# Goose Creek Subbasin Temperature Total Maximum Daily Loads:

## Addendum to the Goose Creek Subbasin Assessment and Total Maximum Daily Loads

**Final**

**State of Idaho**
**Department of Environmental Quality**
**January 2012**
**Revised February 2012**

# Goose Creek Subbasin Temperature Total Maximum Daily Loads

January 2012

Prepared by:
State Technical Services Office
Department of Environmental Quality
1410 N. Hilton St.
Boise, ID 83706

*This page intentionally left blank for correct double-sided printing.*

# Acknowledgments

Cover photo: Goose Creek below Emery Creek (Idaho Department of Environmental Quality, 2008).

*This page intentionally left blank for correct double-sided printing.*

# Table of Contents

# List of Tables



# List of Figures



# List of Appendices

# 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 |
| **AU** | assessment unit |
| **BMP** | best management practice |
| **C** | Celsius |
| **CFR** | Code of Federal Regulations |
| **CGP** | Construction General Permit |
| **CWA** | Clean Water Act |
| **DEQ** | Idaho Department of Environmental Quality |
| **EPA** | United States Environmental Protection Agency |
| **GIS** | geographic information systems |
| **IDAPA** | Refers to citations of Idaho administrative rules |
| **kWh** | kilowatt-hour |
| **LA** | load allocation |
| **LC** | load capacity |
| **m** | meter |
| **mi** | mile |
| **MOS** | margin of safety |
| **NB** | natural background |
| **NPDES** | National Pollutant Discharge Elimination System |
| **NREL** | National Renewable Energy Laboratory |
| **PNV** | potential natural vegetation |
| **PVG** | potential vegetation group |
| **SWPPP** | Stormwater Pollution Prevention Plan |
| **TMDL** | total maximum daily load |
| **U.S.** | United States |
| **U.S.C.** | United States Code |
| **WAG** | watershed advisory group |
| **WLA** | wasteload allocation |

*This page intentionally left blank for correct double-sided printing.*

# Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years and is included as the Category 5 list in the 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.

This document addresses two water bodies in the Goose Creek subbasin that have temperature exceedances of water quality standards. This document only addresses the temperature TMDLs for these streams. For more information about these watersheds and the subbasin as a whole, see the *Goose Creek Subbasin Assessment and Total Maximum Daily Loads* (DEQ 2003).

This TMDL analysis has been developed to comply with Idaho's TMDL requirements. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition meeting water quality standards.

## Subbasin at a Glance

The Goose Creek subbasin (hydrologic unit code 17040211) is located in south-central Idaho south of Burley, Idaho (Figure A). According to the Goose Creek Subbasin Assessment and TMDL (DEQ 2003), 42.1 percent of the lands within the Idaho portion of the subbasin are considered rangeland, with 25.1 percent in Forest, 28.6 in irrigated agriculture and 4.2 percent listed as urban. The urban areas are scattered throughout the subbasin and range in size from Oakley (population 600-700) to Trout (population 1-10). A portion of the subbasin is forested, but rangeland activities predominate in these areas as well. Highway 27 is the main road through the subbasin. The only other paved roads connect the small towns in the area and the section roads out of Oakley and Burley. The remainder of the subbasin is covered with numerous dirt and gravel roads, most of which are not maintained. The Idaho portion of the subbasin lies almost entirely within Cassia County. Privately owned lands (28.9 percent) are essentially the same lands that are used for agriculture. The majority of the land ownership (68.12 percent) falls under federal government management (United States Bureau of Land Management 42.84 percent and United States Forest Service 25.28 percent). The remaining 2.85 percent are scattered state endowment lands, and are managed by Utah, Idaho and Nevada's respective department of lands. There have been no major changes to land use, land ownership, or population in the Subbasin since the TMDL was approved in 2004.

Within the subbasin, Beaverdam Creek, Cold Creek, and Goose Creek were listed on the Idaho 1998 §303d list for temperature pollution. A temperature TMDL for these streams was completed in 2003; however, only the lower portion of Goose Creek from the Utah border to

Goose Creek Reservoir was included (DEQ 2003). In the current §303d list ( 2010 Integrated Report), upper Goose Creek and its tributaries (ID17040211SK008_02) and Trout Creek and its tributaries (ID17040211SK007_02 & _03) are included in the list of streams with impairments. Both of these remote streams are located in the Sawtooth National Forest and drain south from the Monument Peak area to the Nevada border (Figure A). The following analysis includes the temperature TMDLs for upper Goose Creek and Trout Creek watersheds.

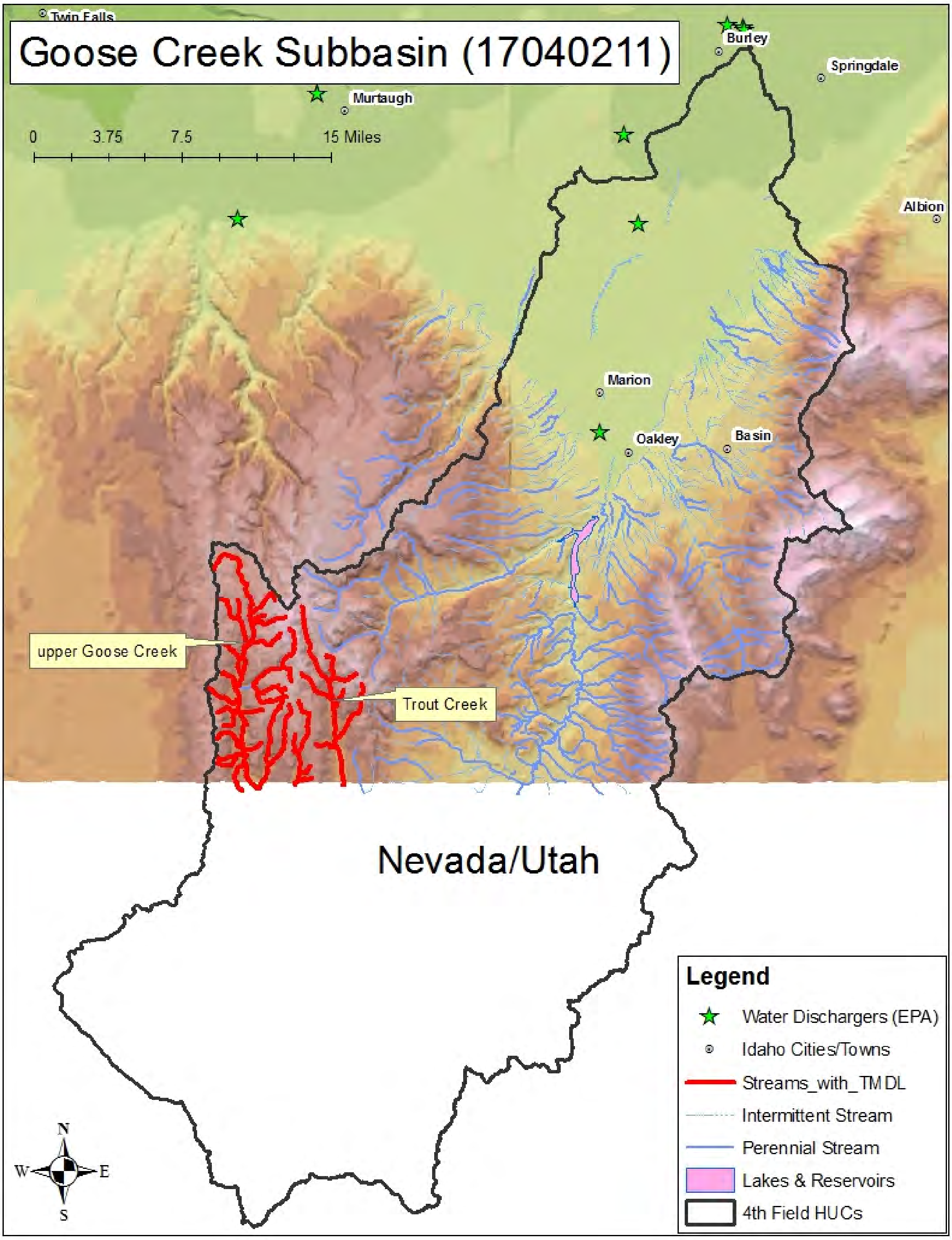


**Figure A. Subbasin at a glance.**

## Key Findings

Two watersheds (upper Goose Creek and Trout Creek) are listed on the 2010 §303d list of impaired waters. (Table A). Effective shade targets were established for the two stream systems based on the concept of maximum shading under potential natural vegetation resulting in natural background temperatures. 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. Although additional stream reaches in Goose Creek were analyzed for shade and included in the overall analysis, they did not receive TMDLs due to lack of temperature data suggesting impairment.

Both stream systems examined lacked shade compared to target levels (Table B). The lack of shade is likely the result of a combination of factors, including natural and human-influenced dewatering of the stream channel and historic removal of riparian vegetation associated with livestock grazing. Much of this lack of shade is due to high target levels set for narrow streams with various tree-dominated vegetation types (e.g., aspen and lodgepole pine). Many such streams now lack these historic vegetation types or only have remnant stands of aspen or lodgepole pine. The reasons for this change in vegetation may be many and varied, from the lack of aspen regeneration due to grazing to a lack of water from diversion and drought throughout the subbasin. While not much can be done to address channel dewatering, most streams would recover riparian vegetation if temporarily or permanently excluded from use. Streams identified for sediment impairment or combined biota/habitat bioassessments will likewise recover for sediment problems caused by bank instability as PNV targets are realized.

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.

**Table A. Streams and pollutants for which TMDLs were developed.**

| Stream | Pollutant(s) |
|---|---|
| Upper Goose Creek and Tributaries | Temperature |
| Trout Creek and Tributaries | Temperature |

**Table B. Summary of assessment outcomes.**

| Water Body Segment/ Assessment Unit | Pollutant | TMDL(s) Completed | Recommended Changes to §303(d) List | Justification |
|---|---|---|---|---|
| Goose Creek ID17040211SK008_02 | Temperature | Yes | Move to Category 4a | Excess solar load due to lack of shade |

| | | | | |
|---|---|---|---|---|
| Trout Creek ID17040211SK007_02 ID17040211SK007_03 | Temperature | Yes | Delist SK007_02 for sediment. Delist SK007_03 for combined biota/habitat bioassessment. Move SK007_02 and SK007_03 to Category 4a for temp | Excess solar load due to lack of shade; Temp TMDL will remedy sediment concerns and combined biota/habitat bioassessment. |

## Public Participation

The Lake Walcott Watershed Advisory Group (WAG) was created in 1995 and contributed to the original Goose Creek subbasin assessment and TMDL. The Lake Walcott WAG has continued to meet several times annually since the approval of the original document. They reviewed the Goose Creek temperature TMDL document and discussed it at their July 21, 2011, meeting. The WAG was given a draft copy and was asked to submit comments to the Idaho Department of Environmental Quality (DEQ). An email was sent to the WAG members the following week that included the DEQ website address to access the draft document and comments were again requested before August 30, 2011. No comments were received. The DEQ Twin Falls Regional Office can provide copies of the document by request.

The draft temperature TMDL was open for a 30 day public comment period from October 5, 2011 to November 4, 2011. EPA was the only entity to return comments. A summary of these comments can be found in Appendix D.

*This page intentionally left blank for correct double-sided printing.*

# Introduction

This total maximum daily load (TMDL) is an addendum to the *Goose Creek Subbasin Assessment and Total Maximum Daily Loads* (DEQ 2003). That document, like all Idaho TMDL documents since 2001 that combine a subbasin assessment with a TMDL determination, has five sections, the first four of which make up the subbasin assessment. This document contains only an addendum to the TMDL determination section (section 5) and is based on the original subbasin assessment and characteristics from the 2003 Goose Creek subbasin assessment and TMDL.

This document addresses two water bodies in the Goose Creek subbasin (hydrologic unit code 17040211) that have temperature exceedances of water quality standards. Upper Goose Creek and Trout Creek were both listed on the §303(d) for impairment on the 2010 Integrated Report. The Trout Creeks assessment units included SK007_02, which was listed for sediment and temperature; and SK007_03, which was listed for combined biota/habitat bioassessment. It was determined that the PNV TMDLs for temperature would remedy any sediment issues being caused by streambank erosion. Goose Creek, SK008_02 was listed for temperature. Effective shade targets were established for the two streams based on the concept of maximum shading under potential natural vegetation (PNV) resulting in natural background temperatures. When PNV is achieved the result is a reduction in stream temperature and typically a reduction in and sediment loading caused from bank instability.

# 5. Total Maximum Daily Loads

A TMDL prescribes an upper limit (i.e., load capacity) on discharge of a pollutant from all sources so as 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 broken out on their own because they represent a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water Quality Planning and Management, 40 CFR Part 130) require a margin of safety be a part of the TMDL. Practically, the margin of safety and natural background are both reductions in the load capacity available for allocation to pollutant sources.

The 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 margin of safety and natural background, if relevant, are determined, 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, determination of critical conditions can be more complicated than it may appear on the surface.

Another step in a load analysis is the quantification of current pollutant loads by source. This step allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. A load is fundamentally a quantity of a pollutant discharged over some period of time and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable and relate to water quality standards, but they allow flexibility to deal with pollutant loads 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, the U.S. Environmental Protection Agency (EPA) allows for seasonal or annual loads.

## 5.1 Instream Water Quality Targets

For the Goose Creek subbasin temperature TMDLs, the Idaho Department of Environmental Quality (DEQ) used a PNV approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) establishing 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 the natural level of shade and channel width become the target of the TMDL. The instream temperature that results from attaining these conditions is consistent with the water quality standards even if it exceeds numeric temperature criteria. See Appendix A for further discussion of water quality standards and background provisions.

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

### Potential Natural Vegetation for Temperature TMDLs

There are several important contributors of heat to a stream, including ground water temperature, air temperature, and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most likely to be controlled. 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 affects the density of riparian vegetation and water storage in the alluvial aquifer. Streamside 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.

Depending on how much vertical elevation surrounds the stream, vegetation further away from the riparian corridor can also provide shade. However, riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. We can measure or estimate the amount of shade that a stream receives in a number of ways. Effective shade (i.e., that 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 other optical equipment that works 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.

PNV along a stream is that riparian plant community that has grown 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 natural disturbance (e.g., wildfire, disease/old age, wind damage, wildlife grazing) or anthropogenically (e.g., domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade-producing vegetation. Anything less than PNV results in the stream heating up from anthropogenically created additional solar inputs.

We can estimate potential vegetation (and therefore target shade) from models of plant community structure (i.e., 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 there is 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 shade was estimated for the two water bodies from visual interpretation of aerial photos. These estimates were partially field verified by measuring shade with a Solar Pathfinder at systematically located points along the streams (see below for methodology). PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in Idaho (see 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.

Existing and PNV target shade was converted to solar loads from data collected on flat-plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather station collecting these data. In this analysis for Goose and Trout Creeks, we used data from the station in Pocatello, Idaho. The difference between existing and target solar load, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with temperature water quality standards (Appendix A). PNV shade and the associated target solar loads are assumed to be the natural condition; thus, stream temperatures under PNV conditions are assumed to be natural (so long as there are no point sources or any other anthropogenic sources of heat 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.[1]

## Aerial Photo Interpretation

Estimates of shade based on plant type and density were marked out on a 1:100,000 or 1:250,000 hydrography, taking into account natural breaks in vegetation density. Each interval 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 stretch of stream was estimated somewhere between 50% and 59%, we assigned a 50% shade-class value to that section. 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 take into account 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 takes into consideration other physical features that block the sun from hitting the stream surface (e.g., hillsides, canyon walls, terraces, man-made structures).

## Pathfinder Methodology

The Solar Pathfinder is a device that allows one to trace the outline of shade-producing objects on monthly solar path charts. The percentage of the sun's path covered by these objects is the effective shade on the stream at the location where the tracing is made. To adequately characterize the effective shade on a stream reach, ten traces are taken at systematic 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. Traces were taken following the manufacturer's instructions. Systematic sampling was used because it is easiest to accomplish while still not biasing the

[1] A unit conversion table is provided in Appendix B.

location of sampling. For each sampled reach, the sampler started at a unique location (such as 50 meters [m] from a bridge or fence line) and proceeded upstream or downstream stopping to take additional traces at fixed intervals (e.g., every 50 m, 50 paces, etc.). One can also 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 stream at several unique locations while taking the 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.

## Stream Morphology

Measures of current bankfull width or near stream disturbance zone width may not reflect widths that were present under PNV. As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase such that streams become wider and shallow. Shadows produced by vegetation cover a lower percentage of the water surface in wider streams, and widened streams can also have less vegetative cover if shoreline vegetation has been eroded away.

This width factor (i.e., near stream disturbance zone or bankfull width) may not be discernible from the aerial photo interpretations. This parameter must be estimated from available information. DEQ 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 1).

For both stream systems evaluated in the load analysis, bankfull width was estimated based on the drainage area of the Upper Snake curve from Figure 1. Additionally, existing width was evaluated from available data. If the stream's existing width was wider than predicted by the Upper Snake curve in Figure 1, then the estimate of bankfull width from Figure 1 was used in the load analysis for natural bankfull width. If existing width was smaller, then existing width was used in the load analysis as the natural bankfull width (i.e., existing = natural).

