek	12	141	Upland-Alder Mix	87%	0.74	2	300	200	70%	1.71	2	300	500	300	-17%
031_02	Dan Lee Creek	13	418	Upland-Alder Mix	87%	0.74	2	800	600	30%	3.99	2	800	3,000	2,000	-57%
031_02	Dan Lee Creek	14	366	Upland-Alder Mix	87%	0.74	2	700	500	50%	2.85	2	700	2,000	2,000	-37%
031_02	Jim Brown Creek	1	309	Upland-Alder Mix	92%	0.46	1	300	100	70%	1.71	1	300	500	400	-22%
031_02	Jim Brown Creek	2	386	Upland-Alder Mix	92%	0.46	1	400	200	80%	1.14	1	400	500	300	-12%
031_02	Jim Brown Creek	3	712	Upland-Alder Mix	92%	0.46	1	700	300	70%	1.71	1	700	1,000	700	-22%
031_02	Jim Brown Creek	4	146	Upland-Alder Mix	87%	0.74	2	300	200	50%	2.85	2	300	900	700	-37%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Jim Brown Creek	5	178	Upland-Alder Mix	87%	0.74	2	400	300	20%	4.56	2	400	2,000	2,000	-67%
031_02	Jim Brown Creek	6	796	Upland-Alder Mix	87%	0.74	2	2,000	1,000	20%	4.56	2	2,000	9,000	8,000	-67%
031_02	Jim Brown Creek	7	608	Upland-Alder Mix	74%	1.48	3	2,000	3,000	20%	4.56	3	2,000	9,000	6,000	-54%
031_02	Jim Brown Creek	8	442	Upland-Alder Mix	74%	1.48	3	1,000	1,000	60%	2.28	3	1,000	2,000	1,000	-14%
031_02	Jim Brown Creek	9	203	Upland-Alder Mix	61%	2.22	4	800	2,000	50%	2.85	4	800	2,000	0	-11%
031_02	Jim Brown Creek	10	268	Upland-Alder Mix	61%	2.22	4	1,000	2,000	60%	2.28	4	1,000	2,000	0	-1%
031_02	Jim Brown Creek	11	287	Upland-Alder Mix	61%	2.22	4	1,000	2,000	40%	3.42	4	1,000	3,000	1,000	-21%
031_02	Jim Brown Creek	12	546	Upland-Alder Mix	52%	2.74	5	3,000	8,000	30%	3.99	5	3,000	10,000	2,000	-22%
031_02	Jim Brown Creek	13	145	Upland-Alder Mix	52%	2.74	5	700	2,000	40%	3.42	5	700	2,000	0	-12%
031_02	Jim Brown Creek	14	582	Upland-Alder Mix	52%	2.74	5	3,000	8,000	20%	4.56	5	3,000	10,000	2,000	-32%
031_02	Jim Brown Creek_Trib 01	1	315	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
031_02	Jim Brown Creek_Trib 01	2	264	Upland	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
031_02	Jim Brown Creek_Trib 01	3	389	Upland	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
031_02	Jim Brown Creek_Trib 01	4	832	Upland-Alder Mix	87%	0.74	2	2,000	1,000	60%	2.28	2	2,000	5,000	4,000	-27%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Jim Brown Creek_Trib 01	5	372	Upland-Alder Mix	87%	0.74	2	700	500	50%	2.85	2	700	2,000	2,000	-37%
031_02	Jim Brown Creek_Trib 01	6	79	Upland-Alder Mix	87%	0.74	2	200	100	20%	4.56	2	200	900	800	-67%
031_02	Jim Brown Creek_Trib 02	1	180	Upland-Alder Mix	92%	0.46	1	200	90	80%	1.14	1	200	200	100	-12%
031_02	Jim Brown Creek_Trib 02	2	449	Upland-Alder Mix	92%	0.46	1	400	200	60%	2.28	1	400	900	700	-32%
031_02	Jim Brown Creek_Trib 02	3	181	Upland-Alder Mix	92%	0.46	1	200	90	70%	1.71	1	200	300	200	-22%
031_02	Jim Brown Creek_Trib 02	4	164	Upland-Alder Mix	92%	0.46	1	200	90	50%	2.85	1	200	600	500	-42%
031_02	Jim Brown Creek_Trib 02	5	225	Upland-Alder Mix	92%	0.46	1	200	90	60%	2.28	1	200	500	400	-32%
031_02	Jim Brown Creek_Trib 02	6	119	Upland-Alder Mix	92%	0.46	1	100	50	50%	2.85	1	100	300	300	-42%
031_02	Jim Brown Creek_Trib 02	7	241	Upland-Alder Mix	92%	0.46	1	200	90	70%	1.71	1	200	300	200	-22%
031_02	Jim Brown Creek_Trib 02	8	150	Upland-Alder Mix	87%	0.74	2	300	200	60%	2.28	2	300	700	500	-27%
031_02	Jim Brown Creek_Trib 02	9	105	Upland-Alder Mix	87%	0.74	2	200	100	70%	1.71	2	200	300	200	-17%
031_02	Jim Brown Creek_Trib 02	10	98	Upland-Alder Mix	87%	0.74	2	200	100	60%	2.28	2	200	500	400	-27%
031_02	Jim Brown Creek_Trib 02	11	562	Upland-Alder Mix	87%	0.74	2	1,000	700	70%	1.71	2	1,000	2,000	1,000	-17%
031_02	Jim Brown Creek_Trib 02	12	346	Upland-Alder Mix	87%	0.74	2	700	500	80%	1.14	2	700	800	300	-7%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Jim Brown Creek_Trib 02	13	425	Upland-Alder Mix	87%	0.74	2	900	700	60%	2.28	2	900	2,000	1,000	-27%
031_02	Lost Creek	1	224	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
031_02	Lost Creek	2	315	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
031_02	Lost Creek	3	225	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
031_02	Lost Creek	4	314	Upland-Alder Mix	92%	0.46	1	300	100	60%	2.28	1	300	700	600	-32%
031_02	Lost Creek	5	315	Upland-Alder Mix	92%	0.46	1	300	100	50%	2.85	1	300	900	800	-42%
031_02	Lost Creek	6	141	Upland-Alder Mix	92%	0.46	1	100	50	70%	1.71	1	100	200	200	-22%
031_02	Lost Creek	7	169	Upland-Alder Mix	92%	0.46	1	200	90	50%	2.85	1	200	600	500	-42%
031_02	Lost Creek	8	134	Upland-Alder Mix	92%	0.46	1	100	50	20%	4.56	1	100	500	500	-72%
031_02	Lost Creek	9	35	Upland-Alder Mix	92%	0.46	1	40	20	20%	4.56	1	40	200	200	-72%
031_02	Mosquito Creek	1	739	Upland	98%	0.11	1	700	80	80%	1.14	1	700	800	700	-18%
031_02	Mosquito Creek	2	199	Upland	98%	0.11	1	200	20	40%	3.42	1	200	700	700	-58%
031_02	Mosquito Creek	3	291	Upland	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
031_02	Mosquito Creek	4	184	Upland-Alder Mix	92%	0.46	1	200	90	30%	3.99	1	200	800	700	-62%
031_02	Mosquito Creek	5	342	Upland-Alder Mix	87%	0.74	2	700	500	20%	4.56	2	700	3,000	3,000	-67%
031_02	Mosquito Creek	6	408	Upland-Alder Mix	87%	0.74	2	800	600	40%	3.42	2	800	3,000	2,000	-47%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Mosquito Creek	7	327	Upland-Alder Mix	87%	0.74	2	700	500	40%	3.42	2	700	2,000	2,000	-47%
031_02	Mosquito Creek	8	383	Upland-Alder Mix	87%	0.74	2	800	600	20%	4.56	2	800	4,000	3,000	-67%
031_02	Mosquito Creek	9	669	Upland-Alder Mix	74%	1.48	3	2,000	3,000	40%	3.42	3	2,000	7,000	4,000	-34%
031_02	Mosquito Creek	10	311	Upland-Alder Mix	74%	1.48	3	900	1,000	0%	5.70	3	900	5,000	4,000	-74%
031_02	Mosquito Creek	11	436	Upland-Alder Mix	74%	1.48	3	1,000	1,000	30%	3.99	3	1,000	4,000	3,000	-44%
031_02	Mosquito Creek	12	177	Upland-Alder Mix	74%	1.48	3	500	700	0%	5.70	3	500	3,000	2,000	-74%
031_02	Mosquito Creek_Trib 01	1	94	Upland	98%	0.11	1	90	10	70%	1.71	1	90	200	200	-28%
031_02	Mosquito Creek_Trib 01	2	315	Upland	98%	0.11	1	300	30	50%	2.85	1	300	900	900	-48%
031_02	Mosquito Creek_Trib 01	3	183	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
031_02	Mosquito Creek_Trib 01	4	183	Upland-Alder Mix	92%	0.46	1	200	90	60%	2.28	1	200	500	400	-32%
031_02	Mosquito Creek_Trib 01	5	290	Upland-Alder Mix	87%	0.74	2	600	400	10%	5.13	2	600	3,000	3,000	-77%
