Wildhorse River Subbasin Assessment and Total Maximum Daily Load

TMDL Five-Year Review

HUC 17050201

State of Idaho
Department of Environmental Quality

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Prepared by

Idaho Department of Environmental Quality
Boise Regional Office
1445 N. Orchard Street
Boise, ID 83706
and
State Technical Services Division
1410 N. Hilton
Boise, ID 83706

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Cover photo of Wildhorse River at confluence of Crooked River and Bear Creek.

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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 (33 USC §1251). 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 (DEQ 2014). 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 5-year review addresses five water bodies in the Wildhorse River watershed of the Brownlee Reservoir subbasin that have been included in the approved temperature *Wildhorse River Subbasin Assessment and Total Maximum Daily Load* (DEQ 2007) and are now subject to 5-year review in compliance with Idaho Code §39-3611(7). This document addresses the temperature TMDLs for these assessment units (AUs). More information about these watersheds and the subbasin as a whole is provided in the *Total Maximum Daily Loads (TMDL) for the Brownlee Reservoir (Weiser Flat) Subbasin* (DEQ 2003) and the Wildhorse River TMDL (DEQ 2007).

This TMDL analysis has been developed to comply with Idaho's water quality standards (IDAPA 58.01.02). A TMDL analysis determines instream water quality targets, calculates load capacities, estimates existing 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 Wildhorse River watershed is part of the Brownlee Reservoir subbasin (hydrologic unit code 17050201) located in southwestern Idaho along the border with Oregon near Brownlee Dam and north of Weiser, Idaho (Figure A). This document addresses water bodies in five AUs of the Wildhorse River watershed that are described in the approved Wildhorse River TMDL (DEQ 2007).