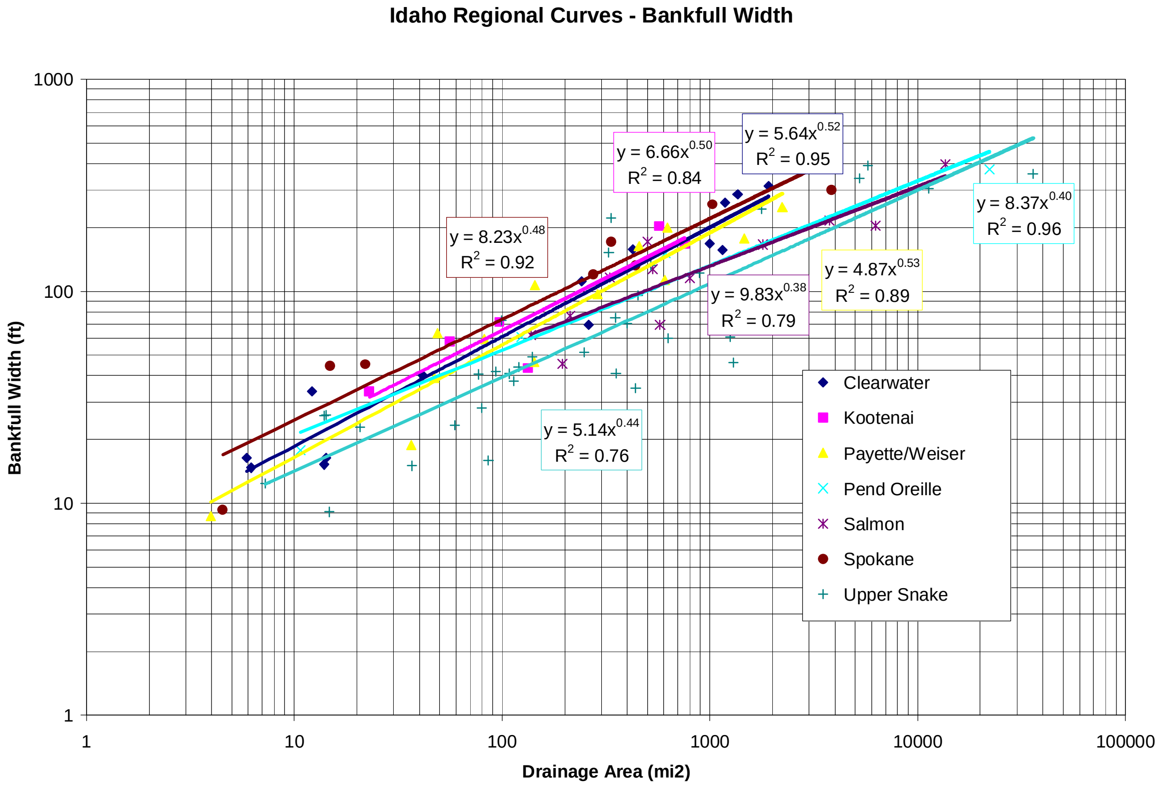


**Figure 1. Bankfull width as a function of drainage area.**

In general, the majority of existing bankfull width data showed that streams are typically equal to or smaller than what is predicted by regional curves (Table 1). This is not surprising in an arid environment where a lack of precipitation results in a predominance of ephemeral and intermittent streams. Only a few locations had existing widths larger than predicted. Therefore, in most cases curve estimated width was used for natural width in the load analysis tables that follow in section 5.3 (Estimates of Existing Pollutant Loads) when no existing data was available. When existing data showed a smaller channel width then predicted, the existing widths were used in the load tables. In only a few cases did existing widths indicate an over-widening of stream channels.

**Table 1. Regional curve estimates and existing measurements of bankfull width for Goose Creek subbasin streams.**

| Location | area (sq mi) | Upper Snake (m) | existing in meters (year measured) |
|---|---|---|---|
| Trout Cr @ stateline | 18.8 | 6 | 3.1(98), 2.7(03) |
| Trout Cr @ 5800ft | 14 | 5 | 3.8(97),2.8(02),3.4(05),4.2(06),1.9(07) |
| Trout Cr @ 6200ft | 3.9 | 3 | 3.6(02), 7.3(08), 7.9(08) |
| Trout Cr @ 6800ft | 1.9 | 2 | |
| Little Willow Creek @ mouth | 2.13 | 2 | |
| Little Willow Creek ab tributary | 0.83 | 1 | |
| tributary to Little Willow Creek | 1.26 | 2 | |
| Swanty Creek @ mouth | 1.77 | 2 | |
| Buck Spring creek @ mouth | 0.54 | 1 | |
| Willow Creek @ mouth | 2.78 | 2 | 1.0(05), 3(11) |
| Willow Creek ab spring @ 6160ft | 1.26 | 2 | |
| Elk Basin Creek @ mouth | 1.06 | 2 | |
| Upper Goose Cr ab Thoroughbred Cr | 38 | 8 | 8.1(97),9.1(99), 6.3(01),7.1(06),4.9(07) |
| Upper Goose Cr @ 5800ft | 32 | 7 | 5.3(97),5.4(04),4.3(06),4.2(07) |
| Upper Goose Cr @ 6000ft | 25.7 | 7 | 5.4(99),4.6(02),3.9(03),4.7(04),4.9(06) |
| Upper Goose Cr @ 6400ft | 8.9 | 4 | 3.4(97),2.5(05) |
| Upper Goose Cr @ 6800ft | 1.69 | 2 | 8.8(08, near ponds) |
| Jones Creek @ mouth | 0.92 | 2 | |
| Buck Creek @ mouth | 0.55 | 1 | |
| Palmer Creek @ mouth | 1.06 | 2 | |
| Elison Hole Creek @ mouth | 1.5 | 2 | |
| Little Goose Creek @ mouth | 4 | 3 | |
| Little Goose Creek ab tributary | 0.63 | 1 | |
| tributary to Little Goose Creek | 1.91 | 2 | |
| Winecup Creek @ mouth | 1.73 | 2 | |
| Little Piney Creek @ mouth | 6.92 | 4 | 2.5(03), 3.0(04) |
| Little Piney Creek ab SF Little Piney | 4.75 | 3 | |
| Little Piney Creek bl tributary | 2.66 | 2 | |
| Little Piney Creek ab tributary | 1.56 | 2 | |
| SF Little Piney Creek @ mouth | 1.88 | 2 | 1.4(03) |
| SF Little Piney Creek ab Humphrey | 0.7 | 1 | |
| Humphrey Creek @ mouth | 1.01 | 2 | |
| tributary to Little Piney Creek | 1.09 | 2 | |
| Meadow Springs Creek @ mouth | 1.49 | 2 | |
| Indian Camp Springs Creek @ mouth | 1.29 | 2 | |
| Indian Camp Springs Creek ab trib | 0.81 | 1 | |
| tributary to Indian Camp Springs | 0.47 | 1 | |
| Un-named bl Indian Camp Springs | 0.65 | 1 | |
| Rattlesnake Creek @ mouth | 1.46 | 2 | |
| Un-named bl Rattlesnake Creek | 0.44 | 1 | |
| Ruby Gulch @ mouth | 0.97 | 2 | |
| tributary to Ruby Gulch | 0.37 | 1 | |
| Quartz Gulch @ mouth | 1.58 | 2 | |
| Thoroughbred Creek @ mouth | 6.81 | 4 | 2.6(06), 2.6(08) |
| Thoroughbred Creek bl WF/EF | 4.59 | 3 | 2.2(99), 1.9(07) |
| WF Thoroughbred Creek @ mouth | 2.1 | 2 | |
| EF Thoroughbred Creek @ mouth | 2.48 | 2 | |
| Piney Creek @ border | 6.1 | 3 | 3.4(97), 2.5(03), 3.3(06) |
| Piney Creek ab Little Willow Springs | 3.95 | 3 | |
| Piney Creek ab tributary | 2.56 | 2 | 1.8(98) |
| tributary to Piney Creek | 0.41 | 1 | |
| Little Willow Springs creek | 0.67 | 1 | |
| Cherry Creek @ mouth | 0.77 | 1 | |
| green = low existing | | | |
| yellow = high existing | | | |

## Design Conditions

The majority of the Goose Creek subbasin lies within the Northern Basin and Range ecoregion (level III) of McGrath et al. (2001). However, the outlet from Goose Creek Reservoir and several other drainages (e.g., Big Cottonwood Creek, Mill Creek) drain to the Magic Valley Province of the Snake River Plain level III ecoregion. The high elevations of Magic Mountain and the Albion Mountains are within the High Elevation Forests and Shrublands level IV ecoregion and are characterized by a mix of conifers, mountain brush, and sagebrush grasslands. North-facing slopes and flatter areas typically contain open Douglas-fir, aspen, and lodgepole pine. On lower slopes of these mountains and Middle Mountain (between Goose Creek and Birch Creek), the Semiarid Hills and Low Mountains level IV ecoregion predominates. Vegetation is characterized by mostly sagebrush steppe with juniper woodlands prevalent on rocky outcrops. In the valleys close to the town of Oakley, Idaho, the Sagebrush Steppe Valleys level IV ecoregion is present. A small portion of lower Goose Creek at the Utah border lies within the Dissected High Lava Plateau level IV ecoregion, a sagebrush grassland that is slightly less wooded and more arid than other provinces in this ecoregion.

Riparian vegetation along streams varies greatly from higher-elevation lodgepole pine (*Pinus contorta*) forests and quaking aspen (*Populus tremuloides*) stands to willow-dominated areas at lower elevations. Above 5,800 feet are willow-dominated riparian communities that become increasingly interspersed with lodgepole pine and aspen communities near 7,000 feet. The willow species were not identified, but for the purposes of developing shade targets a Geyer willow/sedge community type was used to represent these areas. Geyer willow (*Salix geyeriana*) is a typical mid-elevation willow that could exist in these areas. Occasionally stream flows are low enough that only a small ribbon of grass occurs at the interface between the stream and the upland vegetation. These community types are identified as grass-dominated or sagebrush/grass-dominated depending on the proximity of upland sagebrush plants to the stream edge. Grass-dominated streams typically occur only occasionally, while sagebrush/grass-dominated streams are more common.

## Target Selection

To determine PNV shade targets for streams in the Goose Creek subbasin, effective shade curves developed specifically for southern Idaho were examined (Shumar and de Varona 2009). For this analysis, we used shade curves from the southern Idaho non-forest group developed from data by Hansen and Hall (2002) and the persistent lodgepole pine potential vegetation group (PVG 10) shade curve developed for the Sawtooth National Forest. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. As a stream becomes wider, a given vegetation type loses its ability to shade wider and wider streams. For the streams in the Goose Creek subbasin, curves for the most similar vegetation type were selected for shade target determinations. Targets are based on averaging the individual curves for the three aspects (i.e., N/S, E/W, and NE/SW/NW/SE) for any given community type at a particular stream width (Tables 2–6).

**Table 2. Shade targets for the persistent lodgepole pine (PVG 10) vegetation type at various stream widths.**

| Persistent Lodgepole (PVG 10) | 1m | 2m | 3m | 4m | 5m | 6m | 7m | 8m | 9m | 10m | 11m | 12m | 13m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0/180 aspect | 96 | 94 | 91 | 87 | 81 | 75 | 70 | 65 | 61 | 58 | 55 | 52 | 49 |
| 45/135/225/315 aspect | 96 | 94 | 91 | 86 | 81 | 76 | 70 | 65 | 62 | 58 | 55 | 52 | 49 |
| 90/270 aspect | 97 | 95 | 90 | 87 | 83 | 76 | 70 | 64 | 59 | 54 | 49 | 45 | 42 |
| **Target (%)** | **96** | **94** | **91** | **87** | **82** | **76** | **70** | **65** | **61** | **57** | **53** | **50** | **47** |

**Table 3. Shade targets for the quaking aspen vegetation type at various stream widths.**

| Aspen | 1m | 2m | 3m | 4m | 5m | 6m | 7m | 8m | 9m | 10m | 11m | 12m | 13m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0/180 aspect | 99 | 99 | 99 | 96 | 93 | 90 | 86 | 82 | 78 | 75 | 71 | 68 | 65 |
| 45/135/225/315 aspect | 100 | 99 | 99 | 96 | 93 | 89 | 85 | 81 | 77 | 73 | 69 | 65 | 62 |
| 90/270 aspect | 100 | 99 | 99 | 97 | 95 | 91 | 84 | 76 | 67 | 61 | 56 | 52 | 48 |
| **Target (%)** | **100** | **99** | **99** | **96** | **94** | **90** | **85** | **80** | **74** | **70** | **65** | **62** | **58** |

**Table 4. Shade targets for the Geyer willow vegetation type at various stream widths.**

| Geyer Willow/sedge | 1m | 2m | 3m | 4m | 5m | 6m | 7m | 8m | 9m | 10m | 11m | 12m | 13m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0/180 aspect | 92 | 83 | 68 | 59 | 51 | 45 | 41 | 37 | 33 | 31 | 28 | 26 | 24 |
| 45/135/225/315 aspect | 92 | 82 | 66 | 56 | 48 | 42 | 38 | 34 | 31 | 28 | 26 | 24 | 22 |
| 90/270 aspect | 94 | 82 | 58 | 45 | 37 | 31 | 27 | 24 | 21 | 19 | 18 | 16 | 15 |
| **Target (%)** | **93** | **82** | **64** | **53** | **45** | **39** | **35** | **32** | **28** | **26** | **24** | **22** | **20** |

**Table 5. Shade targets for the sagebrush/grass vegetation type at various stream widths.**

| Graminoid/Sagebrush | 1m | 2m | 3m | 4m | 5m | 6m | 7m | 8m | 9m | 10m | 11m | 12m | 13m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0/180 aspect | 71 | 46 | 33 | 25 | 20 | 17 | 15 | 13 | 12 | 10 | 9 | 9 | 8 |
| 45/135/225/315 aspect | 68 | 41 | 28 | 21 | 17 | 14 | 12 | 11 | 10 | 9 | 8 | 7 | 7 |
| 90/270 aspect | 55 | 29 | 20 | 15 | 12 | 10 | 9 | 8 | 7 | 6 | 6 | 5 | 5 |
| **Target (%)** | **65** | **39** | **27** | **20** | **16** | **14** | **12** | **11** | **10** | **8** | **8** | **7** | **7** |

**Table 6. Shade targets for the meadow vegetation type at various stream widths.**

| Graminoid | 1m | 2m | 3m | 4m | 5m | 6m | 7m | 8m | 9m | 10m | 11m | 12m | 13m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0/180 aspect | 62 | 38 | 26 | 20 | 16 | 14 | 12 | 10 | 9 | 8 | 7 | 7 | 6 |
| 45/135/225/315 aspect | 58 | 33 | 22 | 17 | 14 | 11 | 10 | 9 | 8 | 7 | 6 | 6 | 5 |
| 90/270 aspect | 45 | 23 | 16 | 12 | 10 | 8 | 7 | 6 | 5 | 5 | 4 | 4 | 4 |
| **Target (%)** | **55** | **31** | **21** | **16** | **13** | **11** | **10** | **8** | **7** | **7** | **6** | **6** | **5** |

The locations where the various vegetation types were applied to streams in the load analysis tables in section 5.3 were dependent upon our best professional judgment based on field observations and experience to determine where vegetation types occur on streams. The lodgepole pine PVG and aspen locations were enhanced by the Sawtooth National Forest PVG overlay for those lands.

## Monitoring Points

The accuracy of the aerial photo interpretations was field verified with a Solar Pathfinder at three sites on Goose Creek and Trout Creek. The aerial photo estimate of shade proved to be accurate at one of the three Solar Pathfinder sites (see Appendix C for Solar Pathfinder results). At the other two sites, the aerial photo estimates were too high compared to field-measured shade, with an overall average difference of 17% ± 17.3 (mean ± 95% confidence interval). The original aerial photo estimates were corrected accordingly. Specific Solar Pathfinder sites were corrected to represent their field-measured values and data were used to recalibrate our visual estimates to reinterpret all other shade interpretations.

Effective shade monitoring can take place on any reach throughout the Goose or Trout Creek watersheds and be compared to estimates of existing shade described in Tables 7, 8, 9 and 10 and seen on Figure 2. Those areas with the largest disparity between existing and target shade should be monitored with Solar Pathfinders to further verify the existing shade levels and to determine progress towards meeting shade targets. It is important to note that many existing shade estimates have not been field verified and may require adjustment during the implementation process. Stream segment length for each estimate of existing shade varies depending on 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 towards target levels. Ten equally spaced Solar Pathfinder measurements averaged together within that segment should suffice to determine new shade levels in the future.

## 5.2 Load Capacity

The load capacity for a stream under PNV is essentially the solar loading allowed under the shade targets specified for the reaches within that stream (Figure 3). These loads are determined by multiplying the solar load received by a flat-plate collector (under full sun) for a given period of time by the percent of 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), then 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 Pocatello, Idaho. The solar loads used in this TMDL are spring/summer averages (i.e., an average load for the 6-month period from April through September). These months coincide with the time of year when stream temperatures are increasing and deciduous vegetation is in leaf. Tables 7, 8, 9 and 10 show the PNV shade targets and their corresponding target summer load (in kilowatt-hours [kWh] per $m^2$ per 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.

The effective shade calculations are based on a 6-month period from April through September. This time period coincides with the critical time period when temperatures affect beneficial uses such as spring and fall salmonid spawning and when cold water aquatic life criteria may be exceeded during summer months. Late July and early August typically represent the period of highest stream temperatures. 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. Thus, solar loading in these streams is evaluated from spring (April) to early fall (September).

## 5.3 Estimates of Existing Pollutant Loads

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

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. 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 Tables 7, 8, 9 and 10 and Figure 2. Like load capacities (target loads), existing loads in Tables 8 and 9 are presented on an area basis (kWh/$m^2$/day) and as a total load (kWh/day).

Like target loads, existing loads in kWh/day are summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target load and existing load is also summed for the entire table. Should existing load exceed target load, this difference becomes the excess load (i.e., lack of shade) to be discussed in the load allocation section and as seen in Figure 4. The percent reduction shown in the right-hand column of each table represents how much total excess load there is in relation to total existing load for that particular stream segment (Tables 7-10). The loads in the tables are rounded to one significant figure because of the level of precision in that analysis, and as a result the target and existing loads may equal each other despite a lack of shade.