031_02	Mosquito Creek_Trib 01	6	310	Upland-Alder Mix	87%	0.74	2	600	400	30%	3.99	2	600	2,000	2,000	-57%
031_02	Mosquito Creek_Trib 01	7	318	Upland-Alder Mix	87%	0.74	2	600	400	50%	2.85	2	600	2,000	2,000	-37%
031_02	Musselshell Creek_Trib 03	1	269	Upland	98%	0.11	1	300	30	30%	3.99	1	300	1,000	1,000	-68%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Musselshell Creek_Trib 03	2	270	Upland	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
031_02	Musselshell Creek_Trib 03	3	569	Upland	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
031_02	Musselshell Creek_Trib 03	4	306	Upland	98%	0.11	1	300	30	20%	4.56	1	300	1,000	1,000	-78%
031_02	Musselshell Creek_Trib 03	5	430	Upland	98%	0.11	2	900	100	70%	1.71	2	900	2,000	2,000	-28%
031_02	Musselshell Creek_Trib 03	6	878	Upland	98%	0.11	2	2,000	200	60%	2.28	2	2,000	5,000	5,000	-38%
031_02	Pierson Creek	1	135	Upland	98%	0.11	1	100	10	80%	1.14	1	100	100	90	-18%
031_02	Pierson Creek	2	269	Upland	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
031_02	Pierson Creek	3	1040	Upland	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
031_02	Pierson Creek	4	250	Upland	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
031_02	Pierson Creek	5	762	Upland-Alder Mix	92%	0.46	1	800	400	40%	3.42	1	800	3,000	3,000	-52%
031_02	Pierson Creek	6	409	Upland-Alder Mix	87%	0.74	2	800	600	70%	1.71	2	800	1,000	400	-17%
031_02	Pierson Creek	7	761	Upland-Alder Mix	87%	0.74	2	2,000	1,000	60%	2.28	2	2,000	5,000	4,000	-27%
031_02	Pierson Creek	8	251	Upland-Alder Mix	87%	0.74	2	500	400	50%	2.85	2	500	1,000	600	-37%
031_02	Pierson Creek	9	271	Upland-Alder Mix	87%	0.74	2	500	400	10%	5.13	2	500	3,000	3,000	-77%
031_02	Slate Creek	1	270	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
031_02	Slate Creek	2	405	Upland-Alder Mix	92%	0.46	1	400	200	30%	3.99	1	400	2,000	2,000	-62%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Slate Creek	3	257	Upland-Alder Mix	92%	0.46	1	300	100	40%	3.42	1	300	1,000	900	-52%
031_02	Slate Creek	4	312	Upland-Alder Mix	92%	0.46	1	300	100	30%	3.99	1	300	1,000	900	-62%
031_02	Slate Creek	5	390	Upland-Alder Mix	92%	0.46	1	400	200	50%	2.85	1	400	1,000	800	-42%
031_02	Slate Creek	6	428	Upland	98%	0.11	2	900	100	60%	2.28	2	900	2,000	2,000	-38%
031_02	Slate Creek	7	204	Upland-Alder Mix	87%	0.74	2	400	300	30%	3.99	2	400	2,000	2,000	-57%
031_02	Slate Creek	8	282	Upland-Alder Mix	87%	0.74	2	600	400	50%	2.85	2	600	2,000	2,000	-37%
031_02	Slate Creek	9	399	Upland	98%	0.11	2	800	90	60%	2.28	2	800	2,000	2,000	-38%
031_02	Slate Creek	10	509	Upland	98%	0.11	2	1,000	100	70%	1.71	2	1,000	2,000	2,000	-28%
031_02	Sourdough Creek	1	234	Upland-Alder Mix	92%	0.46	1	200	90	70%	1.71	1	200	300	200	-22%
031_02	Sourdough Creek	2	361	Upland-Alder Mix	92%	0.46	1	400	200	60%	2.28	1	400	900	700	-32%
031_02	Sourdough Creek	3	1292	Upland-Alder Mix	87%	0.74	2	3,000	2,000	70%	1.71	2	3,000	5,000	3,000	-17%
031_02	Swede Creek	1	973	Upland	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
031_02	Swede Creek	2	490	Upland	98%	0.11	1	500	60	90%	0.57	1	500	300	200	-8%
031_02	Swede Creek	3	511	Upland	98%	0.11	2	1,000	100	80%	1.14	2	1,000	1,000	900	-18%
031_02	Swede Creek	4	254	Upland	98%	0.11	2	500	60	90%	0.57	2	500	300	200	-8%
031_02	Swede Creek	5	269	Upland	98%	0.11	2	500	60	80%	1.14	2	500	600	500	-18%
031_02	Swede Creek	6	756	Upland	98%	0.11	2	2,000	200	90%	0.57	2	2,000	1,000	800	-8%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_02	Swede Creek	7	252	Upland	96%	0.23	3	800	200	80%	1.14	3	800	900	700	-16%
031_02	Swede Creek	8	407	Upland-Alder Mix	74%	1.48	3	1,000	1,000	70%	1.71	3	1,000	2,000	1,000	-4%
031_02	Swede Creek	9	192	Upland-Alder Mix	74%	1.48	3	600	900	50%	2.85	3	600	2,000	1,000	-24%
031_02	Swede Creek	10	255	Upland-Alder Mix	74%	1.48	3	800	1,000	60%	2.28	3	800	2,000	1,000	-14%
031_02	Swede Creek	11	86	Upland-Alder Mix	74%	1.48	3	300	400	30%	3.99	3	300	1,000	600	-44%
031_02	Swede Creek	12	272	Upland-Alder Mix	74%	1.48	3	800	1,000	70%	1.71	3	800	1,000	0	-4%
031_02	Swede Creek	13	282	Upland-Alder Mix	74%	1.48	3	800	1,000	50%	2.85	3	800	2,000	1,000	-24%
031_02	Swede Creek	14	294	Upland-Alder Mix	61%	2.22	4	1,000	2,000	60%	2.28	4	1,000	2,000	0	-1%
031_02	Swede Creek	15	1353	Upland-Alder Mix	61%	2.22	4	5,000	10,000	10%	5.13	4	5,000	30,000	20,000	-51%
031_02	Weaver Creek	1	995	Breakland	95%	0.29	1	1,000	300	90%	0.57	1	1,000	600	300	-5%
031_02	Weaver Creek	2	702	Upland	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
031_02	Weaver Creek	3	410	Upland	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
031_02	Weaver Creek	4	887	Upland-Alder Mix	92%	0.46	1	900	400	60%	2.28	1	900	2,000	2,000	-32%
031_02	Weaver Creek	5	131	Upland-Alder Mix	87%	0.74	2	300	200	70%	1.71	2	300	500	300	-17%
031_02	Weaver Creek	6	379	Upland-Alder Mix	87%	0.74	2	800	600	60%	2.28	2	800	2,000	1,000	-27%
031_02	Weaver Creek	7	174	Upland-Alder	87%	0.74	2	300	200	70%	1.71	2	300	500	300	-17%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
				Mix												
031_02	Weaver Creek	8	152	Upland-Alder Mix	87%	0.74	2	300	200	50%	2.85	2	300	900	700	-37%
031_02	Weaver Creek	9	80	Upland-Alder Mix	87%	0.74	2	200	100	70%	1.71	2	200	300	200	-17%
031_02	Weaver Creek	10	221	Upland-Alder Mix	87%	0.74	2	400	300	60%	2.28	2	400	900	600	-27%
031_02	Weaver Creek	11	126	Upland-Alder Mix	87%	0.74	2	300	200	70%	1.71	2	300	500	300	-17%
031_02	Weaver Creek	12	198	Upland-Alder Mix	87%	0.74	2	400	300	50%	2.85	2	400	1,000	700	-37%
031_02	Weaver Creek	13	290	Upland-Alder Mix	87%	0.74	2	600	400	60%	2.28	2	600	1,000	600	-27%
031_02	Weaver Creek	14	238	Upland-Alder Mix	87%	0.74	2	500	400	60%	2.28	2	500	1,000	600	-27%
031_02	Weaver Creek	15	142	Upland-Alder Mix	87%	0.74	2	300	200	70%	1.71	2	300	500	300	-17%
031_02	Weaver Creek	16	652	Upland-Alder Mix	74%	1.48	3	2,000	3,000	50%	2.85	3	2,000	6,000	3,000	-24%
031_02	Weaver Creek	17	434	Upland-Alder Mix	74%	1.48	3	1,000	1,000	70%	1.71	3	1,000	2,000	1,000	-4%
031_02	Weaver Creek	18	1478	Upland-Alder Mix	74%	1.48	3	4,000	6,000	60%	2.28	3	4,000	9,000	3,000	-14%
031_02	Weaver Creek	19	205	Upland-Alder Mix	74%	1.48	3	600	900	10%	5.13	3	600	3,000	2,000	-64%
							Totals		110,000					360,000	250,000	