**Table 7. Existing and target solar loads for Trout Creek.**

| Segment Details | | | | | Target | | | | | Existing | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | Stream Name | Number (top to bottom) | Length (m) | Vegetation Type | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Excess Load (kWh/day) | Lack of Shade |
| 007_02 | Trout Creek | 1 | 1100 | meadow | 55% | 2.77 | 1 | 1,000 | 3,000 | 50% | 3.08 | 1 | 1,000 | 3,000 | 0 | -5% |
| 007_02 | Trout Creek | 2 | 2300 | lodgepole | 94% | 0.37 | 2 | 5,000 | 2,000 | 80% | 1.23 | 2 | 5,000 | 6,000 | 4,000 | -14% |
| 007_02 | Trout Creek | 3 | 210 | Geyer willow | 82% | 1.11 | 2 | 400 | 400 | 80% | 1.23 | 2 | 400 | 500 | 100 | -2% |
| 007_02 | Trout Creek | 4 | 350 | Geyer willow | 82% | 1.11 | 2 | 700 | 800 | 40% | 3.69 | 2 | 700 | 3,000 | 2,000 | -42% |
| 007_02 | Trout Creek | 5 | 520 | lodgepole | 94% | 0.37 | 2 | 1,000 | 400 | 90% | 0.62 | 2 | 1,000 | 600 | 200 | -4% |
| 007_02 | Trout Creek | 6 | 1500 | aspen | 99% | 0.06 | 2 | 3,000 | 200 | 70% | 1.85 | 2 | 3,000 | 6,000 | 6,000 | -29% |
| 007_02 | Trout Creek | 7 | 220 | lodgepole | 94% | 0.37 | 2 | 400 | 100 | 90% | 0.62 | 2 | 400 | 200 | 100 | -4% |
| 007_02 | Trout Creek | 8 | 570 | aspen | 99% | 0.06 | 3 | 2,000 | 100 | 90% | 0.62 | 3 | 2,000 | 1,000 | 900 | -9% |
| 007_02 | Trout Creek | 9 | 310 | Geyer willow | 64% | 2.21 | 3 | 900 | 2,000 | 40% | 3.69 | 4 | 1,000 | 4,000 | 2,000 | -24% |
| 007_02 | Trout Creek | 10 | 1500 | sage/grass | 27% | 4.49 | 3 | 5,000 | 20,000 | 20% | 4.92 | 4 | 6,000 | 30,000 | 10,000 | -7% |
| 007_02 | Trout Creek | 11 | 220 | Geyer willow | 64% | 2.21 | 3 | 700 | 2,000 | 30% | 4.31 | 6 | 1,000 | 4,000 | 2,000 | -34% |
| 007_02 | Trout Creek | 12 | 240 | | 64% | 2.21 | 3 | 700 | 2,000 | 60% | 2.46 | 6 | 1,000 | 2,000 | 0 | -4% |
| 007_02 | Trout Creek | 13 | 300 | | 64% | 2.21 | 3 | 900 | 2,000 | 40% | 3.69 | 6 | 2,000 | 7,000 | 5,000 | -24% |
| 007_02 | Trout Creek | 14 | 180 | | 64% | 2.21 | 3 | 500 | 1,000 | 30% | 4.31 | 6 | 1,000 | 4,000 | 3,000 | -34% |
| 007_02 | Trout Creek | 15 | 530 | | 64% | 2.21 | 3 | 2,000 | 4,000 | 10% | 5.54 | 5 | 3,000 | 20,000 | 20,000 | -54% |
| 007_02 | Trout Creek | 16 | 560 | | 53% | 2.89 | 4 | 2,000 | 6,000 | 20% | 4.92 | 5 | 3,000 | 10,000 | 4,000 | -33% |
| 007_02 | Trout Creek | 17 | 1200 | | 53% | 2.89 | 4 | 5,000 | 10,000 | 30% | 4.31 | 4 | 5,000 | 20,000 | 10,000 | -23% |
| 007_02 | Trout Creek | 18 | 700 | | 53% | 2.89 | 4 | 3,000 | 9,000 | 50% | 3.08 | 4 | 3,000 | 9,000 | 0 | -3% |
| 007_02 | Trout Creek | 19 | 230 | | 53% | 2.89 | 4 | 900 | 3,000 | 40% | 3.69 | 4 | 900 | 3,000 | 0 | -13% |
| 007_03 | Trout Creek | 20 | 800 | | 53% | 2.89 | 4 | 3,000 | 9,000 | 20% | 4.92 | 4 | 3,000 | 10,000 | 1,000 | -33% |
| 007_03 | Trout Creek | 21 | 340 | | 53% | 2.89 | 4 | 1,000 | 3,000 | 30% | 4.31 | 4 | 1,000 | 4,000 | 1,000 | -23% |
| 007_03 | Trout Creek | 22 | 250 | | 53% | 2.89 | 4 | 1,000 | 3,000 | 10% | 5.54 | 4 | 1,000 | 6,000 | 3,000 | -43% |
| 007_03 | Trout Creek | 23 | 820 | | 53% | 2.89 | 4 | 3,000 | 9,000 | 0% | 6.15 | 4 | 3,000 | 20,000 | 10,000 | -53% |
| 007_03 | Trout Creek | 24 | 1100 | | 53% | 2.89 | 4 | 4,000 | 10,000 | 10% | 5.54 | 4 | 4,000 | 20,000 | 10,000 | -43% |
| 007_03 | Trout Creek | 25 | 420 | | 53% | 2.89 | 4 | 2,000 | 6,000 | 0% | 6.15 | 4 | 2,000 | 10,000 | 4,000 | -53% |
| 007_03 | Trout Creek | 23 | 270 | | 53% | 2.89 | 4 | 1,000 | 3,000 | 10% | 5.54 | 4 | 1,000 | 6,000 | 3,000 | -43% |
| | | | | | | | *Totals* | | 110,000 | | | | | 210,000 | 100,000 | |

*Note*: All assessment unit (AU) numbers start with ID17040211SK in all load tables (Tables 7-10).

**Table 8. Existing and target solar loads for Trout Creek Tributaries.**

| Segment Details | | | | | Target | | | | | Existing | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | Stream Name | Number (top to bottom) | Length (m) | Vegetation Type | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Excess Load (kWh/day) | Lack of Shade |
| 007_02 | Little Willow Creek | 1 | 950 | sage/grass | 65% | 2.15 | 1 | 1,000 | 2,000 | 60% | 2.46 | 1 | 1,000 | 2,000 | 0 | -5% |
| 007_02 | Little Willow Creek | 2 | 940 | aspen | 100% | 0.00 | 1 | 900 | 0 | 90% | 0.62 | 1 | 900 | 600 | 600 | -10% |
| 007_02 | Little Willow Creek | 3 | 80 | sage/grass | 65% | 2.15 | 1 | 80 | 200 | 60% | 2.46 | 1 | 80 | 200 | 0 | -5% |
| 007_02 | Little Willow Creek | 4 | 70 | aspen | 100% | 0.00 | 1 | 70 | 0 | 90% | 0.62 | 1 | 70 | 40 | 40 | -10% |
| 007_02 | Little Willow Creek | 5 | 140 | sage/grass | 65% | 2.15 | 1 | 100 | 200 | 50% | 3.08 | 1 | 100 | 300 | 100 | -15% |
| 007_02 | Little Willow Creek | 6 | 150 | meadow | 55% | 2.77 | 1 | 200 | 600 | 40% | 3.69 | 1 | 200 | 700 | 100 | -15% |
| 007_02 | Little Willow Creek | 7 | 120 | aspen | 99% | 0.06 | 2 | 200 | 10 | 70% | 1.85 | 2 | 200 | 400 | 400 | -29% |
| 007_02 | Little Willow Creek | 8 | 110 | | 99% | 0.06 | 2 | 200 | 10 | 90% | 0.62 | 2 | 200 | 100 | 90 | -9% |
| 007_02 | Little Willow Creek | 9 | 220 | Geyer willow | 82% | 1.11 | 2 | 400 | 400 | 50% | 3.08 | 2 | 400 | 1,000 | 600 | -32% |
| 007_02 | trib to Little Willow | 1 | 930 | aspen | 100% | 0.00 | 1 | 900 | 0 | 90% | 0.62 | 1 | 900 | 600 | 600 | -10% |
| 007_02 | trib to Little Willow | 2 | 60 | sage/grass | 65% | 2.15 | 1 | 60 | 100 | 60% | 2.46 | 1 | 60 | 100 | 0 | -5% |
| 007_02 | trib to Little Willow | 3 | 160 | aspen | 100% | 0.00 | 1 | 200 | 0 | 90% | 0.62 | 1 | 200 | 100 | 100 | -10% |
| 007_02 | trib to Little Willow | 4 | 740 | sage/grass | 65% | 2.15 | 1 | 700 | 2,000 | 60% | 2.46 | 1 | 700 | 2,000 | 0 | -5% |
| 007_02 | trib to Little Willow | 5 | 160 | Geyer willow | 82% | 1.11 | 2 | 300 | 300 | 40% | 3.69 | 2 | 300 | 1,000 | 700 | -42% |
| 007_02 | trib to Little Willow | 6 | 100 | | 82% | 1.11 | 2 | 200 | 200 | 80% | 1.23 | 2 | 200 | 200 | 0 | -2% |
| 007_02 | trib to Little Willow | 7 | 130 | | 82% | 1.11 | 2 | 300 | 300 | 40% | 3.69 | 2 | 300 | 1,000 | 700 | -42% |
| 007_02 | trib to Little Willow | 8 | 220 | aspen | 99% | 0.06 | 2 | 400 | 20 | 80% | 1.23 | 2 | 400 | 500 | 500 | -19% |
| 007_02 | Swanty Creek | 1 | 300 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 007_02 | Swanty Creek | 2 | 320 | lodgepole | 94% | 0.37 | 1 | 300 | 100 | 90% | 0.62 | 1 | 300 | 200 | 100 | -4% |
| 007_02 | Swanty Creek | 3 | 40 | sage/grass | 65% | 2.15 | 1 | 40 | 90 | 0% | 6.15 | 1 | 40 | 200 | 100 | -65% |
| 007_02 | Swanty Creek | 4 | 360 | | 65% | 2.15 | 1 | 400 | 900 | 60% | 2.46 | 1 | 400 | 1,000 | 100 | -5% |
| 007_02 | Swanty Creek | 5 | 150 | aspen | 100% | 0.00 | 1 | 200 | 0 | 80% | 1.23 | 1 | 200 | 200 | 200 | -20% |
| 007_02 | Swanty Creek | 6 | 770 | sage/grass | 65% | 2.15 | 1 | 800 | 2,000 | 50% | 3.08 | 1 | 800 | 2,000 | 0 | -15% |
| 007_02 | Swanty Creek | 7 | 220 | Geyer willow | 82% | 1.11 | 2 | 400 | 400 | 70% | 1.85 | 2 | 400 | 700 | 300 | -12% |
| 007_02 | Swanty Creek | 8 | 120 | aspen | 99% | 0.06 | 2 | 200 | 10 | 90% | 0.62 | 2 | 200 | 100 | 90 | -9% |
| 007_02 | Swanty Creek | 9 | 110 | Geyer willow | 82% | 1.11 | 2 | 200 | 200 | 60% | 2.46 | 2 | 200 | 500 | 300 | -22% |
| 007_02 | Swanty Creek | 10 | 90 | aspen | 99% | 0.06 | 2 | 200 | 10 | 80% | 1.23 | 2 | 200 | 200 | 200 | -19% |
| 007_02 | Swanty Creek | 11 | 290 | sage/grass | 39% | 3.75 | 2 | 600 | 2,000 | 40% | 3.69 | 2 | 600 | 2,000 | 0 | 0% |
| 007_02 | Swanty Creek | 12 | 440 | Geyer willow | 82% | 1.11 | 2 | 900 | 1,000 | 70% | 1.85 | 2 | 900 | 2,000 | 1,000 | -12% |
| 007_02 | Swanty Creek | 13 | 520 | | 82% | 1.11 | 2 | 1,000 | 1,000 | 60% | 2.46 | 2 | 1,000 | 2,000 | 1,000 | -22% |
| 007_02 | Buck Spring Creek | 1 | 1800 | sage/grass | 65% | 2.15 | 1 | 2,000 | 4,000 | 60% | 2.46 | 1 | 2,000 | 5,000 | 1,000 | -5% |
| 007_02 | Willow Creek | 1 | 1700 | | 65% | 2.15 | 1 | 2,000 | 4,000 | 60% | 2.46 | 1 | 2,000 | 5,000 | 1,000 | -5% |
| 007_02 | Willow Creek | 2 | 810 | | 65% | 2.15 | 1 | 800 | 2,000 | 50% | 3.08 | 1 | 800 | 2,000 | 0 | -15% |
| 007_02 | Willow Creek | 3 | 280 | aspen | 100% | 0.00 | 1 | 300 | 0 | 90% | 0.62 | 1 | 300 | 200 | 200 | -10% |
| 007_02 | Willow Creek | 4 | 1500 | sage/grass | 65% | 2.15 | 1 | 2,000 | 4,000 | 50% | 3.08 | 1 | 2,000 | 6,000 | 2,000 | -15% |
| 007_02 | Willow Creek | 5 | 550 | | 39% | 3.75 | 2 | 1,000 | 4,000 | 40% | 3.69 | 3 | 2,000 | 7,000 | 3,000 | 0% |
| 007_02 | Willow Creek | 6 | 220 | | 39% | 3.75 | 2 | 400 | 2,000 | 20% | 4.92 | 7 | 2,000 | 10,000 | 8,000 | -19% |
| 007_02 | Willow Creek | 7 | 220 | Geyer willow | 82% | 1.11 | 2 | 400 | 400 | 30% | 4.31 | 4 | 900 | 4,000 | 4,000 | -52% |
| 007_02 | Willow Creek | 8 | 230 | Geyer willow | 82% | 1.11 | 2 | 500 | 600 | 50% | 3.08 | 3 | 700 | 2,000 | 1,000 | -32% |
| 007_02 | Elk Basin Creek | 1 | 280 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 007_02 | Elk Basin Creek | 2 | 500 | Geyer willow | 93% | 0.43 | 1 | 500 | 200 | 70% | 1.85 | 1 | 500 | 900 | 700 | -23% |
| 007_02 | Elk Basin Creek | 3 | 590 | sage/grass | 65% | 2.15 | 1 | 600 | 1,000 | 60% | 2.46 | 1 | 600 | 1,000 | 0 | -5% |
| 007_02 | Elk Basin Creek | 4 | 660 | Geyer willow | 82% | 1.11 | 2 | 1,000 | 1,000 | 80% | 1.23 | 2 | 1,000 | 1,000 | 0 | 0% |
| | | | | | | | *Totals* | | 38,000 | | | | | 67,000 | 29,000 | |

**Table 9. Existing and target solar loads for upper Goose Creek.**

| 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 |
| 008_02 | Goose Creek | 1 | 1270 | lodgepole | 96% | 0.25 | 1 | 1,000 | 200 | 90% | 0.62 | 1 | 1,000 | 600 | 400 | -6% |
| 008_02 | Goose Creek | 2 | 380 | mtn brush | 93% | 0.43 | 1 | 400 | 200 | 70% | 1.85 | 1 | 400 | 700 | 500 | -23% |
| 008_02 | Goose Creek | 3 | 410 | sage/grass | 65% | 2.15 | 1 | 400 | 900 | 60% | 2.46 | 1 | 400 | 1,000 | 100 | -5% |
| 008_02 | Goose Creek | 4 | 740 | Geyer willow | 82% | 1.11 | 2 | 1,000 | 1,000 | 80% | 1.23 | 2 | 1,000 | 1,000 | 0 | -2% |
| 008_02 | Goose Creek | 5 | 1300 | | 82% | 1.11 | 2 | 3,000 | 3,000 | 70% | 1.85 | 2 | 3,000 | 6,000 | 3,000 | -12% |
| 008_02 | Goose Creek | 6 | 470 | | 82% | 1.11 | 2 | 900 | 1,000 | 30% | 4.31 | 2 | 900 | 4,000 | 3,000 | -52% |
| 008_02 | Goose Creek | 7 | 700 | | 82% | 1.11 | 2 | 1,000 | 1,000 | 60% | 2.46 | 2 | 1,000 | 2,000 | 1,000 | -22% |
| 008_02 | Goose Creek | 8 | 1200 | | 64% | 2.21 | 3 | 4,000 | 9,000 | 60% | 2.46 | 3 | 4,000 | 10,000 | 1,000 | -4% |
| 008_02 | Goose Creek | 9 | 580 | | 64% | 2.21 | 3 | 2,000 | 4,000 | 40% | 3.69 | 3 | 2,000 | 7,000 | 3,000 | -24% |
| 008_02 | Goose Creek | 10 | 720 | | 64% | 2.21 | 3 | 2,000 | 4,000 | 60% | 2.46 | 3 | 2,000 | 5,000 | 1,000 | -4% |
| 008_03 | Goose Creek | 11 | 990 | | 53% | 2.89 | 4 | 4,000 | 10,000 | 50% | 3.08 | 4 | 4,000 | 10,000 | 0 | -3% |
| 008_03 | Goose Creek | 12 | 610 | | 53% | 2.89 | 4 | 2,000 | 6,000 | 40% | 3.69 | 4 | 2,000 | 7,000 | 1,000 | -13% |
| 008_03 | Goose Creek | 13 | 1800 | | 53% | 2.89 | 4 | 7,000 | 20,000 | 60% | 2.46 | 4 | 7,000 | 20,000 | 0 | 0% |
| 008_03 | Goose Creek | 14 | 2500 | | 45% | 3.38 | 5 | 10,000 | 30,000 | 50% | 3.08 | 5 | 10,000 | 30,000 | 0 | 0% |
| 008_03 | Goose Creek | 15 | 1200 | | 45% | 3.38 | 5 | 6,000 | 20,000 | 40% | 3.69 | 5 | 6,000 | 20,000 | 0 | -5% |
| 008_04 | Goose Creek | 16 | 970 | | 45% | 3.38 | 5 | 5,000 | 20,000 | 40% | 3.69 | 5 | 5,000 | 20,000 | 0 | -5% |
| 008_04 | Goose Creek | 17 | 330 | | 45% | 3.38 | 5 | 2,000 | 7,000 | 30% | 4.31 | 5 | 2,000 | 9,000 | 2,000 | -15% |
| 008_04 | Goose Creek | 18 | 900 | | 45% | 3.38 | 5 | 5,000 | 20,000 | 40% | 3.69 | 5 | 5,000 | 20,000 | 0 | -5% |
| 008_04 | Goose Creek | 19 | 170 | | 45% | 3.38 | 5 | 900 | 3,000 | 10% | 5.54 | 5 | 900 | 5,000 | 2,000 | -35% |
| 008_04 | Goose Creek | 20 | 330 | | 45% | 3.38 | 5 | 2,000 | 7,000 | 20% | 4.92 | 5 | 2,000 | 10,000 | 3,000 | -25% |
| 008_04 | Goose Creek | 21 | 670 | | 45% | 3.38 | 5 | 3,000 | 10,000 | 30% | 4.31 | 5 | 3,000 | 10,000 | 0 | -15% |
| 008_04 | Goose Creek | 22 | 420 | | 45% | 3.38 | 5 | 2,000 | 7,000 | 40% | 3.69 | 5 | 2,000 | 7,000 | 0 | -5% |
| 008_04 | Goose Creek | 23 | 1100 | | 45% | 3.38 | 5 | 6,000 | 20,000 | 30% | 4.31 | 5 | 6,000 | 30,000 | 10,000 | -15% |
| 008_04 | Goose Creek | 24 | 1660 | | 40% | 3.69 | 6 | 10,000 | 40,000 | 20% | 4.92 | 6 | 10,000 | 50,000 | 10,000 | -20% |
| 008_04 | Goose Creek | 25 | 660 | | 40% | 3.69 | 6 | 4,000 | 10,000 | 40% | 3.69 | 6 | 4,000 | 10,000 | 0 | 0% |
| 008_04 | Goose Creek | 26 | 410 | | 40% | 3.69 | 6 | 2,000 | 7,000 | 20% | 4.92 | 6 | 2,000 | 10,000 | 3,000 | -20% |
| 008_04 | Goose Creek | 27 | 910 | | 40% | 3.69 | 6 | 5,000 | 20,000 | 40% | 3.69 | 6 | 5,000 | 20,000 | 0 | 0% |
| 008_04 | Goose Creek | 28 | 1130 | | 35% | 4.00 | 7 | 8,000 | 30,000 | 20% | 4.92 | 7 | 8,000 | 40,000 | 10,000 | -15% |
| 008_04 | Goose Creek | 29 | 420 | | 35% | 4.00 | 7 | 3,000 | 10,000 | 30% | 4.31 | 7 | 3,000 | 10,000 | 0 | -5% |
| | | | | | | | *Totals* | | 320,000 | | | | | 380,000 | 54,000 | |

**Table 10. Existing and target solar loads for upper Goose Creek Tributaries.**

| 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 |
| 008_02 | Jones Creek | 1 | 1400 | lodgepole | 96% | 0.25 | 1 | 1,000 | 200 | 90% | 0.62 | 1 | 1,000 | 600 | 400 | -6% |
| 008_02 | Jones Creek | 2 | 120 | Geyer willow | 93% | 0.43 | 1 | 100 | 40 | 50% | 3.08 | 1 | 100 | 300 | 300 | -43% |
| 008_02 | Jones Creek | 3 | 690 | | 93% | 0.43 | 1 | 700 | 300 | 80% | 1.23 | 1 | 700 | 900 | 600 | -13% |
| 008_02 | Jones Creek | 4 | 730 | | 82% | 1.11 | 2 | 1,000 | 1,000 | 80% | 1.23 | 2 | 1,000 | 1,000 | 0 | -2% |
| 008_02 | Jones Creek | 5 | 200 | | 82% | 1.11 | 2 | 400 | 400 | 90% | 0.62 | 2 | 400 | 200 | (200) | 0% |
| 008_02 | Buck Creek | 1 | 930 | lodgepole | 96% | 0.25 | 1 | 900 | 200 | 90% | 0.62 | 1 | 900 | 600 | 400 | -6% |
| 008_02 | Buck Creek | 2 | 340 | Geyer willow | 93% | 0.43 | 1 | 300 | 100 | 90% | 0.62 | 1 | 300 | 200 | 100 | -3% |
| 008_02 | Palmer Creek | 1 | 2500 | lodgepole | 96% | 0.25 | 1 | 3,000 | 700 | 90% | 0.62 | 1 | 3,000 | 2,000 | 1,000 | -6% |
| 008_02 | Palmer Creek | 2 | 130 | | 96% | 0.25 | 2 | 300 | 70 | 80% | 1.23 | 2 | 300 | 400 | 300 | -16% |
| 008_02 | Palmer Creek | 3 | 380 | sage/grass | 39% | 3.75 | 2 | 800 | 3,000 | 40% | 3.69 | 2 | 800 | 3,000 | 0 | 0% |
| 008_02 | Elison Hole Cr | 1 | 170 | | 65% | 2.15 | 1 | 200 | 400 | 60% | 2.46 | 1 | 200 | 500 | 100 | -5% |
| 008_02 | Elison Hole Cr | 2 | 380 | Geyer willow | 93% | 0.43 | 1 | 400 | 200 | 80% | 1.23 | 1 | 400 | 500 | 300 | -13% |
| 008_02 | Elison Hole Cr | 3 | 280 | | 93% | 0.43 | 1 | 300 | 100 | 90% | 0.62 | 1 | 300 | 200 | 100 | -3% |
| 008_02 | Elison Hole Cr | 4 | 90 | sage/grass | 65% | 2.15 | 1 | 90 | 200 | 50% | 3.08 | 1 | 90 | 300 | 100 | -15% |
| 008_02 | Elison Hole Cr | 5 | 560 | Geyer willow | 93% | 0.43 | 1 | 600 | 300 | 90% | 0.62 | 1 | 600 | 400 | 100 | -3% |
| 008_02 | Elison Hole Cr | 6 | 730 | lodgepole | 96% | 0.25 | 2 | 1,000 | 200 | 90% | 0.62 | 2 | 1,000 | 600 | 400 | -6% |
| 008_02 | Elison Hole Cr | 7 | 560 | | 96% | 0.25 | 2 | 1,000 | 200 | 80% | 1.23 | 2 | 1,000 | 1,000 | 800 | -16% |
| 008_02 | Elison Hole Cr | 8 | 110 | Geyer willow | 82% | 1.11 | 2 | 200 | 200 | 70% | 1.85 | 2 | 200 | 400 | 200 | -12% |
| 008_02 | Elison Hole Cr | 9 | 370 | | 82% | 1.11 | 2 | 700 | 800 | 80% | 1.23 | 2 | 700 | 900 | 100 | -2% |
| 008_02 | Little Goose Cr | 1 | 60 | sage/grass | 65% | 2.15 | 1 | 60 | 100 | 60% | 2.46 | 1 | 60 | 100 | 0 | -5% |
| 008_02 | Little Goose Cr | 2 | 200 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 90% | 0.62 | 1 | 200 | 100 | 10 | -3% |
| 008_02 | Little Goose Cr | 3 | 80 | sage/grass | 65% | 2.15 | 1 | 80 | 200 | 30% | 4.31 | 1 | 80 | 300 | 100 | 0% |
| 008_02 | Little Goose Cr | 4 | 180 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 70% | 1.85 | 1 | 200 | 400 | 300 | -23% |
| 008_02 | Little Goose Cr | 5 | 170 | | 93% | 0.43 | 1 | 200 | 90 | 60% | 2.46 | 1 | 200 | 500 | 400 | -33% |
| 008_02 | Little Goose Cr | 6 | 230 | | 93% | 0.43 | 1 | 200 | 90 | 30% | 4.31 | 1 | 200 | 900 | 800 | -63% |
| 008_02 | Little Goose Cr | 7 | 330 | | 93% | 0.43 | 1 | 300 | 100 | 70% | 1.85 | 1 | 300 | 600 | 500 | -23% |
| 008_02 | Little Goose Cr | 8 | 140 | sage/grass | 65% | 2.15 | 1 | 100 | 200 | 50% | 3.08 | 1 | 100 | 300 | 100 | -15% |
| 008_02 | Little Goose Cr | 9 | 370 | Geyer willow | 82% | 1.11 | 2 | 700 | 800 | 80% | 1.23 | 2 | 700 | 900 | 100 | -2% |
| 008_02 | Little Goose Cr | 10 | 50 | | 82% | 1.11 | 2 | 100 | 100 | 0% | 6.15 | 2 | 100 | 600 | 500 | -82% |
| 008_02 | Little Goose Cr | 11 | 800 | | 82% | 1.11 | 2 | 2,000 | 2,000 | 70% | 1.85 | 2 | 2,000 | 4,000 | 2,000 | -12% |
| 008_02 | Little Goose Cr | 12 | 900 | | 64% | 2.21 | 3 | 3,000 | 7,000 | 70% | 1.85 | 3 | 3,000 | 6,000 | (1,000) | 0% |
| 008_02 | Little Goose Cr | 13 | 370 | | 64% | 2.21 | 3 | 1,000 | 2,000 | 40% | 3.69 | 3 | 1,000 | 4,000 | 2,000 | -24% |
| 008_02 | Little Goose Cr | 14 | 240 | | 64% | 2.21 | 3 | 700 | 2,000 | 70% | 1.85 | 3 | 700 | 1,000 | (1,000) | 0% |
| 008_02 | trib to Little Goose | 1 | 300 | mtn brush | 93% | 0.43 | 1 | 300 | 100 | 90% | 0.62 | 1 | 300 | 200 | 100 | -3% |
| 008_02 | trib to Little Goose | 2 | 330 | lodgepole | 96% | 0.25 | 1 | 300 | 70 | 90% | 0.62 | 1 | 300 | 200 | 100 | -6% |
| 008_02 | trib to Little Goose | 3 | 160 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 80% | 1.23 | 1 | 200 | 200 | 100 | -13% |
| 008_02 | trib to Little Goose | 4 | 450 | | 93% | 0.43 | 1 | 500 | 200 | 70% | 1.85 | 1 | 500 | 900 | 700 | -23% |
| 008_02 | trib to Little Goose | 5 | 290 | | 82% | 1.11 | 2 | 600 | 700 | 80% | 1.23 | 2 | 600 | 700 | 0 | -2% |
| 008_02 | trib to Little Goose | 6 | 250 | | 82% | 1.11 | 2 | 500 | 600 | 60% | 2.46 | 2 | 500 | 1,000 | 400 | -22% |
| 008_02 | trib to Little Goose | 7 | 1000 | | 82% | 1.11 | 2 | 2,000 | 2,000 | 80% | 1.23 | 2 | 2,000 | 2,000 | 0 | -2% |

**Table 10 (cont.). Existing and target solar loads for upper Goose Creek Tributaries.**

| Segment Details | | | | | Target | | | | | Existing | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | Stream Name | Number (top to bottom) | Length (m) | Vegetation Type | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Excess Load (kWh/day) | Lack of Shade |
| 008_02 | Winecup Creek | 1 | 860 | | 93% | 0.43 | 1 | 900 | 400 | 90% | 0.62 | 1 | 900 | 600 | 200 | -3% |
| 008_02 | Winecup Creek | 2 | 260 | lodgepole | 96% | 0.25 | 1 | 300 | 70 | 90% | 0.62 | 1 | 300 | 200 | 100 | -6% |
| 008_02 | Winecup Creek | 3 | 190 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 70% | 1.85 | 1 | 200 | 400 | 300 | -23% |
| 008_02 | Winecup Creek | 4 | 400 | | 93% | 0.43 | 1 | 400 | 200 | 80% | 1.23 | 1 | 400 | 500 | 300 | -13% |
| 008_02 | Winecup Creek | 5 | 300 | sage/grass | 39% | 3.75 | 2 | 600 | 2,000 | 40% | 3.69 | 2 | 600 | 2,000 | 0 | 0% |
| 008_02 | Winecup Creek | 6 | 190 | Geyer willow | 82% | 1.11 | 2 | 400 | 400 | 70% | 1.85 | 2 | 400 | 700 | 300 | -12% |
| 008_02 | Winecup Creek | 7 | 1100 | sage/grass | 39% | 3.75 | 2 | 2,000 | 8,000 | 40% | 3.69 | 2 | 2,000 | 7,000 | (1,000) | 0% |
| 008_02 | Winecup Creek | 8 | 140 | Geyer willow | 82% | 1.11 | 2 | 300 | 300 | 80% | 1.23 | 2 | 300 | 400 | 100 | -2% |
| 008_02 | Little Piney Creek | 1 | 1600 | lodgepole | 96% | 0.25 | 1 | 2,000 | 500 | 90% | 0.62 | 1 | 2,000 | 1,000 | 500 | -6% |
| 008_02 | Little Piney Creek | 2 | 420 | Geyer willow | 93% | 0.43 | 1 | 400 | 200 | 80% | 1.23 | 1 | 400 | 500 | 300 | -13% |
| 008_02 | Little Piney Creek | 3 | 240 | sage/grass | 65% | 2.15 | 1 | 200 | 400 | 60% | 2.46 | 1 | 200 | 500 | 100 | -5% |
| 008_02 | Little Piney Creek | 4 | 960 | aspen | 99% | 0.06 | 2 | 2,000 | 100 | 90% | 0.62 | 2 | 2,000 | 1,000 | 900 | -9% |
| 008_02 | Little Piney Creek | 5 | 740 | lodgepole | 96% | 0.25 | 2 | 1,000 | 200 | 90% | 0.62 | 2 | 1,000 | 600 | 400 | -6% |
| 008_02 | Little Piney Creek | 6 | 230 | | 96% | 0.25 | 2 | 500 | 100 | 70% | 1.85 | 2 | 500 | 900 | 800 | -26% |
| 008_02 | Little Piney Creek | 7 | 650 | aspen | 99% | 0.06 | 2 | 1,000 | 60 | 90% | 0.62 | 2 | 1,000 | 600 | 500 | -9% |
| 008_02 | Little Piney Creek | 8 | 950 | | 99% | 0.06 | 3 | 3,000 | 200 | 90% | 0.62 | 3 | 3,000 | 2,000 | 2,000 | -9% |
| 008_02 | Little Piney Creek | 9 | 630 | | 99% | 0.06 | 3 | 2,000 | 100 | 80% | 1.23 | 3 | 2,000 | 2,000 | 2,000 | -19% |
| 008_02 | Little Piney Creek | 10 | 420 | | 99% | 0.06 | 3 | 1,000 | 60 | 90% | 0.62 | 3 | 1,000 | 600 | 500 | -9% |
| 008_03 | Little Piney Creek | 11 | 410 | Geyer willow | 64% | 2.21 | 3 | 1,000 | 2,000 | 70% | 1.85 | 3 | 1,000 | 2,000 | 0 | 0% |
| 008_03 | Little Piney Creek | 12 | 980 | | 64% | 2.21 | 3 | 3,000 | 7,000 | 80% | 1.23 | 3 | 3,000 | 4,000 | (3,000) | 0% |
| 008_02 | trib to Little Piney | 1 | 170 | mtn brush | 93% | 0.43 | 1 | 200 | 90 | 90% | 0.62 | 1 | 200 | 100 | 10 | -3% |
| 008_02 | trib to Little Piney | 2 | 610 | sage/grass | 65% | 2.15 | 1 | 600 | 1,000 | 60% | 2.46 | 1 | 600 | 1,000 | 0 | -5% |
| 008_02 | trib to Little Piney | 3 | 550 | lodgepole | 96% | 0.25 | 1 | 600 | 100 | 90% | 0.62 | 1 | 600 | 400 | 300 | -6% |
| 008_02 | trib to Little Piney | 4 | 280 | | 96% | 0.25 | 2 | 600 | 100 | 70% | 1.85 | 2 | 600 | 1,000 | 900 | -26% |
| 008_02 | SF Little Piney Cr | 1 | 1100 | sage/grass | 65% | 2.15 | 1 | 1,000 | 2,000 | 60% | 2.46 | 1 | 1,000 | 2,000 | 0 | -5% |
| 008_02 | SF Little Piney Cr | 2 | 230 | aspen | 100% | 0.00 | 1 | 200 | 0 | 90% | 0.62 | 1 | 200 | 100 | 100 | -10% |
| 008_02 | SF Little Piney Cr | 3 | 220 | sage/grass | 65% | 2.15 | 1 | 200 | 400 | 60% | 2.46 | 1 | 200 | 500 | 100 | -5% |
| 008_02 | SF Little Piney Cr | 4 | 320 | Geyer willow | 93% | 0.43 | 1 | 300 | 100 | 80% | 1.23 | 1 | 300 | 400 | 300 | -13% |
| 008_02 | SF Little Piney Cr | 5 | 170 | aspen | 100% | 0.00 | 1 | 200 | 0 | 90% | 0.62 | 1 | 200 | 100 | 100 | -10% |
| 008_02 | SF Little Piney Cr | 6 | 220 | meadow | 55% | 2.77 | 1 | 200 | 600 | 60% | 2.46 | 1 | 200 | 500 | (100) | 0% |
| 008_02 | SF Little Piney Cr | 7 | 590 | sage/grass | 65% | 2.15 | 1 | 600 | 1,000 | 50% | 3.08 | 1 | 600 | 2,000 | 1,000 | -15% |
| 008_02 | SF Little Piney Cr | 8 | 150 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 80% | 1.23 | 1 | 200 | 200 | 100 | -13% |
| 008_02 | SF Little Piney Cr | 9 | 800 | | 82% | 1.11 | 2 | 2,000 | 2,000 | 70% | 1.85 | 2 | 2,000 | 4,000 | 2,000 | -12% |
| 008_02 | Humphrey Creek | 1 | 910 | sage/grass | 65% | 2.15 | 1 | 900 | 2,000 | 60% | 2.46 | 1 | 900 | 2,000 | 0 | -5% |
| 008_02 | Humphrey Creek | 2 | 130 | aspen | 100% | 0.00 | 1 | 100 | 0 | 90% | 0.62 | 1 | 100 | 60 | 60 | -10% |
| 008_02 | Humphrey Creek | 3 | 250 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 008_02 | Humphrey Creek | 4 | 950 | Geyer willow | 82% | 1.11 | 2 | 2,000 | 2,000 | 80% | 1.23 | 2 | 2,000 | 2,000 | 0 | -2% |