Table D3. Existing and target solar loads for Jim Brown Creek (ID17060306CL031_03).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_03	Jim Brown Creek	15	627	Upland-Alder Mix	46%	3.08	6	4,000	10,000	10%	5.13	6	4,000	20,000	10,000	-36%
031_03	Jim Brown Creek	16	213	Upland-Alder Mix	46%	3.08	6	1,000	3,000	30%	3.99	6	1,000	4,000	1,000	-16%
031_03	Jim Brown Creek	17	295	Upland-Alder Mix	46%	3.08	6	2,000	6,000	10%	5.13	6	2,000	10,000	4,000	-36%
031_03	Jim Brown Creek	18	336	Upland-Alder Mix	46%	3.08	6	2,000	6,000	20%	4.56	6	2,000	9,000	3,000	-26%
031_03	Jim Brown Creek	19	902	Upland-Alder Mix	41%	3.36	7	6,000	20,000	10%	5.13	7	6,000	30,000	10,000	-31%
031_03	Jim Brown Creek	20	27	Upland-Alder Mix	41%	3.36	7	200	700	0%	5.70	7	200	1,000	300	-41%
031_03	Jim Brown Creek	21	154	Upland-Alder Mix	41%	3.36	7	1,000	3,000	10%	5.13	7	1,000	5,000	2,000	-31%
031_03	Jim Brown Creek	22	535	Upland-Alder Mix	41%	3.36	7	4,000	10,000	20%	4.56	7	4,000	20,000	10,000	-21%
031_03	Jim Brown Creek	23	791	Upland-Alder Mix	37%	3.59	8	6,000	20,000	10%	5.13	8	6,000	30,000	10,000	-27%
031_03	Jim Brown Creek	24	586	Upland-Alder Mix	37%	3.59	8	5,000	20,000	20%	4.56	8	5,000	20,000	0	-17%
031_03	Jim Brown Creek	25	303	Upland-Alder Mix	37%	3.59	8	2,000	7,000	0%	5.70	8	2,000	10,000	3,000	-37%
031_03	Jim Brown Creek	26	1078	Upland-Alder Mix	33%	3.82	9	10,000	40,000	0%	5.70	9	10,000	60,000	20,000	-33%
031_03	Jim Brown Creek	27	160	Upland-Alder Mix	33%	3.82	9	1,000	4,000	0%	5.70	9	1,000	6,000	2,000	-33%
031_03	Jim Brown Creek	28	918	Upland-Alder Mix	33%	3.82	9	8,000	30,000	0%	5.70	9	8,000	50,000	20,000	-33%
031_03	Jim Brown Creek	29	149	Upland-Alder Mix	33%	3.82	9	1,000	4,000	20%	4.56	9	1,000	5,000	1,000	-13%
031_03	Jim Brown Creek	30	808	Upland-Alder Mix	31%	3.93	10	8,000	30,000	10%	5.13	10	8,000	40,000	10,000	-21%
031_03	Jim Brown Creek	31	233	Upland-Alder Mix	31%	3.93	10	2,000	8,000	0%	5.70	10	2,000	10,000	2,000	-31%
031_03	Jim Brown Creek	32	83	Upland-Alder Mix	31%	3.93	10	800	3,000	10%	5.13	10	800	4,000	1,000	-21%
031_03	Jim Brown Creek	33	69	Upland-Alder Mix	31%	3.93	10	700	3,000	20%	4.56	10	700	3,000	0	-11%
031_03	Jim Brown Creek	34	165	Upland-Alder Mix	31%	3.93	10	2,000	8,000	10%	5.13	10	2,000	10,000	2,000	-21%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
031_03	Jim Brown Creek	35	296	Upland-Alder Mix	31%	3.93	10	3,000	10,000	0%	5.70	10	3,000	20,000	10,000	-31%
031_03	Jim Brown Creek	36	59	Upland-Alder Mix	31%	3.93	10	600	2,000	10%	5.13	10	600	3,000	1,000	-21%
031_03	Jim Brown Creek	37	86	Upland-Alder Mix	31%	3.93	10	900	4,000	20%	4.56	10	900	4,000	0	-11%
							Totals		250,000					370,000	120,000	