**Table 10 (cont.). Existing and target solar loads for upper Goose Creek Tributaries.**

| Segment Details | | | | | Target | | | | | Existing | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | Stream Name | Number (top to bottom) | Length (m) | Vegetation Type | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Shade | Solar Radiation (kWh/m²/day) | Segment Width (m) | Segment Area (m²) | Solar Load (kWh/day) | Excess Load (kWh/day) | Lack of Shade |
| 008_02 | Meadow Spring Cr | 1 | 290 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 008_02 | Meadow Spring Cr | 2 | 360 | lodgepole | 96% | 0.25 | 1 | 400 | 100 | 90% | 0.62 | 1 | 400 | 200 | 100 | -6% |
| 008_02 | Meadow Spring Cr | 3 | 170 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 70% | 1.85 | 1 | 200 | 400 | 300 | -23% |
| 008_02 | Meadow Spring Cr | 4 | 490 | | 93% | 0.43 | 1 | 500 | 200 | 80% | 1.23 | 1 | 500 | 600 | 400 | -13% |
| 008_02 | Meadow Spring Cr | 5 | 200 | lodgepole | 96% | 0.25 | 1 | 200 | 50 | 90% | 0.62 | 1 | 200 | 100 | 50 | -6% |
| 008_02 | Meadow Spring Cr | 6 | 110 | | 96% | 0.25 | 1 | 100 | 20 | 80% | 1.23 | 1 | 100 | 100 | 80 | -16% |
| 008_02 | Meadow Spring Cr | 7 | 640 | sage/grass | 39% | 3.75 | 2 | 1,000 | 4,000 | 40% | 3.69 | 2 | 1,000 | 4,000 | 0 | 0% |
| 008_02 | Meadow Spring Cr | 8 | 110 | Geyer willow | 82% | 1.11 | 2 | 200 | 200 | 70% | 1.85 | 2 | 200 | 400 | 200 | -12% |
| 008_02 | Meadow Spring Cr | 9 | 50 | | 82% | 1.11 | 2 | 100 | 100 | 0% | 6.15 | 2 | 100 | 600 | 500 | -82% |
| 008_02 | Meadow Spring Cr | 10 | 70 | | 82% | 1.11 | 2 | 100 | 100 | 50% | 3.08 | 2 | 100 | 300 | 200 | -32% |
| 008_02 | Meadow Spring Cr | 11 | 310 | | 82% | 1.11 | 2 | 600 | 700 | 80% | 1.23 | 2 | 600 | 700 | 0 | -2% |
| 008_02 | Meadow Spring Cr | 12 | 220 | sage/grass | 39% | 3.75 | 2 | 400 | 2,000 | 40% | 3.69 | 2 | 400 | 1,000 | (1,000) | 0% |
| 008_02 | Meadow Spring Cr | 13 | 160 | Geyer willow | 82% | 1.11 | 2 | 300 | 300 | 80% | 1.23 | 2 | 300 | 400 | 100 | -2% |
| 008_02 | Indian Camp Springs ( | 1 | 490 | mtn brush | 93% | 0.43 | 1 | 500 | 200 | 90% | 0.62 | 1 | 500 | 300 | 100 | -3% |
| 008_02 | Indian Camp Springs ( | 2 | 1400 | sage/grass | 65% | 2.15 | 1 | 1,000 | 2,000 | 60% | 2.46 | 1 | 1,000 | 2,000 | 0 | -5% |
| 008_02 | Indian Camp Springs ( | 3 | 160 | aspen | 100% | 0.00 | 1 | 200 | 0 | 90% | 0.62 | 1 | 200 | 100 | 100 | -10% |
| 008_02 | Indian Camp Springs ( | 4 | 160 | Geyer willow | 82% | 1.11 | 2 | 300 | 300 | 70% | 1.85 | 2 | 300 | 600 | 300 | -12% |
| 008_02 | trib to Indian Camp | 1 | 280 | aspen | 100% | 0.00 | 1 | 300 | 0 | 90% | 0.62 | 1 | 300 | 200 | 200 | -10% |
| 008_02 | trib to Indian Camp | 2 | 370 | mtn brush | 93% | 0.43 | 1 | 400 | 200 | 80% | 1.23 | 1 | 400 | 500 | 300 | -13% |
| 008_02 | trib to Indian Camp | 3 | 210 | aspen | 100% | 0.00 | 1 | 200 | 0 | 90% | 0.62 | 1 | 200 | 100 | 100 | -10% |
| 008_02 | trib to Indian Camp | 4 | 700 | sage/grass | 65% | 2.15 | 1 | 700 | 2,000 | 60% | 2.46 | 1 | 700 | 2,000 | 0 | -5% |
| 008_02 | trib to Indian Camp | 5 | 270 | aspen | 100% | 0.00 | 1 | 300 | 0 | 90% | 0.62 | 1 | 300 | 200 | 200 | -10% |
| 008_02 | Un-named | 1 | 420 | sage/grass | 65% | 2.15 | 1 | 400 | 900 | 60% | 2.46 | 1 | 400 | 1,000 | 100 | -5% |
| 008_02 | Un-named | 2 | 1200 | aspen | 100% | 0.00 | 1 | 1,000 | 0 | 90% | 0.62 | 1 | 1,000 | 600 | 600 | -10% |
| 008_02 | Un-named | 3 | 240 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 80% | 1.23 | 1 | 200 | 200 | 100 | -13% |
| 008_02 | Rattlesnake Creek | 1 | 1400 | aspen | 100% | 0.00 | 1 | 1,000 | 0 | 90% | 0.62 | 1 | 1,000 | 600 | 600 | -10% |
| 008_02 | Rattlesnake Creek | 2 | 650 | sage/grass | 39% | 3.75 | 2 | 1,000 | 4,000 | 40% | 3.69 | 2 | 1,000 | 4,000 | 0 | 0% |
| 008_02 | Rattlesnake Creek | 3 | 180 | Geyer willow | 82% | 1.11 | 2 | 400 | 400 | 80% | 1.23 | 2 | 400 | 500 | 100 | -2% |
| 008_02 | Rattlesnake Creek | 4 | 160 | sage/grass | 39% | 3.75 | 2 | 300 | 1,000 | 40% | 3.69 | 2 | 300 | 1,000 | 0 | 0% |
| 008_02 | Rattlesnake Creek | 5 | 530 | Geyer willow | 82% | 1.11 | 2 | 1,000 | 1,000 | 70% | 1.85 | 2 | 1,000 | 2,000 | 1,000 | -12% |
| 008_02 | Rattlesnake Creek | 6 | 100 | | 82% | 1.11 | 2 | 200 | 200 | 50% | 3.08 | 2 | 200 | 600 | 400 | -32% |
| 008_02 | Rattlesnake Creek | 7 | 170 | | 82% | 1.11 | 2 | 300 | 300 | 80% | 1.23 | 2 | 300 | 400 | 100 | -2% |
| 008_02 | Un-named | 1 | 770 | sage/grass | 65% | 2.15 | 1 | 800 | 2,000 | 60% | 2.46 | 1 | 800 | 2,000 | 0 | -5% |
| 008_02 | Un-named | 2 | 910 | aspen | 100% | 0.00 | 1 | 900 | 0 | 90% | 0.62 | 1 | 900 | 600 | 600 | -10% |

**Table 10 (cont.). Existing and target solar loads for upper Goose Creek Tributaries.**

| 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 |
| 008_02 | Ruby Gulch | 1 | 340 | mtn brush | 93% | 0.43 | 1 | 300 | 100 | 90% | 0.62 | 1 | 300 | 200 | 100 | -3% |
| 008_02 | Ruby Gulch | 2 | 400 | lodgepole | 96% | 0.25 | 1 | 400 | 100 | 90% | 0.62 | 1 | 400 | 200 | 100 | -6% |
| 008_02 | Ruby Gulch | 3 | 320 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 008_02 | Ruby Gulch | 4 | 150 | aspen | 100% | 0.00 | 1 | 200 | 0 | 90% | 0.62 | 1 | 200 | 100 | 100 | -10% |
| 008_02 | Ruby Gulch | 5 | 300 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 008_02 | Ruby Gulch | 6 | 270 | | 39% | 3.75 | 2 | 500 | 2,000 | 50% | 3.08 | 2 | 500 | 2,000 | 0 | 0% |
| 008_02 | Ruby Gulch | 7 | 130 | Geyer willow | 82% | 1.11 | 2 | 300 | 300 | 80% | 1.23 | 2 | 300 | 400 | 100 | -2% |
| 008_02 | Ruby Gulch | 8 | 450 | sage/grass | 39% | 3.75 | 2 | 900 | 3,000 | 40% | 3.69 | 2 | 900 | 3,000 | 0 | 0% |
| 008_02 | trib to Ruby Gulch | 1 | 1600 | aspen | 100% | 0.00 | 1 | 2,000 | 0 | 90% | 0.62 | 1 | 2,000 | 1,000 | 1,000 | -10% |
| 008_02 | trib to Ruby Gulch | 2 | 440 | sage/grass | 65% | 2.15 | 1 | 400 | 900 | 60% | 2.46 | 1 | 400 | 1,000 | 100 | -5% |
| 008_02 | Quartz Gulch | 1 | 260 | | 65% | 2.15 | 1 | 300 | 600 | 40% | 3.69 | 1 | 300 | 1,000 | 400 | -25% |
| 008_02 | Quartz Gulch | 2 | 40 | | 65% | 2.15 | 1 | 40 | 90 | 0% | 6.15 | 1 | 40 | 200 | 100 | -65% |
| 008_02 | Quartz Gulch | 3 | 290 | | 65% | 2.15 | 1 | 300 | 600 | 50% | 3.08 | 1 | 300 | 900 | 300 | -15% |
| 008_02 | Quartz Gulch | 4 | 40 | | 65% | 2.15 | 1 | 40 | 90 | 0% | 6.15 | 1 | 40 | 200 | 100 | -65% |
| 008_02 | Quartz Gulch | 5 | 1600 | | 65% | 2.15 | 1 | 2,000 | 4,000 | 50% | 3.08 | 1 | 2,000 | 6,000 | 2,000 | -15% |
| 008_02 | Quartz Gulch | 6 | 410 | Geyer willow | 82% | 1.11 | 2 | 800 | 900 | 80% | 1.23 | 2 | 800 | 1,000 | 100 | -2% |
| 008_02 | Quartz Gulch | 7 | 300 | | 82% | 1.11 | 2 | 600 | 700 | 70% | 1.85 | 2 | 600 | 1,000 | 300 | -12% |
| 008_02 | WF Thoroughbred Cr | 1 | 820 | sage/grass | 65% | 2.15 | 1 | 800 | 2,000 | 60% | 2.46 | 1 | 800 | 2,000 | 0 | -5% |
| 008_02 | WF Thoroughbred Cr | 2 | 340 | mtn brush | 93% | 0.43 | 1 | 300 | 100 | 80% | 1.23 | 1 | 300 | 400 | 300 | -13% |
| 008_02 | WF Thoroughbred Cr | 3 | 280 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 50% | 3.08 | 1 | 300 | 900 | 300 | -15% |
| 008_02 | WF Thoroughbred Cr | 4 | 490 | lodgepole | 96% | 0.25 | 1 | 500 | 100 | 90% | 0.62 | 1 | 500 | 300 | 200 | -6% |
| 008_02 | WF Thoroughbred Cr | 5 | 230 | sage/grass | 65% | 2.15 | 1 | 200 | 400 | 50% | 3.08 | 1 | 200 | 600 | 200 | -15% |
| 008_02 | WF Thoroughbred Cr | 6 | 150 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 70% | 1.85 | 1 | 200 | 400 | 300 | -23% |
| 008_02 | WF Thoroughbred Cr | 7 | 210 | sage/grass | 65% | 2.15 | 1 | 200 | 400 | 30% | 4.31 | 1 | 200 | 900 | 500 | -35% |
| 008_02 | WF Thoroughbred Cr | 8 | 120 | Geyer willow | 93% | 0.43 | 1 | 100 | 40 | 40% | 3.69 | 1 | 100 | 400 | 400 | -53% |
| 008_02 | WF Thoroughbred Cr | 9 | 570 | aspen | 99% | 0.06 | 2 | 1,000 | 60 | 90% | 0.62 | 2 | 1,000 | 600 | 500 | -9% |
| 008_02 | WF Thoroughbred Cr | 10 | 150 | Geyer willow | 82% | 1.11 | 2 | 300 | 300 | 70% | 1.85 | 2 | 300 | 600 | 300 | -12% |
| 008_02 | WF Thoroughbred Cr | 11 | 1900 | | 82% | 1.11 | 2 | 4,000 | 4,000 | 80% | 1.23 | 2 | 4,000 | 5,000 | 1,000 | -2% |
| 008_02 | WF Thoroughbred Cr | 12 | 350 | | 82% | 1.11 | 2 | 700 | 800 | 70% | 1.85 | 2 | 700 | 1,000 | 200 | -12% |
| 008_02 | WF Thoroughbred Cr | 13 | 220 | | 82% | 1.11 | 2 | 400 | 400 | 80% | 1.23 | 2 | 400 | 500 | 100 | -2% |
| 008_02 | EF Thoroughbred Cr | 1 | 580 | sage/grass | 65% | 2.15 | 1 | 600 | 1,000 | 60% | 2.46 | 1 | 600 | 1,000 | 0 | -5% |
| 008_02 | EF Thoroughbred Cr | 2 | 200 | aspen | 100% | 0.00 | 1 | 200 | 0 | 90% | 0.62 | 1 | 200 | 100 | 100 | -10% |
| 008_02 | EF Thoroughbred Cr | 3 | 380 | | 100% | 0.00 | 1 | 400 | 0 | 70% | 1.85 | 1 | 400 | 700 | 700 | -30% |
| 008_02 | EF Thoroughbred Cr | 4 | 700 | lodgepole | 96% | 0.25 | 1 | 700 | 200 | 80% | 1.23 | 1 | 700 | 900 | 700 | -16% |
| 008_02 | EF Thoroughbred Cr | 5 | 390 | Geyer willow | 93% | 0.43 | 1 | 400 | 200 | 60% | 2.46 | 1 | 400 | 1,000 | 800 | -33% |
| 008_02 | EF Thoroughbred Cr | 6 | 90 | | 93% | 0.43 | 1 | 90 | 40 | 40% | 3.69 | 1 | 90 | 300 | 300 | -53% |
| 008_02 | EF Thoroughbred Cr | 7 | 320 | | 93% | 0.43 | 1 | 300 | 100 | 70% | 1.85 | 1 | 300 | 600 | 500 | -23% |
| 008_02 | EF Thoroughbred Cr | 8 | 140 | | 93% | 0.43 | 1 | 100 | 40 | 90% | 0.62 | 1 | 100 | 60 | 20 | -3% |
| 008_02 | EF Thoroughbred Cr | 9 | 2400 | | 82% | 1.11 | 2 | 5,000 | 6,000 | 80% | 1.23 | 2 | 5,000 | 6,000 | 0 | -2% |
| 008_02 | EF Thoroughbred Cr | 10 | 400 | | 82% | 1.11 | 2 | 800 | 900 | 60% | 2.46 | 2 | 800 | 2,000 | 1,000 | -22% |
| 008_02 | EF Thoroughbred Cr | 11 | 130 | | 82% | 1.11 | 2 | 300 | 300 | 80% | 1.23 | 2 | 300 | 400 | 100 | -2% |

**Table 10 (cont.). Existing and target solar loads for upper Goose Creek Tributaries.**

| 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 |
| 008_02 | Thoroughbred Creek | 1 | 90 | | 64% | 2.21 | 3 | 300 | 700 | 80% | 1.23 | 3 | 300 | 400 | (300) | 0% |
| 008_02 | Thoroughbred Creek | 2 | 330 | | 64% | 2.21 | 3 | 1,000 | 2,000 | 70% | 1.85 | 3 | 1,000 | 2,000 | 0 | 0% |
| 008_02 | Thoroughbred Creek | 3 | 380 | | 64% | 2.21 | 3 | 1,000 | 2,000 | 80% | 1.23 | 3 | 1,000 | 1,000 | (1,000) | 0% |
| 008_02 | Thoroughbred Creek | 4 | 500 | | 64% | 2.21 | 3 | 2,000 | 4,000 | 70% | 1.85 | 3 | 2,000 | 4,000 | 0 | 0% |
| 008_02 | Thoroughbred Creek | 5 | 270 | | 64% | 2.21 | 3 | 800 | 2,000 | 40% | 3.69 | 3 | 800 | 3,000 | 1,000 | -24% |
| 008_02 | Thoroughbred Creek | 6 | 490 | | 64% | 2.21 | 3 | 1,000 | 2,000 | 80% | 1.23 | 3 | 1,000 | 1,000 | (1,000) | 0% |
| 008_02 | Thoroughbred Creek | 7 | 260 | | 64% | 2.21 | 3 | 800 | 2,000 | 60% | 2.46 | 3 | 800 | 2,000 | 0 | -4% |
| 008_02 | Piney Creek | 1 | 180 | lodgepole | 96% | 0.25 | 1 | 200 | 50 | 90% | 0.62 | 1 | 200 | 100 | 50 | -6% |
| 008_02 | Piney Creek | 2 | 490 | sage/grass | 65% | 2.15 | 1 | 500 | 1,000 | 60% | 2.46 | 1 | 500 | 1,000 | 0 | -5% |
| 008_02 | Piney Creek | 3 | 610 | Geyer willow | 93% | 0.43 | 1 | 600 | 300 | 90% | 0.62 | 1 | 600 | 400 | 100 | -3% |
| 008_02 | Piney Creek | 4 | 410 | | 93% | 0.43 | 1 | 400 | 200 | 80% | 1.23 | 1 | 400 | 500 | 300 | -13% |
| 008_02 | Piney Creek | 5 | 270 | beaver ponds | 30% | 4.31 | 1 | 300 | 1,000 | 30% | 4.31 | 1 | 300 | 1,000 | 0 | 0% |
| 008_02 | Piney Creek | 6 | 590 | | 93% | 0.43 | 1 | 600 | 300 | 80% | 1.23 | 1 | 600 | 700 | 400 | -13% |
| 008_02 | Piney Creek | 7 | 180 | | 82% | 1.11 | 2 | 400 | 400 | 60% | 2.46 | 2 | 400 | 1,000 | 600 | -22% |
| 008_02 | Piney Creek | 8 | 110 | | 82% | 1.11 | 2 | 200 | 200 | 30% | 4.31 | 2 | 200 | 900 | 700 | -52% |
| 008_02 | Piney Creek | 9 | 2100 | | 82% | 1.11 | 2 | 4,000 | 4,000 | 80% | 1.23 | 2 | 4,000 | 5,000 | 1,000 | -2% |
| 008_02 | Piney Creek | 10 | 70 | | 82% | 1.11 | 2 | 100 | 100 | 60% | 2.46 | 2 | 100 | 200 | 100 | -22% |
| 008_02 | Piney Creek | 11 | 100 | | 64% | 2.21 | 3 | 300 | 700 | 60% | 2.46 | 3 | 300 | 700 | 0 | -4% |
| 008_02 | Piney Creek | 12 | 750 | | 64% | 2.21 | 3 | 2,000 | 4,000 | 70% | 1.85 | 3 | 2,000 | 4,000 | 0 | 0% |
| 008_02 | Piney Creek | 13 | 350 | | 64% | 2.21 | 3 | 1,000 | 2,000 | 60% | 2.46 | 3 | 1,000 | 2,000 | 0 | -4% |
| 008_02 | Piney Creek | 14 | 410 | | 64% | 2.21 | 3 | 1,000 | 2,000 | 70% | 1.85 | 3 | 1,000 | 2,000 | 0 | 0% |
| 008_02 | Piney Creek | 15 | 570 | | 64% | 2.21 | 3 | 2,000 | 4,000 | 80% | 1.23 | 3 | 2,000 | 2,000 | (2,000) | 0% |
| 008_02 | Piney Creek | 16 | 560 | | 64% | 2.21 | 3 | 2,000 | 4,000 | 70% | 1.85 | 3 | 2,000 | 4,000 | 0 | 0% |
| 008_02 | tributary to Piney Cr | 1 | 1300 | sage/grass | 65% | 2.15 | 1 | 1,000 | 2,000 | 60% | 2.46 | 1 | 1,000 | 2,000 | 0 | -5% |
| 008_02 | tributary to Piney Cr | 2 | 90 | Geyer willow | 93% | 0.43 | 1 | 90 | 40 | 80% | 1.23 | 1 | 90 | 100 | 60 | -13% |
| 008_02 | tributary to Piney Cr | 3 | 280 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 008_02 | tributary to Piney Cr | 4 | 150 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 80% | 1.23 | 1 | 200 | 200 | 100 | -13% |
| 008_02 | Little Willow Springs | 1 | 700 | sage/grass | 65% | 2.15 | 1 | 700 | 2,000 | 50% | 3.08 | 1 | 700 | 2,000 | 0 | -15% |
| 008_02 | Little Willow Springs | 2 | 200 | Geyer willow | 93% | 0.43 | 1 | 200 | 90 | 70% | 1.85 | 1 | 200 | 400 | 300 | -23% |
| 008_02 | Little Willow Springs | 3 | 90 | sage/grass | 65% | 2.15 | 1 | 90 | 200 | 60% | 2.46 | 1 | 90 | 200 | 0 | -5% |
| 008_02 | Little Willow Springs | 4 | 370 | Geyer willow | 93% | 0.43 | 1 | 400 | 200 | 80% | 1.23 | 1 | 400 | 500 | 300 | -13% |
| 008_02 | Cherry Creek | 1 | 190 | | 93% | 0.43 | 1 | 200 | 90 | 90% | 0.62 | 1 | 200 | 100 | 10 | -3% |
| 008_02 | Cherry Creek | 2 | 270 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 008_02 | Cherry Creek | 3 | 130 | Geyer willow | 93% | 0.43 | 1 | 100 | 40 | 80% | 1.23 | 1 | 100 | 100 | 60 | -13% |
| 008_02 | Cherry Creek | 4 | 260 | sage/grass | 65% | 2.15 | 1 | 300 | 600 | 60% | 2.46 | 1 | 300 | 700 | 100 | -5% |
| 008_02 | Cherry Creek | 5 | 280 | Geyer willow | 93% | 0.43 | 1 | 300 | 100 | 80% | 1.23 | 1 | 300 | 400 | 300 | -13% |
| | | | | | | | *Totals* | | 160,000 | | | | | 210,000 | 42,000 | |

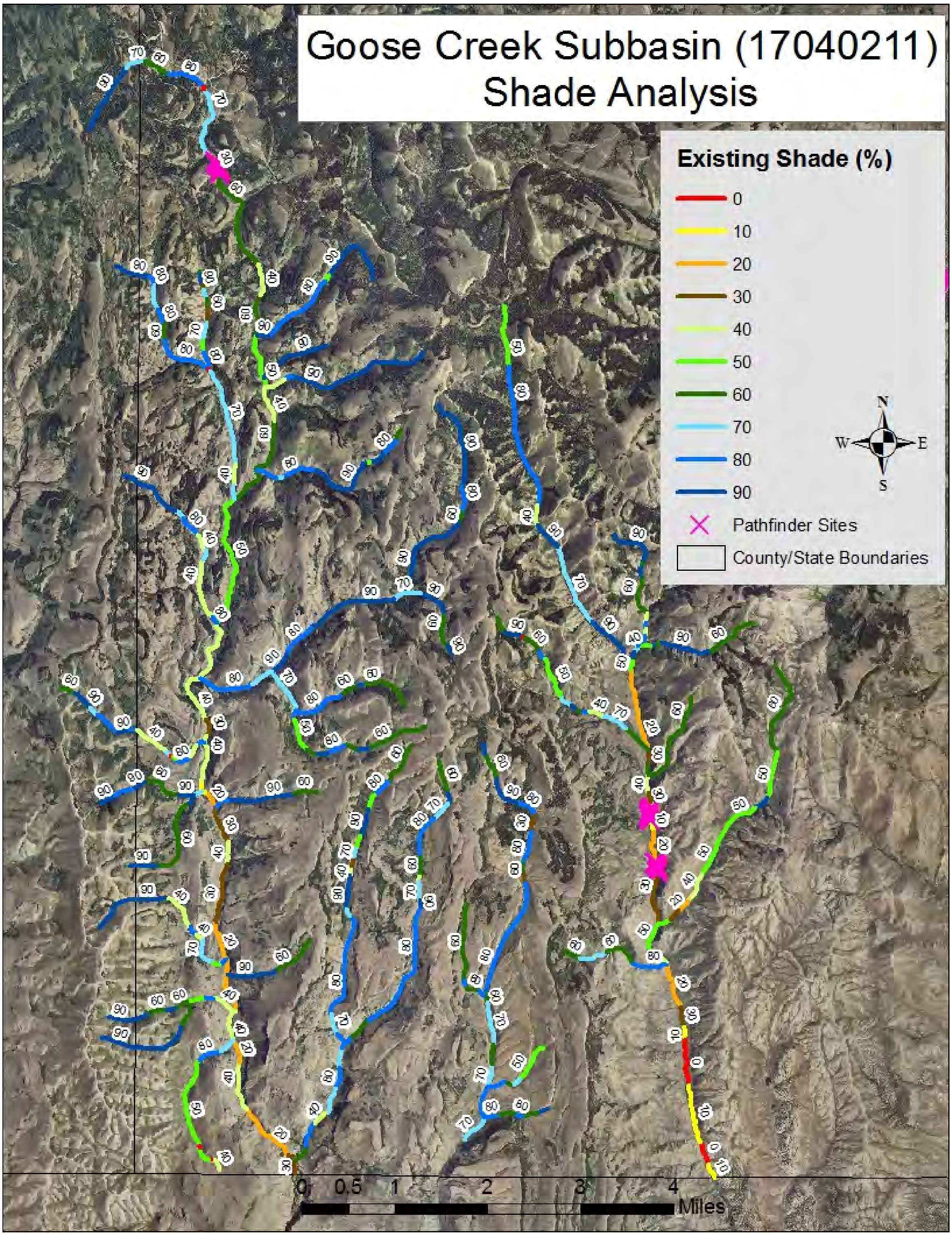


**Figure 2. Existing shade estimated for the Goose Creek subbasin by aerial photo interpretation.**

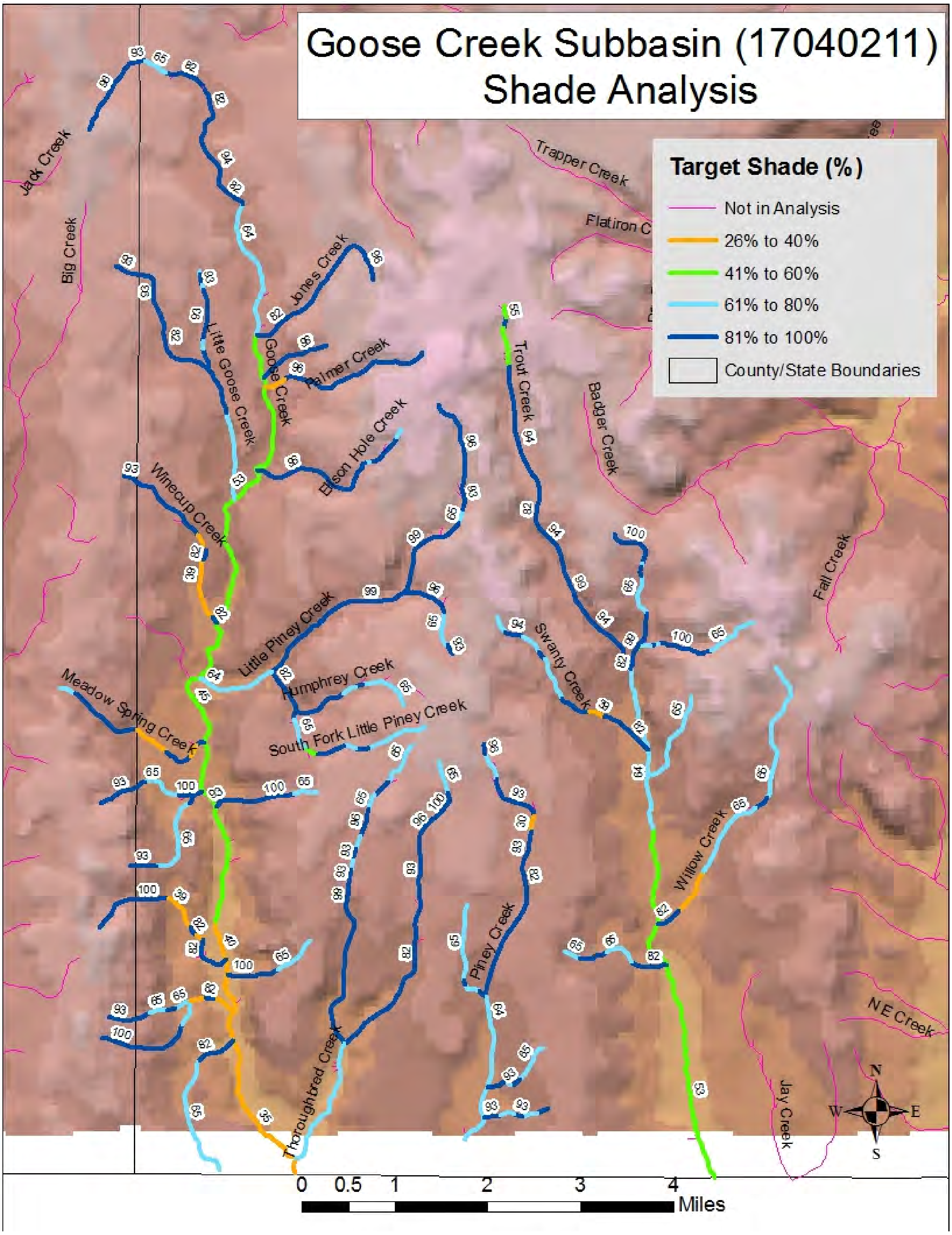


Figure 3. Target shade for the Goose Creek subbasin.

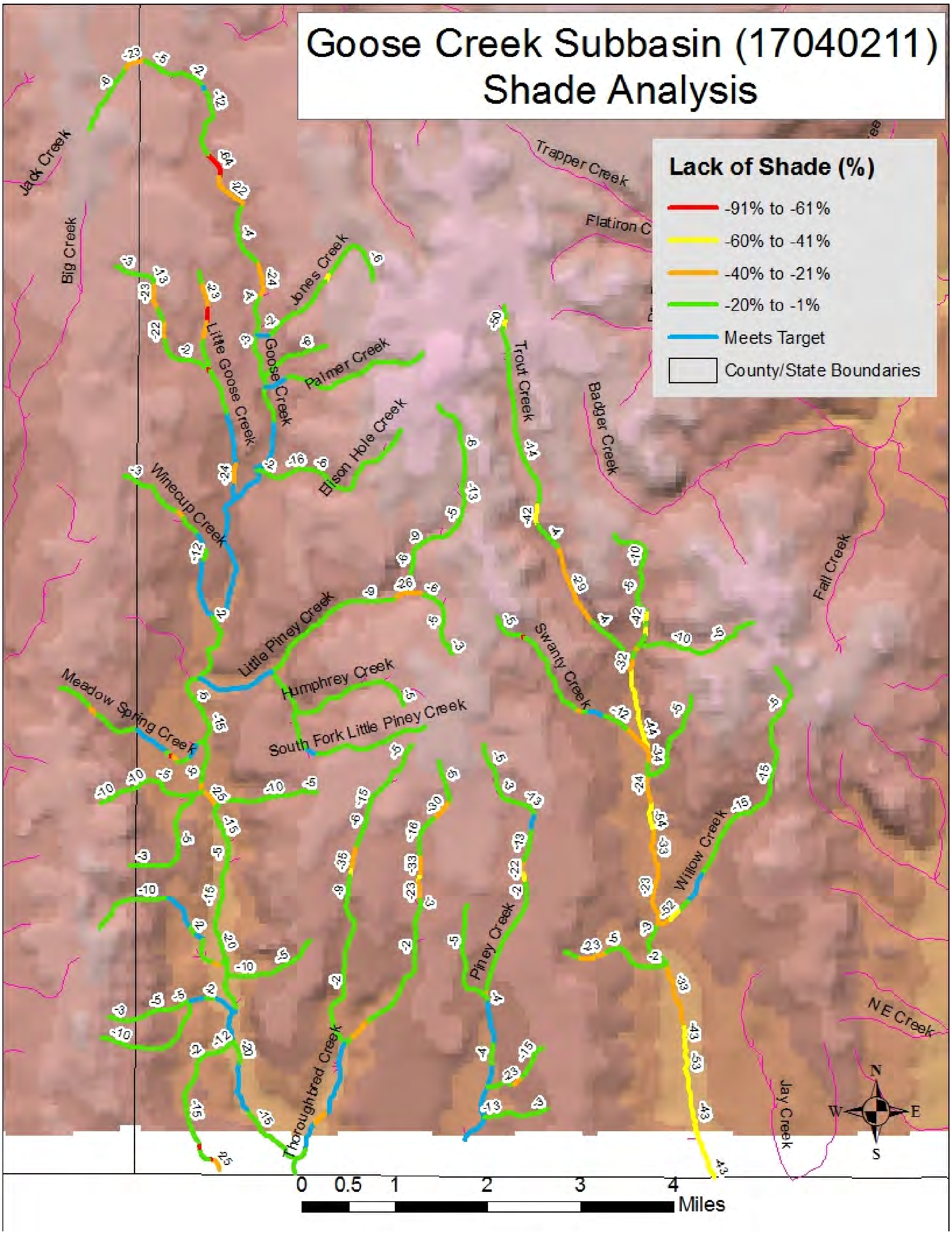


**Figure 4. Lack of shade (difference between existing and target) for the Goose Creek subbasin.**

## 5.4 Load Allocation

Because this TMDL is based on PNV, which is equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, in order 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 therefore reach specific and are dependent upon the target load for a given reach. Tables 7, 8, 9 and 10 show the target shade, which is converted to a target summer solar load by multiplying the inverse fraction (1 minus shade fraction) by the average load received by a flat-plate collector for the months of April through September. This calculation results in the load capacity of the stream, and it is necessary to achieve background conditions. At that point, there is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL is dependent upon background conditions for achieving water quality standards, all tributaries to the waters examined here need to be in natural conditions in order to prevent excess heat loads to the system.

Table 11 shows the total existing, total target, and excess heat load (kWh/day) for each water body examined, as well as the percent reduction needed to meet target loads. The table also presents the average lack of shade, which is the result of averaging all the differences between existing shade and target shade for the creek. The last column of each load analysis table (Tables 7–10) shows these differences between existing and target shade for each segment examined.

**Table 11. Total existing, target, and excess solar loads; percent reductions; and average lack of shade for Goose and Trout Creeks.**

| Water Body | Total Existing Load (kWh/day) | Total Target Load (kWh/day) | Excess Load (kWh/day) | Necessary Percent (%) Reduction | Average Lack of Shade (%) |
|---|---|---|---|---|---|
| Goose Creek | 380,000 | 320,000 | 54,000 | 14 | -12 |
| Goose Creek Tributaries | 210,000 | 160,000 | 42,000 | 20 | -12 |
| Trout Creek | 210,000 | 110,000 | 100,000 | 48 | -29 |
| Trout Creek Tributaries | 67,000 | 38,000 | 29,000 | 76 | -15 |

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

Although Goose Creek is larger than Trout Creek as depicted by a larger target load, Goose Creek had a smaller excess load and necessary percent reduction than Trout Creek. The average lack-of-shade values reflect that Goose Creek is generally in better condition than Trout Creek. Trout Creek had more segments where lack of shade exceeded 20% (Figure 4). Additionally, Goose Creek tributaries are in better condition than Trout Creek tributaries. Goose Creek tributaries require only a 20% reduction in solar load whereas Trout Creek tributaries require a 76% reduction.