Table D4. Existing and target solar loads for Musselshell Creek (ID17060306CL032_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
032_02	Alder Creek	1	540	Breakland	95%	0.29	1	500	100	90%	0.57	1	500	300	200	0%
032_02	Alder Creek	2	649	Upland	98%	0.11	1	600	70	90%	0.57	1	600	300	200	-8%
032_02	Alder Creek	3	1249	Upland	98%	0.11	2	2,000	200	80%	1.14	2	2,000	2,000	2,000	-18%
032_02	Alder Creek	4	679	Upland	98%	0.11	2	1,000	100	70%	1.71	2	1,000	2,000	2,000	-28%
032_02	Cole Creek	1	225	Breakland	95%	0.29	1	200	60	70%	1.71	1	200	300	200	-25%
032_02	Cole Creek	2	781	Upland	98%	0.11	1	800	90	80%	1.14	1	800	900	800	-18%
032_02	Cole Creek	3	476	Upland	98%	0.11	1	500	60	90%	0.57	1	500	300	200	-8%
032_02	Cole Creek	4	1146	Upland	98%	0.11	2	2,000	200	80%	1.14	2	2,000	2,000	2,000	-18%
032_02	Cole Creek	5	405	Upland	98%	0.11	2	800	90	90%	0.57	2	800	500	400	-8%
032_02	Deer Gulch	1	943	Upland	95%	0.29	1	900	300	90%	0.57	1	900	500	200	-5%
032_02	Deer Gulch	2	210	Upland-Alder Mix	92%	0.46	1	200	90	50%	2.85	1	200	600	500	-42%
032_02	Deer Gulch	3	505	Upland-Alder Mix	92%	0.46	1	500	200	30%	3.99	1	500	2,000	2,000	-62%
032_02	Deer Gulch	4	147	Upland-Alder Mix	87%	0.74	2	300	200	50%	2.85	2	300	900	700	-37%
032_02	Deer Gulch	5	1318	Upland-Alder Mix	87%	0.74	2	3,000	2,000	40%	3.42	2	3,000	10,000	8,000	-47%
032_02	Dewey Creek	1	2160	Breakland	95%	0.29	1	2,000	600	90%	0.57	1	2,000	1,000	400	-5%
032_02	Dewey Creek	2	587	Upland	98%	0.11	2	1,000	100	80%	1.14	2	1,000	1,000	900	-18%
032_02	Gold Creek	1	1515	Upland	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
032_02	Gold Creek	2	344	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
032_02	Gold Creek	3	239	Upland	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
032_02	Gold Creek	4	320	Upland	98%	0.11	2	600	70	60%	2.28	2	600	1,000	900	-38%
032_02	Gold Creek	5	236	Upland	98%	0.11	2	500	60	80%	1.14	2	500	600	500	-18%
032_02	Gold Creek	6	1065	Upland	98%	0.11	2	2,000	200	60%	2.28	2	2,000	5,000	5,000	-38%
032_02	Gold Creek	7	345	Upland	98%	0.11	2	700	80	70%	1.71	2	700	1,000	900	-28%
032_02	Gold Creek	8	361	Upland	96%	0.23	3	1,000	200	60%	2.28	3	1,000	2,000	2,000	-36%
032_02	Gold Creek	9	519	Upland	96%	0.23	3	2,000	500	80%	1.14	3	2,000	2,000	2,000	-16%
032_02	Gold Creek	10	908	Upland	96%	0.23	3	3,000	700	60%	2.28	3	3,000	7,000	6,000	-36%
032_02	Gold Creek	11	319	Upland-Alder Mix	74%	1.48	3	1,000	1,000	50%	2.85	3	1,000	3,000	2,000	-24%
032_02	Greer Gulch	1	675	Breakland	95%	0.29	1	700	200	90%	0.57	1	700	400	200	-5%
032_02	Greer Gulch	2	1575	Upland	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
032_02	Greer Gulch	3	735	Upland	98%	0.11	2	1,000	100	70%	1.71	2	1,000	2,000	2,000	-28%
032_02	Greer Gulch	4	901	Upland	98%	0.11	2	2,000	200	80%	1.14	2	2,000	2,000	2,000	-18%
032_02	Johnson Draw	1	630	Upland	98%	0.11	1	600	70	90%	0.57	1	600	300	200	-8%
032_02	Johnson Draw	2	110	Upland	98%	0.11	1	100	10	60%	2.28	1	100	200	200	-38%
032_02	Johnson Draw	3	243	Upland	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
032_02	Musselshell Creek	1	907	Breakland	95%	0.29	1	900	300	90%	0.57	1	900	500	200	-5%
032_02	Musselshell Creek	2	1205	Upland	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
032_02	Musselshell Creek	3	1072	Upland	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
032_02	Musselshell Creek	4	890	Upland	98%	0.11	2	2,000	200	90%	0.57	2	2,000	1,000	800	-8%
032_02	Musselshell Creek	5	306	Upland	98%	0.11	2	600	70	80%	1.14	2	600	700	600	-18%
032_02	Musselshell Creek	6	748	Upland	98%	0.11	2	1,000	100	80%	1.14	2	1,000	1,000	900	-18%
032_02	Musselshell Creek	7	1137	Upland	98%	0.11	2	2,000	200	70%	1.71	2	2,000	3,000	3,000	-28%
032_02	Musselshell Creek	8	335	Upland	96%	0.23	3	1,000	200	90%	0.57	3	1,000	600	400	-6%
032_02	Musselshell Creek	9	698	Upland	96%	0.23	3	2,000	500	80%	1.14	3	2,000	2,000	2,000	-16%
032_02	Musselshell Creek	10	287	Upland	96%	0.23	3	900	200	90%	0.57	3	900	500	300	-6%
032_02	Musselshell Creek	11	69	Upland	96%	0.23	3	200	50	70%	1.71	3	200	300	300	-26%
032_02	Musselshell Creek	12	175	Upland	96%	0.23	3	500	100	70%	1.71	3	500	900	800	-26%
032_02	Musselshell Creek	13	392	Upland	96%	0.23	3	1,000	200	40%	3.42	3	1,000	3,000	3,000	-56%
032_02	Musselshell Creek	14	182	Upland	96%	0.23	3	500	100	60%	2.28	3	500	1,000	900	-36%
032_02	Musselshell Creek	15	140	Upland	94%	0.34	4	600	200	50%	2.85	4	600	2,000	2,000	-44%
032_02	Musselshell Creek	16	194	Upland	94%	0.34	4	800	300	60%	2.28	4	800	2,000	2,000	-34%
032_02	Musselshell Creek	17	165	Upland	94%	0.34	4	700	200	80%	1.14	4	700	800	600	-14%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
032_02	Musselshell Creek	18	295	Upland	94%	0.34	4	1,000	300	70%	1.71	4	1,000	2,000	2,000	-24%
032_02	Musselshell Creek	19	158	Upland	94%	0.34	4	600	200	70%	1.71	4	600	1,000	800	-24%
032_02	Musselshell Creek	20	964	Upland-Alder Mix	61%	2.22	4	4,000	9,000	60%	2.28	4	4,000	9,000	0	-1%
032_02	Musselshell Creek	21	618	Upland-Alder Mix	52%	2.74	5	3,000	8,000	40%	3.42	5	3,000	10,000	2,000	-12%
032_02	Musselshell Creek	22	208	Upland-Alder Mix	52%	2.74	5	1,000	3,000	60%	2.28	5	1,000	2,000	(1,000)	8%
032_02	Musselshell Creek	23	790	Upland-Alder Mix	52%	2.74	5	4,000	10,000	40%	3.42	5	4,000	10,000	0	-12%
032_02	Musselshell Creek	24	218	Upland-Alder Mix	52%	2.74	5	1,000	3,000	60%	2.28	5	1,000	2,000	(1,000)	8%
032_02	Musselshell Creek	25	723	Upland-Alder Mix	52%	2.74	5	4,000	10,000	40%	3.42	5	4,000	10,000	0	-12%
032_02	Musselshell Creek	26	64	Upland-Alder Mix	46%	3.08	6	400	1,000	60%	2.28	6	400	900	(100)	14%
032_02	Musselshell Creek	27	218	Upland-Alder Mix	46%	3.08	6	1,000	3,000	60%	2.28	6	1,000	2,000	(1,000)	14%
032_02	Musselshell Creek	28	102	Upland-Alder Mix	46%	3.08	6	600	2,000	40%	3.42	6	600	2,000	0	-6%
032_02	Musselshell Creek	29	178	Upland-Alder Mix	46%	3.08	6	1,000	3,000	60%	2.28	6	1,000	2,000	(1,000)	14%
032_02	Musselshell Creek	30	677	Upland-Alder Mix	46%	3.08	6	4,000	10,000	50%	2.85	6	4,000	10,000	0	4%
032_02	Musselshell Creek	31	393	Upland-Alder Mix	46%	3.08	6	2,000	6,000	40%	3.42	6	2,000	7,000	1,000	-6%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
032_02	Musselshell Creek	32	264	Upland-Alder Mix	46%	3.08	6	2,000	6,000	30%	3.99	6	2,000	8,000	2,000	-16%
032_02	Musselshell Creek	33	117	Upland-Alder Mix	46%	3.08	6	700	2,000	50%	2.85	6	700	2,000	0	4%
032_02	Musselshell Creek	34	944	Upland-Alder Mix	41%	3.36	7	7,000	20,000	40%	3.42	7	7,000	20,000	0	-1%
032_02	Musselshell Creek	35	527	Upland-Alder Mix	41%	3.36	7	4,000	10,000	10%	5.13	7	4,000	20,000	10,000	-31%
032_02	Musselshell Creek	36	1361	Upland-Alder Mix	41%	3.36	7	10,000	30,000	20%	4.56	7	10,000	50,000	20,000	-21%
032_02	Musselshell Creek	37	627	Upland-Alder Mix	37%	3.59	8	5,000	20,000	20%	4.56	8	5,000	20,000	0	-17%
032_02	Musselshell Creek	38	244	Upland-Alder Mix	37%	3.59	8	2,000	7,000	10%	5.13	8	2,000	10,000	3,000	-27%
032_02	Musselshell Creek	39	182	Upland-Alder Mix	37%	3.59	8	1,000	4,000	20%	4.56	8	1,000	5,000	1,000	-17%
032_02	Musselshell Creek	40	229	Upland-Alder Mix	37%	3.59	8	2,000	7,000	10%	5.13	8	2,000	10,000	3,000	-27%
032_02	Musselshell Creek	41	85	Upland-Alder Mix	37%	3.59	8	700	3,000	20%	4.56	8	700	3,000	0	-17%
032_02	Musselshell Creek	42	199	Upland-Alder Mix	37%	3.59	8	2,000	7,000	10%	5.13	8	2,000	10,000	3,000	-27%
032_02	Musselshell Creek	43	822	Upland-Alder Mix	37%	3.59	8	7,000	30,000	20%	4.56	8	7,000	30,000	0	-17%
032_02	Musselshell Creek_Trib 01	1	601	Upland	98%	0.11	1	600	70	50%	2.85	1	600	2,000	2,000	-48%
032_02	Musselshell Creek_Trib 01	2	783	Upland	98%	0.11	1	800	90	60%	2.28	1	800	2,000	2,000	-38%