Both streams and their tributaries lacked shade and had excess loads. Much of this excess can be attributed to high target levels due to narrow streams with various tree-dominated vegetation types (aspen, lodgepole pine, etc.). Many of these streams now lack these vegetation types or only have remnant stands of aspen or lodgepole. The reasons for this vegetation change may be many and varied, from the lack of aspen regeneration due to grazing to a lack of water from diversion and drought throughout the subbasin.

Although this analysis focuses on total heat loads for streams in the subbasin, it is important to note that differences between existing shade and target shade, as depicted in Figure 4, 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.

A certain amount of excess load, and hence necessary percent reduction, 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 is a unique integer, there is usually a difference between the two. For example, say a particular stretch of stream has a target shade of 86% based on its vegetation type and natural bankfull width. If existing shade on that stretch of stream was at target level, it would be recorded as 80% existing shade 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 margin of safety.

## 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 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 affects 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 reads:

> *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 in Section IDAPA 58.01.02.050.01 indicate that:

> *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.*

In this TMDL we have not quantified what impact if any diversions are having on stream temperature. Water diversions are allowed for in state statue 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 the resulting water temperature that that shade provides. The Idaho Department of Environmental Quality encourages local land owners 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.

## Wasteload Allocation

There are no known National Pollutant Discharge Elimination System (NPDES) permitted point sources in the affected watersheds and therefore no wasteload allocations. Should a point source be proposed that would have thermal consequences on these waters, then background provisions in Idaho water quality standards addressing such discharges (i.e., IDAPA 58.01.02.200.09 and IDAPA 58.01.02.401.01) should be involved (see Appendix A).

## Margin of Safety

The margin of safety 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 interval, which likely underestimates actual shade in the loading 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.

## Seasonal Variation

This TMDL is based on average summer loads. All loads have been calculated to be inclusive of the 6-month period from April through September. This time period was chosen because it represents the time when the combination of increasing air and water temperatures coincide with increasing solar inputs and vegetative shade. The critical time period is June when spring salmonid spawning is occurring, July and August when maximum temperatures may exceed cold water aquatic life criteria, and September during fall salmonid spawning. 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.

## Construction Stormwater and TMDL Wasteload Allocations

### *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. In the past, stormwater was treated as a nonpoint source of pollutants. However, because stormwater can be managed on-site through management practices or when discharged through a discrete conveyance such as a storm sewer, it now requires an NPDES permit.

### *The Construction General Permit*

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 Construction General Permit (CGP) from EPA after developing a site-specific Stormwater Pollution Prevention Plan (SWPPP).

### *Stormwater Pollution Prevention Plan*

In order to obtain the CGP, operators must develop a site-specific SWPPP. The operator must document the erosion, sediment, and pollution controls they intend to use; inspect the controls periodically; and maintain best management practices (BMPs) throughout the life of the project.

### *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. TMDLs developed in the past that did not have a wasteload allocation for construction stormwater activities will be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate BMPs.

Typically, specific requirements must be followed to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for post-construction stormwater management. Sediment is usually the main pollutant of concern in stormwater from construction sites. The application of specific BMPs from Idaho's *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties* (DEQ 2005) is generally sufficient to meet the standards and requirements of the CGP, unless local ordinances have more stringent and site-specific standards that are applicable.

## 5.5 Public Participation

The Lake Walcott Watershed Advisory Group (WAG) was created in 1995 and contributed to the original Goose Creek subbasin assessment and TMDL. The Lake Walcott WAG has continued to meet several times annually since the approval of the original document. They reviewed the Goose Creek temperature TMDL document and discussed it at their July 21, 2011, meeting. The WAG was given a draft copy and was asked to submit comments to DEQ. An email was sent to the WAG members the following week that included the DEQ website address to access the draft document, and comments were again requested before August 30, 2011. No comments were received. The DEQ Twin Falls Regional Office can provide copies of the document by request.

The draft temperature TMDL was open for a 30 day public comment period from October 5, 2011 to November 4, 2011. EPA was the only entity to return comments. A summary of these comments can be found in Appendix D.

## 5.6 Implementation Strategies

Implementation strategies for TMDLs produced using PNV-based shade and solar loading should incorporate the load analysis tables presented in this TMDL (Tables 8 and 9). These tables need to be updated, first to field verify the existing shade levels that have not yet been field verified and second to monitor progress towards achieving load reductions and the goals of the TMDL. 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 loading 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 towards achieving desired reductions in solar loads.

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

### Time Frame

The time frame for implementation will follow the goals as outlined in the *Goose Creek Subbasin Assessment and Total Maximum Daily Loads* (DEQ 2003, p. 205), which includes a time span from year 1 through year 25.

### Approach

The approach for implementation will be similar to that in the Goose Creek subbasin assessment and TMDL (DEQ 2003, p. 202). With the use of past management experiences to evaluate success and failures, insight into the practices that promote the best implementation techniques and restoration of beneficial uses can be utilized.

### Responsible Parties

The responsible parties for implementation will be similar to those outlined in the Goose Creek subbasin assessment and TMDL (DEQ 2003, p. 201). These include state and federal agencies as well as private stakeholders.

### Monitoring Strategy

The monitoring strategy for implementation will be similar to that listed in the Goose Creek subbasin assessment and TMDL (DEQ 2003, p. 204). The strategy includes tracking the implementation progress of specific plans and tracking the progress of improving water quality by monitoring physical, chemical, and biological parameters.

## 5.7 Conclusions

Effective shade targets were established for the upper Goose Creek and Trout Creek watersheds 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 vegetation types in southern Idaho. Existing shade was determined from aerial photo interpretation and partially field verified with Solar Pathfinder data.

Both stream systems examined lacked shade compared to target levels (Table 12). The lack of shade is likely the result of a combination of factors, including natural and human-influenced dewatering of the stream channel and historic removal of riparian vegetation associated with livestock grazing and agricultural practices. Much of the lack of shade is also due to high target levels set for narrow streams with various tree-dominated vegetation types (e.g., aspen, lodgepole pine). Many of these streams now lack these vegetation types or only have remnant stands of aspen or lodgepole pine. The reasons for this vegetation change may be many and varied, from the lack of aspen regeneration due to grazing to a lack of water from diversion and drought throughout the subbasin. While not much can be done about dewatered channels, most streams would recover riparian vegetation if temporarily or permanently excluded from use. These same measures will reduce any sediment loading due to improved vegetative complex

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.

**Table 12. Summary of assessment outcomes.**

| Water Body Segment/ Assessment Unit | Pollutant | TMDL(s) Completed | Recommended Changes to §303(d) List | Justification |
|---|---|---|---|---|
| Goose Creek ID17040211SK008_02 | Temperature | Yes | Move to Category 4a | Excess solar load due to lack of shade |
| Trout Creek ID17040211SK007_02 ID17040211SK007_03 | Temperature | Yes | Delist SK007_02 for sediment. Delist SK007_03 for combined biota/habitat bioassessment. Move SK007_02 and SK007_03 to Category 4a for temp | Excess solar load due to lack of shade; Temp TMDL will remedy sediment concerns and combined biota/habitat bioassessment |

# References Cited

American Geological Institute. 1962. Dictionary of geological terms. Garden City, NY: Doubleday and Company. 545 p.

Armantrout, N.B., compiler. 1998. Glossary of aquatic habitat inventory terminology. Bethesda, MD: American Fisheries Society. 136 p.

Clean Water Act (Federal water pollution control act), 33 U.S.C. § 1251-1387. 1972.

DEQ (Idaho Department of Environmental Quality). 2003. Goose Creek Subbasin Assessment and Total Maximum Daily Loads. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2005. Catalog of Stormwater Best Management Practices for Idaho Cities and Counties. Boise, ID: DEQ.

EPA (U.S. Environmental Protection Agency). 1996. Biological criteria: Technical guidance for streams and small rivers. Washington, DC: EPA, Office of Water. EPA 822-B-96-001. 162 p.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, and D.T. Mosier. 2002. The Idaho Department of Environmental Quality water body assessment guidance, second edition-final. Boise, ID: Department of Environmental Quality. 114 p.

Hansen, P.L., and J.B. Hall. 2002. Classification and Management of USDI BLM's Riparian and Wetland Sites in Eastern and Southern Idaho. Corvallis, MT: Bitterroot Restoration, Inc. 272 p.

Hughes, R.M. 1995. Defining acceptable biological status by comparing with reference condition. In: Davis, W.S. and T.P. Simon, editors. Biological assessment and criteria: Tools for water resource planning and decision making. Boca Raton, FL: CRC Press. pp. 31–48.

Idaho Code § 39.3611. Development and implementation of total maximum daily load or equivalent processes.

Idaho Code § 39.3615. Creation of watershed advisory groups.

IDAPA 58.01.02. Idaho water quality standards.

IDL (Idaho Department of Lands). 2000. Forest Practices Cumulative Watershed Effects Process for Idaho. Boise, ID: IDL.

Karr, J.R. 1991. Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1:66–84.

McGrath, C.L., A.J. Woods, J.M. Omernik, S.A. Bryce, M. Edmondson, J.A. Nesser, J. Shelden, R.C. Crawford, J.A. Comstock, and M.D. Plocher. 2001. Ecoregions of Idaho. Reston, VA: U.S. Geological Survey.

OWEB (Oregon's Watershed Enhancement Board). 2001. Addendum to Water Quality Monitoring Technical Guide Book: Chapter 14 Stream Shade and Canopy Cover Monitoring Methods. Salem, OR: OWEB.

Poole, G.C., and C.H. Berman. 2001. An ecological perspective on in-stream temperature: Natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27(6):787–802.

Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology.

Shumar, M.L., and J. de Varona. 2009. The Potential Natural Vegetation (PNV) Temperature TMDL Procedures Manual. Boise, ID: Idaho Department of Environmental Quality.

USGS (U.S. Geological Survey). 1987. Hydrologic unit maps. Denver, CO: USGS. Water supply paper 2294. 63 p.

Water Environment Federation. 1987. The Clean Water Act of 1987. Alexandria, VA: Water Environment Federation. 318 p.

Water Quality Act of 1987, Public Law 100-4. 1987.

Water quality planning and management, 40 CFR Part 130.

### *GIS Coverages*

Restriction of liability: Neither the State of Idaho, nor the Department of Environmental Quality, nor any of their employees make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information or data provided. Metadata is provided for all data sets, and no data should be used without first reading and understanding its limitations. The data could include technical inaccuracies or typographical errors. The Department of Environmental Quality may update, modify, or revise the data used at any time, without notice.

# Glossary

| | |
|---|---|
| **§303(d)** | Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval. |
| **Acre-foot** | A volume of water that would cover an acre to a depth of one foot. Often used to quantify reservoir storage and the annual discharge of large rivers. |
| **Alevin** | A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk. |
| **Algae** | Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments. |
| **Ambient** | General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996). |
| **Anthropogenic** | Relating to, or resulting from, the influence of human beings on nature. |
| **Aquatic** | Occurring, growing, or living in water. |
| **Aquifer** | An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs. |
| **Assemblage (aquatic)** | An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996). |

**Assessment Unit (AU)**

A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit.

**Beneficial Use**

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

**Benthic**

Pertaining to or living on or in the bottom sediments of a water body

**Best Management Practices (BMPs)**

Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

**Best Professional Judgment**

A conclusion and/or interpretation derived by a trained and/or technically competent individual by applying interpretation and synthesizing information.

**Biological Integrity**

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

**Biota**

The animal and plant life of a given region.

**Clean Water Act (CWA)**

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

**Community**

A group of interacting organisms living together in a given place.

**Criteria**

In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.

**Cubic Feet per Second**

A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.

**Designated Uses**

Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.

**Discharge**

The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

**Disturbance**

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

**Ecosystem**

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

**Environment**

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

**Ephemeral Stream**

A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from melting snow or other sources. Its channel is at all times above the water table (American Geological Institute 1962).

**Erosion**

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

**Exceedance**

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

**Existing Beneficial Use or Existing Use**

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

**Flow**

See *Discharge*.

**Fully Supporting**

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

**Ground Water**

Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as streamflow.

**Habitat**

The living place of an organism or community.

**Headwater**

The origin or beginning of a stream.

**Hydrologic Basin**

The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).

**Hydrologic Unit**

One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, and cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth- and sixth-field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.

**Hydrologic Unit Code (HUC)**

The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.

**Intermittent Stream**

1) A stream that flows only part of the year, such as when the ground water table is high or when the stream receives water from springs or from surface sources such as melting snow in mountainous areas. The stream ceases to flow above the streambed when losses from evaporation or seepage exceed the available streamflow. 2) A stream that has a period of zero flow for at least one week during most years.

**Load Allocation (LA)**

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

**Load(ing)**

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

**Load(ing) Capacity (LC)**

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

**Macroinvertebrate**

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

**Margin of Safety (MOS)**

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

**Mean**

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

**Milligrams per Liter (mg/L)**

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

**Monitoring**

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

**Mouth**

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

**National Pollutant Discharge Elimination System (NPDES)**

A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

**Natural Condition**

The condition that exists with little or no anthropogenic influence.

**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 discernible point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

**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).

**Nuisance**

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

**Nutrient**

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

**Parameter**

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

**Phosphorus**

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

**Point Source**

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

**Pollutant**

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

**Pollution**

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

**Population**

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

**Reach**

A stream section with fairly homogenous physical characteristics.

**Reference**

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

**Reference Condition**

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

| | |
|---|---|
| | historical conditions, quantitative models, and expert judgment (Hughes 1995). |
| **Reference Site** | A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies. |
| **Riparian** | Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body. |
| **River** | A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels. |
| **Runoff** | The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams. |
| **Sediments** | Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air. |
| **Species** | 1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category. |
| **Stream** | A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone. |
| **Stormwater Runoff** | Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and directly into the stream. The water often carries pollutants picked up from these surfaces. |
| **Subbasin** | A large watershed of several hundred thousand acres. This is the name commonly given to 4th-field hydrologic units (also see Hydrologic Unit). |

**Subbasin Assessment (SBA)**

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

**Subwatershed**

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

**Surface Water**

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

**Total Maximum Daily Load (TMDL)**

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

**Tributary**

A stream feeding into a larger stream or lake.

**Wasteload Allocation (WLA)**

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

**Water Body**

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

**Water Pollution**

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

**Water Quality**

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

**Water Quality Criteria**

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

**Water Quality Limited**

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

**Water Quality Limited Segment (WQLS)**

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

**Water Quality Standards**

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

**Water Table**

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

**Watershed**

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

# Appendix A. State and Site-Specific Water Quality Standards and Criteria

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning and egg incubation period, which varies with species. For spring spawning salmonids, the default spawning and incubation period recognized by the Idaho Department of Environmental Quality (DEQ) is generally March 15 to July 1 each year (Grafe et al. 2002). Fall spawning can occur as early as August 15 and continue with incubation into the following spring up to June 1. Per IDAPA 58.01.02.250.02.f.ii., the water quality criteria that need to be met during those time periods are as follows:

- 13 °C as a daily maximum water temperature
- 9 °C as a daily average water temperature

For the purposes of a temperature total maximum daily load (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).

*This page intentionally left blank for correct double-sided printing.*

# Appendix B. Unit Conversion Chart

*This page intentionally left blank for correct double-sided printing.*

**Table B-1. Metric–English unit conversions.**

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

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day = 1.55 cfs.
[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water.