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
032_02	Musselshell Creek_Trib 01	3	305	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
032_02	Musselshell Creek_Trib 02	1	975	Upland	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
032_02	Musselshell Creek_Trib 02	2	662	Upland	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
032_02	Nelson Creek	1	422	Upland	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%
032_02	Nelson Creek	2	1481	Upland	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
032_02	Winter Draw	1	362	Upland	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%
032_02	Winter Draw	2	229	Upland	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
032_02	Winter Draw	3	335	Upland	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
032_02	Winter Draw	4	297	Upland	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
							Totals		230,000					340,000	120,000	

Table D5. Existing and target solar loads for Musselshell Creek (ID17060306CL032_03).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
032_03	Musselshell Creek	44	556	Upland-Alder Mix	33%	3.82	9	5,000	20,000	10%	5.13	9	5,000	30,000	10,000	-23%
032_03	Musselshell Creek	45	952	Breakland	54%	2.62	9	9,000	20,000	20%	4.56	9	9,000	40,000	20,000	-34%
032_03	Musselshell Creek	46	1357	Breakland	48%	2.96	10	10,000	30,000	20%	4.56	10	10,000	50,000	20,000	-28%
032_03	Musselshell Creek	47	1310	Breakland	45%	3.14	11	10,000	30,000	20%	4.56	11	10,000	50,000	20,000	-25%
032_03	Musselshell Creek	48	175	Breakland	42%	3.31	12	2,000	7,000	10%	5.13	12	2,000	10,000	3,000	-32%
032_03	Musselshell Creek	49	602	Breakland	42%	3.31	12	7,000	20,000	20%	4.56	12	7,000	30,000	10,000	-22%
032_03	Musselshell Creek	50	283	Breakland	42%	3.31	12	3,000	10,000	40%	3.42	12	3,000	10,000	0	-2%
032_03	Musselshell Creek	51	891	Breakland	40%	3.42	13	10,000	30,000	50%	2.85	13	10,000	30,000	0	10%
032_03	Musselshell Creek	52	840	Breakland	38%	3.53	14	10,000	40,000	50%	2.85	14	10,000	30,000	(10,000)	12%
							Totals		210,000					280,000	73,000	

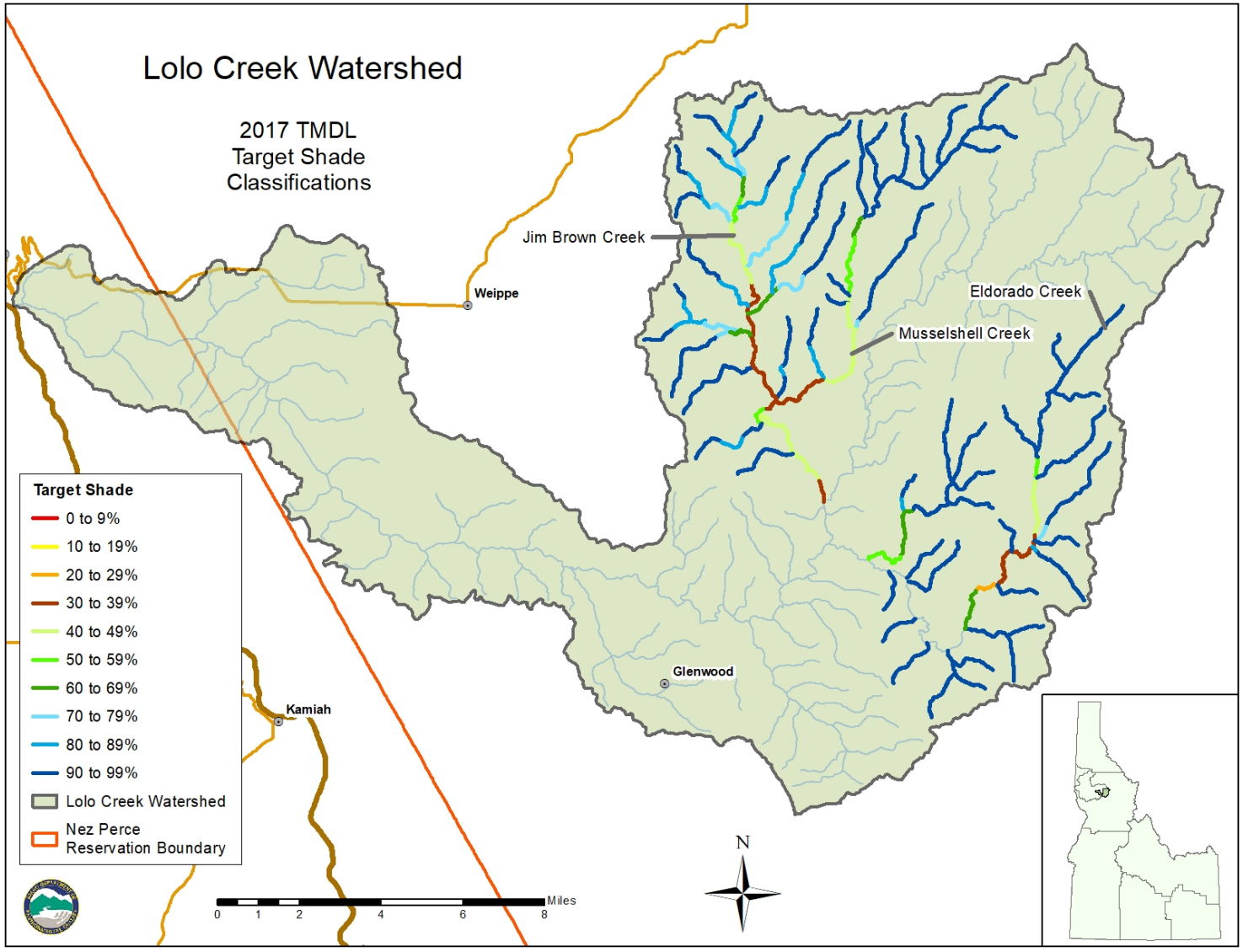


Figure D1. Target shade for Lolo Creek watershed.