*This page intentionally left blank for correct double-sided printing.*

# Appendix C. Data Sources, Solar Pathfinder Results, and Temperature Data

**Table C-1. Data sources for the Goose Creek subbasin TMDLs.**

| Water Body | Data Source | Type of Data | Collection Date |
|---|---|---|---|
| Goose Creek and Trout Creek | DEQ State Technical Services Office | Pathfinder effective shade and stream width | July–August 2008 |
| Goose Creek and Trout Creek | DEQ State Technical Services Office | Aerial photo interpretation of existing shade and stream width estimation | June–September 2008 and June 2011 |
| Goose Creek and Trout Creek | DEQ IDASA Database | Temperature | June – October 2001 |

**Table C-2. Solar Pathfinder field verification results.**

| aerial class | pathfinder actual | pathfinder class | delta | | stream site |
|---|---|---|---|---|---|
| 30 | 29.7 | 30 | 0 | | trout1 |
| 30 | 18.4 | 10 | 20 | | trout2 |
| 60 | 35.5 | 30 | 30 | | goose |
| | | | 17 | average | |
| | | | 15.28 | std dev | |
| | | | 17.29 | 95%CI | |

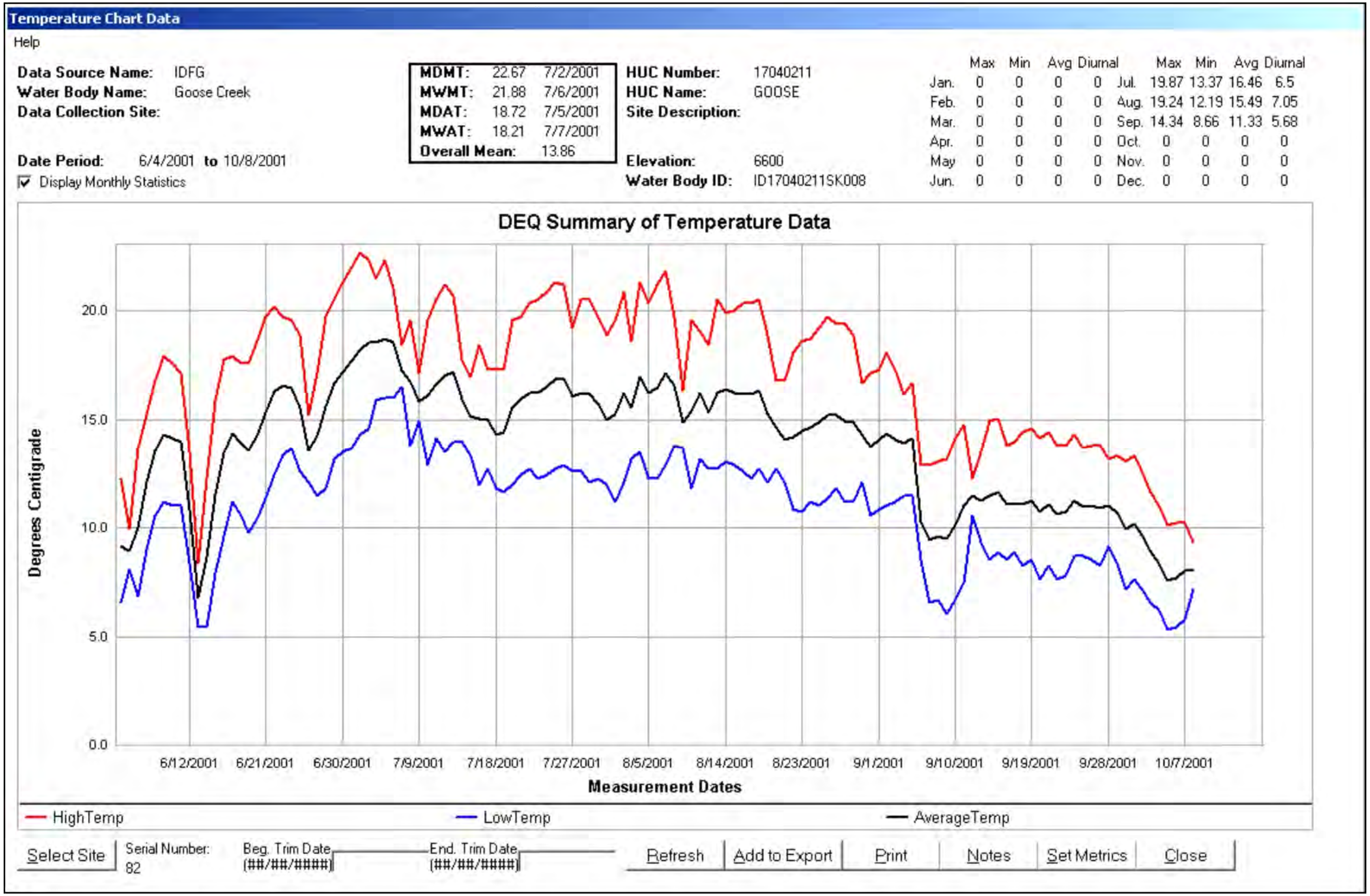

**Figure C-1. Listing temperature data for upper Goose Creek (2001IDFGTL083).**

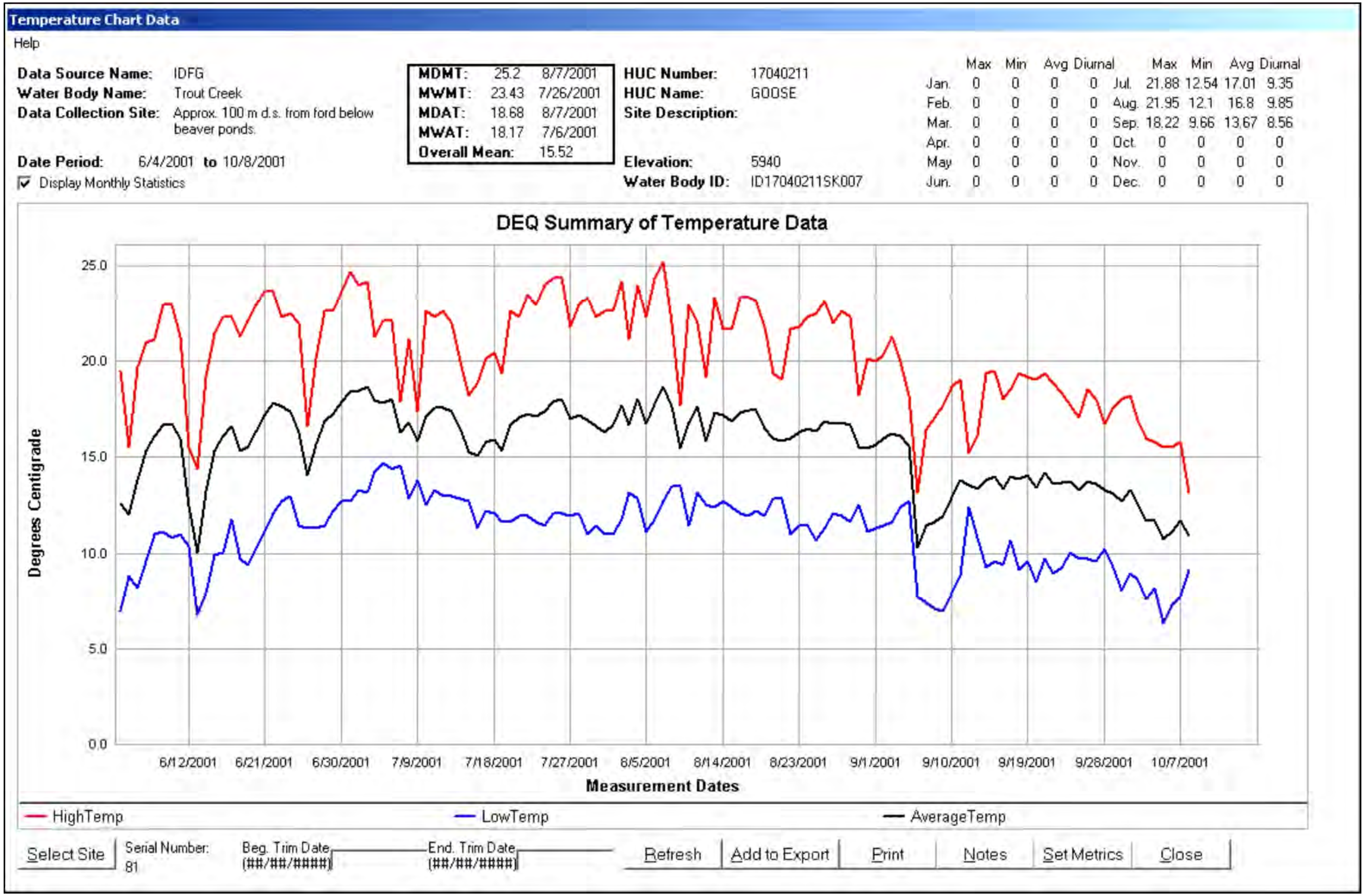


**Figure C-2. Listing temperature data for Trout Creek (2001IDFGTL082).**


**Figure C-3. Listing temperature data for Piney Creek (2001IDFGTL081).**

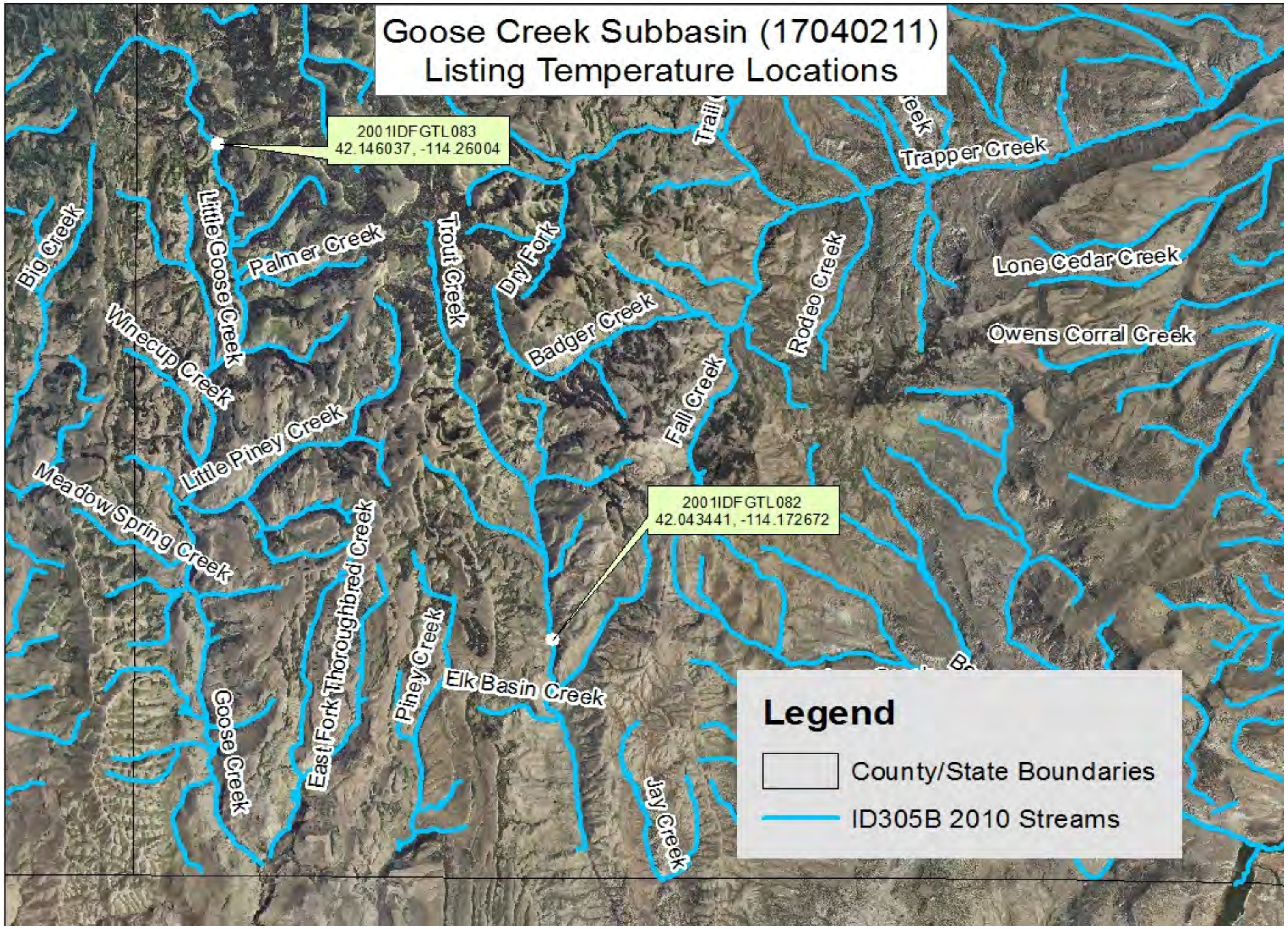


**Figure C-3. Listing temperature data locations.**

*This page intentionally left blank for correct double-sided printing.*

# Appendix D. Public Comments

| Comments from: | Comment: | DEQ Response: |
|---|---|---|
| EPA | From the maps provided Upper Goose Creek and Trout Creek appear to be two major streams in the Sawtooth National Forest. It would be helpful to know if there are other streams in the upper watershed that have not been listed and why. | The TMDL focuses on the streams that are specifically listed in the Integrated Report. We did change the document to include the addition of tributaries to these two streams because they were included in the listed AU. Streams not mentioned in this document, are not listed for temperature in the Integrated Report. Also, additional streams may not be listed due to lack of water quality data and resources. |
| | Targeted shade analysis is restricted to the main stem and does not include the tributaries to these waters. It would be helpful to include a rational for this approach. It is likely that the tributaries are also deficient in shade. In previous PNV TMDLs we have recommended that the TMDL at least include a narrative allocation that tributaries which did not receive a specific numeric allocation must also achieve a natural stream temperature. | The TMDL focuses on the streams that are specifically listed in the Integrated Report. We did change the document to include the addition of tributaries to these two streams because they were included in the listed AU. Streams not mentioned in this document, are not listed for temperature in the Integrated Report. Also, additional streams may not be listed due to lack of water quality data and resources. |
| | Is there temperature data available on these streams particularly for summer months? If so, it should be included in the TMDL to establish the timing and location of criteria violations. Are these streams being monitored for other parameters that may be of concern such as bacteria and sediments? | Temperature data from available temperature loggers is included in Appendix C for Goose Creek, Trout Creek and Piney Creek. DEQ had not monitored lately for other parameters on these streams due to lack of funding availability. |
| | There is very limited information on current land -use and land-use practices except in general terms. The document discusses historic practices of grazing and tree removal as reasons for lack of shade and water withdrawal as a current practice without much information on how much water withdrawal is occurring. Given that improving shade will depend on water availability and restricting grazing at stream edges, it would be helpful to have a more descriptive section on the current conditions. Who manages these critical areas? What is the current grazing practice? | The following language was added to the Subbasin at a Glance section to more accurately describe the current land–use and land-use practices (Subbasin at a Glance, p xi). The Goose Creek subbasin (hydrologic unit code 17040211) is located in south-central Idaho south of Burley, Idaho (Figure A). According to the Goose Creek Subbasin Assessment and TMDL (DEQ 2003), 42.1 percent of the lands within the Idaho portion of the subbasin are considered rangeland, with 25.1 percent in Forest, 28.6 in irrigated agriculture and 4.2 percent listed as urban. The urban areas are scattered throughout the subbasin and range in size from Oakley (population 600-700) to Trout (population 1-10). A portion of the subbasin is forested, but rangeland activities predominate in these areas as well. Highway 27 is the main road through the subbasin. The only other paved roads connect the small towns in the area and the section roads out of Oakley and Burley. The remainder of the subbasin is covered with numerous dirt and gravel roads, most of which are not maintained. The Idaho portion of the subbasin lies almost entirely within Cassia County. Privately owned lands (28.9 percent) are essentially the same lands that are used for agriculture. The majority of the land ownership (68.12 percent) falls under federal government management (United States Bureau of Land Management 42.84 percent and United States Forest Service |

| Comments from: | Comment: | DEQ Response: |
|---|---|---|
| | | 25.28 percent). The remaining 2.85 percent are scattered state endowment lands, and are managed by Utah, Idaho and Nevada's respective department of lands. There have been no major changes to land use, land ownership, or population in the Subbasin since the TMDL was approved in 2004. |
| | Has there been any analysis on trends and climate change impacts to this basin? If conditions of drought and heat were to increase and become more frequent as is anticipated, how will this impact the implicit margin of safety? Will this change the pattern of vegetative shade types used to make your assessments? | It is possible that the aspen and lodgepole stands will continue to disappear with climate change. They will be replaced by some other vegetation, likely mountain shrubs. When this occurs, DEQ can evaluate the appropriateness of our shade targets at that time in the five –year review. |
| | Is there any information on groundwater impacts to these streams and is there any plans to include this type of information in future studies? Restoration of riparian zones have been known to benefit ground water supplies and positively impact stream recovery. | At the present time IDEQ has determined that there is little, if any, water quality information on groundwater to these streams. IDEQ researched these streams from various sources (BLM, USFS, USGS, IDWR, and IDFG) and determined that very little water quality information was available for both surface water and groundwater. At the present time, IDEQ has little funding available to seek water quality monitoring for these groundwater sources. However, this may change as budget allowances are modified in the near future. Yet, there some projects that have included restoration of riparian zones that have been implemented through the 319 Grant process. IDEQ has also made public comments to BLM and USFS on their EIS and grazing allotment renewals that suggest that groundwater/spring sources should be protected for their water quality resource benefits. |
| | In several places in the document it is mentioned that excessive dewatering of streams is a given in this watershed. Are there best management practices being considered to address this issue since it is also a contributor to excessive heat in streams? | It is stated in Key Findings (p. xii) and in the Conclusion section (p. 27), that the lack of shade is likely the result of a combination of factors, including natural and human-influenced dewatering of the stream channel and historic removal of riparian vegetation associated with livestock grazing and agricultural practices. DEQ did not find that excessive dewatering occurs. There are legal water diversions that occur and these may have an effect on temperature. However, there is currently no available data that supports this one way or the other. Best management practices have been observed by DEQ on private and public ground in the watershed, and staff continues to explore opportunities for 319 grants in that area as well. The following language was added to the TMDL (see Water Diversions, p. 24) In this TMDL we have not quantified what impact if any diversions are having on stream temperature. Water diversions are allowed for in state statue 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 the resulting water temperature that that shade provides. The Idaho Department of Environmental Quality encourages local land owners 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. |

| Comments from: | Comment: | DEQ Response: |
|---|---|---|
| | Table 8 page 11, there are several AU's that have zero (0) for an Excess Load summary number, but lack a percent of shade coverage. Also Table 9 has zero numbers for certain segments to express Excess Load. | The loads in the tables are rounded to one significant figure to reflect the level of precision in that analysis. Because of the precision factor, rounded results for target and existing loads can equal each other despite a lack of shade. For example, a load for a segment equal to 4,323 is rounded to 4,000, and a load for another segment equal to 3,982 is also rounded to 4,000 despite the fact that the two segments may have different levels of shade. |
| | The target is based on PNV shade targets using shade curves and natural channel widths for southern Idaho. If potential shade is reached and fully implemented it is assumed that the targeted load allocation conditions will be met. The TMDL states that the "Natural conditions essentially become the water quality standard and the natural level of shade and channel width become the target of the TMDL." We strongly support IDEQ's use of a PNV shade curve approach, but the TMDL also alludes to anthropogenic reductions (diversions) of flow. Even though flow is not a pollutant as defined by the Clean Water Act it is part of the natural condition that effects temperature, and anthropogenically reduced flows can result in increased stream temperature. These impacts are not addressed in the TMDL loading analysis. We will need additional time to respond to the flow issues in the TMDL, and are consulting with EPA headquarters. We should be able to provide additional comments over the next few weeks. | The following language was added to the TMDL (see Water Diversions, p. 24). In this TMDL we have not quantified what impact if any diversions are having on stream temperature. Water diversions are allowed for in state statue 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 the resulting water temperature that that shade provides. The Idaho Department of Environmental Quality encourages local land owners 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. |

*This page intentionally left blank for correct double-sided printing.*