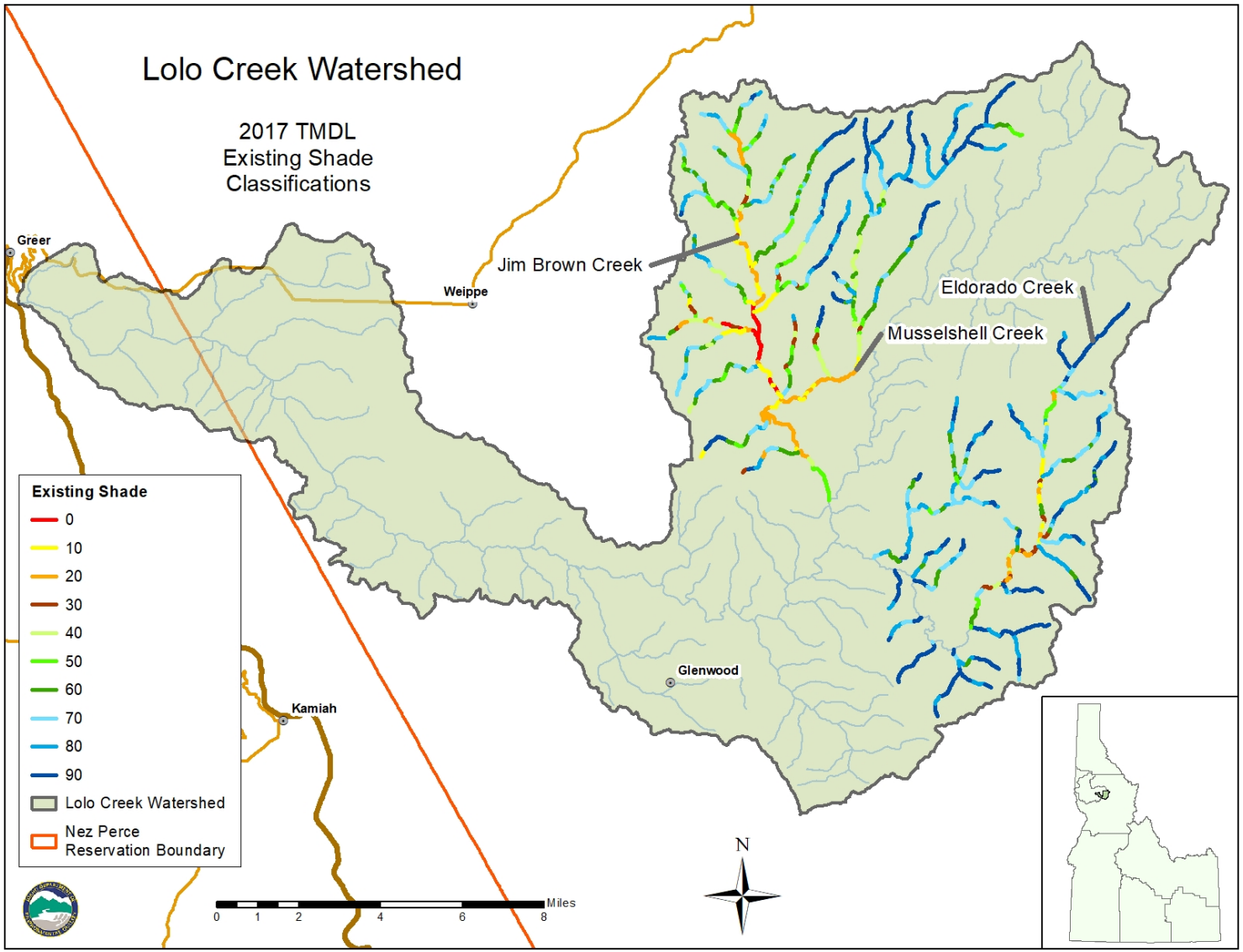


Figure D2. Existing shade values in the Lolo Creek watershed.

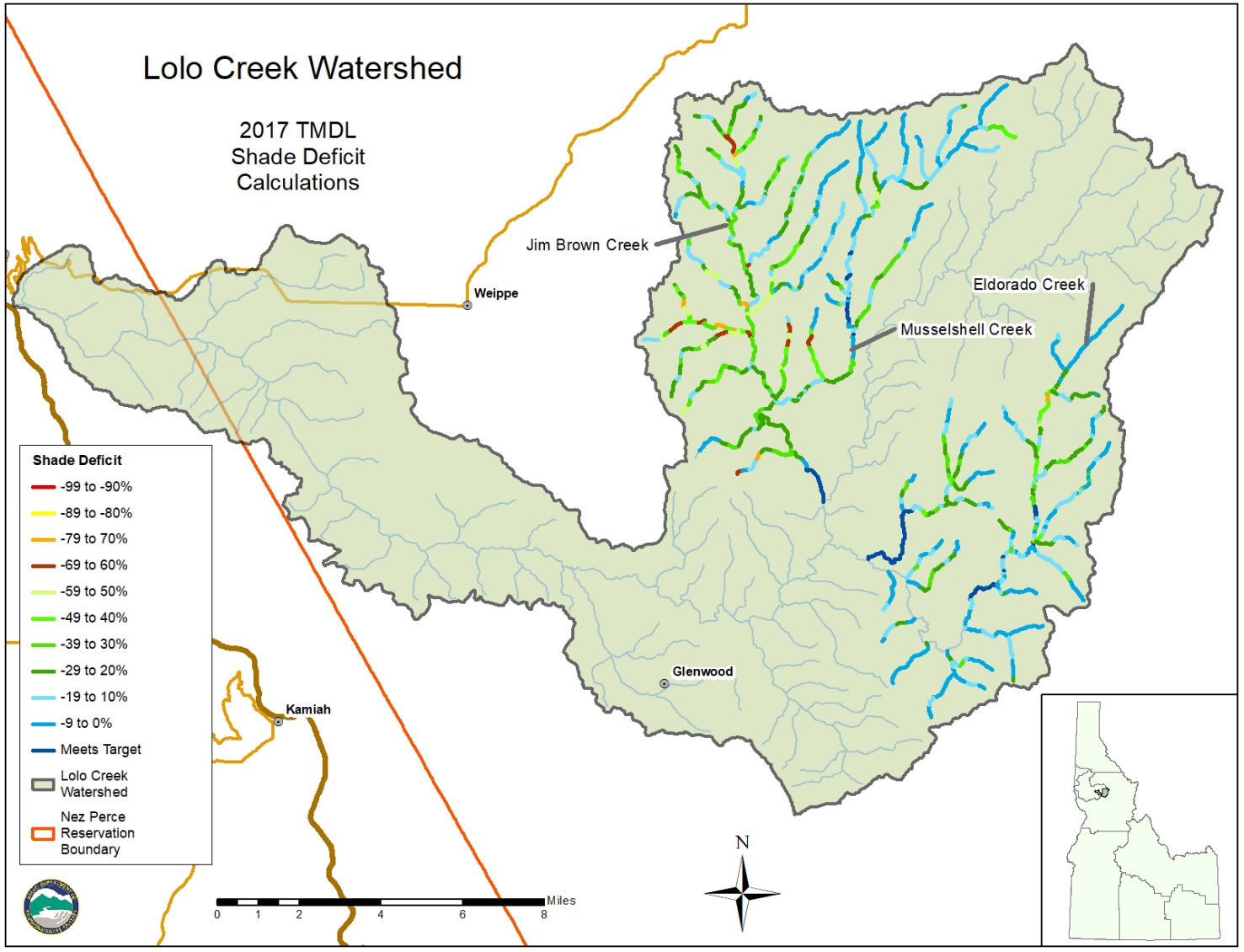


Figure D3. Lack of shade (difference between existing and target) for Lolo Creek watershed.

Appendix E. Managing Stormwater

Municipal Separate Storm Sewer Systems

Polluted stormwater runoff is commonly transported through municipal separate storm sewer systems (MS4s), from which it is often discharged untreated into local water bodies. An MS4, according to 40 CFR 122.26(b)(8), is a conveyance or system of conveyances that meets the following criteria:

- Owned by a state, city, town, village, or other public entity that discharges to waters of the United States
- Designed or used to collect or convey stormwater (including storm drains, pipes, ditches, etc.)
- Not a combined sewer
- Not part of a publicly owned treatment works (sewage treatment plant)

To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a National Pollutant Discharge Elimination System (NPDES) permit from the US Environmental Protection Agency (EPA), implement a comprehensive municipal stormwater management program (SWMP), and use best management practices (BMPs) to control pollutants in stormwater discharges to the maximum extent practicable.

Industrial Stormwater Requirements

Stormwater runoff picks up industrial pollutants and typically discharges them into nearby water bodies directly or indirectly via storm sewer systems. When facility practices allow exposure of industrial materials to stormwater, runoff from industrial areas can contain toxic pollutants (e.g., heavy metals and organic chemicals) and other pollutants such as trash, debris, and oil and grease. This increased flow and pollutant load can impair water bodies, degrade biological habitats, pollute drinking water sources, and cause flooding and hydrologic changes, such as channel erosion, to the receiving water body.

Multi-Sector General Permit and Stormwater Pollution Prevention Plans

In Idaho, if an industrial facility discharges industrial stormwater into waters of the US, the facility must be permitted under EPA's most recent Multi-Sector General Permit (MSGP). To obtain an MSGP, the facility must prepare a stormwater pollution prevention plan (SWPPP) before submitting a notice of intent for permit coverage. The SWPPP must document the site description, design, and installation of control measures; describe monitoring procedures; and summarize potential pollutant sources. A copy of the SWPPP must be kept on site in a format that is accessible to workers and inspectors and be updated to reflect changes in site conditions, personnel, and stormwater infrastructure.

Industrial Facilities Discharging to Impaired Water Bodies

Any facility that discharges to an impaired water body must monitor all pollutants for which the water body is impaired and for which a standard analytical method exists (40 CFR 136).

Also, because different industrial activities have sector-specific types of material that may be exposed to stormwater, EPA grouped the different regulated industries into 29 sectors, based on their typical activities. Part 8 of EPA's MSGP details the stormwater management practices and monitoring that are required for the different industrial sectors. DEQ anticipates including specific requirements for impaired waters as a condition of the 401 certification. The MSGP will detail the specific monitoring requirements.

TMDL Industrial Stormwater Requirements

When a stream is on Idaho's §303(d) list and has a TMDL developed, DEQ may incorporate a wasteload allocation for industrial stormwater activities under the MSGP. However, most load analyses developed in the past have not identified sector-specific numeric wasteload allocations for industrial stormwater activities. Industrial stormwater activities are considered in compliance with provisions of the TMDL if operators obtain an MSGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The next MSGP will have specific monitoring requirements that must be followed.

Construction Stormwater

The Clean Water Act requires operators of construction sites to obtain permit coverage to discharge stormwater to a water body or municipal storm sewer. In Idaho, EPA has issued a general permit for stormwater discharges from construction sites.

Construction General Permit (CGP) and Stormwater Pollution Prevention Plans

If a construction project disturbs more than 1 acre of land (or is part of a larger common development that will disturb more than 1 acre), the operator is required to apply for a CGP from EPA after developing a site-specific SWPPP. The SWPPP must provide for the erosion, sediment, and pollution controls they intend to use; inspection of the controls periodically; and maintenance of BMPs throughout the life of the project. Operators are required to keep a current copy of their SWPPP on site or at an easily accessible location.

TMDL Construction Stormwater Requirements

When a stream is on Idaho's §303(d) list and has a TMDL developed, DEQ may incorporate a gross wasteload allocation for anticipated construction stormwater activities. Most loads developed in the past did not have a numeric wasteload allocation for construction stormwater activities. Construction stormwater activities are considered in compliance with provisions of the TMDL if operators obtain a CGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The CGP has monitoring requirements that must be followed.

Postconstruction Stormwater Management

Many communities throughout Idaho are currently developing rules for postconstruction stormwater management. Sediment is usually the main pollutant of concern in construction site stormwater. DEQ's *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties* (DEQ 2005b) should be used to select the proper suite of BMPs for the specific site, soils, climate, and project phasing in order to sufficiently meet the standards and requirements of

the CGP to protect water quality. Where local ordinances have more stringent and site-specific standards, those are applicable.

Appendix F. Pollutant Trading

Pollutant trading (also known as water quality trading) is a contractual agreement to exchange pollution reductions between two parties. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost-effective, local solutions to problems caused by pollutant discharges to surface waters. Pollutant trading is one of the tools available to meet reductions called for in a TMDL where point and nonpoint sources both exist in a watershed.

The appeal of trading emerges when pollutant sources face substantially different pollutant reduction costs. Typically, a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction.

Pollutant trading is voluntary. Parties trade only if both are better off because of the trade, and trading allows parties to decide how to best reduce pollutant loadings within the limits of certain requirements.

Pollutant trading is recognized in Idaho's water quality standards at IDAPA 58.01.02.055.06. DEQ allows for pollutant trading as a means to meet TMDLs, thus restoring water quality limited water bodies to compliance with water quality standards. DEQ's *Water Quality Trading Guidance* sets forth the procedures to be followed for pollutant trading (DEQ 2016b).

Trading Components

The major components of pollutant trading are trading parties (buyers and sellers) and credits (the commodity being bought and sold). Ratios are used to ensure environmental equivalency of trades on water bodies covered by a TMDL. All trading activity must be recorded in the trading database by DEQ or its designated party.

Both point and nonpoint sources may create marketable credits, which are a reduction of a pollutant beyond a level set by a TMDL:

- Point sources create credits by reducing pollutant discharges below NPDES effluent limits set initially by the wasteload allocation.
- Nonpoint sources create credits by implementing approved BMPs that reduce the amount of pollutant runoff. Nonpoint sources must follow specific design, maintenance, and monitoring requirements for that BMP; apply discounts to credits generated, if required; and provide a water quality contribution to ensure a net environmental benefit. The water quality contribution also ensures the reduction (the marketable credit) is surplus to the reductions the TMDL assumes the nonpoint source is achieving to meet the water quality goals of the TMDL.

Watershed-Specific Environmental Protection

Trades must be implemented so that the overall water quality of the water bodies covered by the TMDL is protected. To do this, hydrologically based ratios are developed to ensure trades between sources distributed throughout TMDL water bodies result in environmentally equivalent or better outcomes at the point of environmental concern. Moreover, localized adverse impacts to water quality are not allowed.

Trading Framework

For pollutant trading to be authorized, it must be specifically mentioned within a TMDL document. After adoption of an EPA-approved TMDL, DEQ, in concert with the WAG, must develop a pollutant trading framework document. The framework would mesh with the implementation plan for the watershed that is the subject of the TMDL. The elements of a trading document are described in DEQ's pollutant trading guidance (DEQ 2016b).

Appendix G. Public Participation and Public Comments

This TMDL was developed with participation from the Lolo Creek Watershed Advisory Group (WAG). The Lolo Creek WAG met on July 12, 2018, to discuss the Lolo Creek Watershed Temperature TMDL Review.

The Lolo Creek WAG met on May 28, 2020 to discuss the Lolo Creek Watershed Temperature TMDL Review and the changes that were made in order for the document to become a TMDL and go out for public comment. During this meeting the Lolo Creek WAG voted to provide a 30-day public comment period for a draft of the Lolo Creek Watershed Temperature TMDL. Notice was provided to the public through the DEQ website of the opportunity to comment from June 1, 2020 to July 1, 2020. Copies of the document were available through the DEQ website and by request from the Lewiston Regional Office. DEQ received no public comments on the draft Lolo Creek Watershed Temperature TMDL.

Appendix H. Distribution List

Clearwater Basin Advisory Group

Lolo Creek Watershed Advisory Group

Department of Environmental Quality – State Office

Department of Environmental Quality – Lewiston Regional Office

US Environmental Protection Agency, Idaho Operations Office