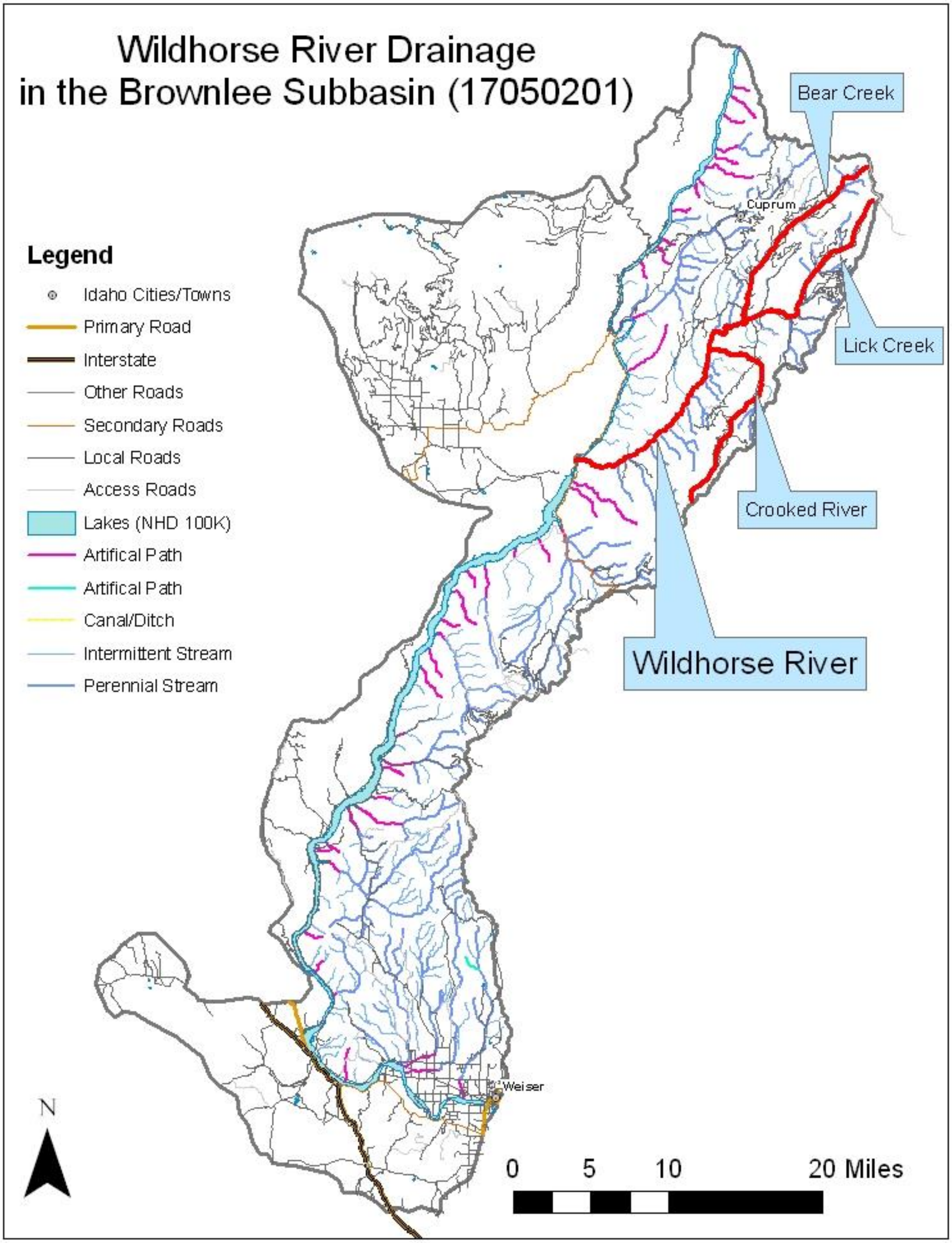

Figure A. Subbasin at a glance.

Key Findings

The Wildhorse River was placed on the 1998 §303(d) list of impaired waters, or subsequent lists, for reasons associated with temperature criteria violations, and the Idaho Department of Environmental Quality (DEQ) has developed temperature TMDLs for these waters (Table A).

Effective target shade levels were established for five AUs based on the concept of maximum shading under potential natural vegetation (PNV) resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation that was partially field verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02). In addition to analyzing PNV, water temperatures in Wildhorse River and tributaries were measured between May and October 2014. A summary of assessment outcomes, including recommended changes to listing status in the next Integrated Report, is presented in Table B.

The 5-year review analysis involved better aerial imagery, new and improved target settings based on Idaho plant communities, and instream water temperature data. A comparison of these new data with data presented in the Wildhorse River TMDL (DEQ 2007) showed that Wildhorse and Crooked Rivers are not sources of excess solar loads although both Wildhorse and Crooked Rivers still exceed numeric temperature criteria for cold water aquatic life and salmonid spawning. Target shade levels and solar loads under PNV proved to be a better approach than inflexible numeric criteria to identify whether instream temperatures given natural conditions are being met, especially in arid areas. To add complexity, the instream temperature in Wildhorse River is due, in part, to inflow from temperature-impaired tributaries (i.e, Bear and Lick Creeks) and the natural shading of vegetation that is already at full potential. The AU that includes Crooked River has no temperature-impaired tributaries flowing into it; therefore, DEQ assumes that instream temperature in this AU is a direct result of natural conditions and shading at full potential. Crooked River water temperatures barely exceeded numeric criteria during a very short period in early July 2014, but given the facts stated above, it is unlikely that the Crooked River water temperatures would meet numeric criteria. Bear and Lick Creeks continue to be sources of excess solar loads and also exceed cold water aquatic life and salmonid spawning temperature criteria. Shade restoration efforts in the Wildhorse River watershed should be directed at Bear and Lick Creeks in an effort to improve overall watershed stream temperatures.

Table A. Streams and pollutants for which TMDLs were developed

Stream Name	Pollutant
Wildhorse River	Temperature
Crooked River	Temperature
Bear Creek	Temperature
Lick Creek	Temperature

Table B. Summary of assessment outcomes.

Assessment Unit Name	Assessment Unit Number	Pollutant	TMDL Completed	Recommended Changes to Next Integrated Report	Justification
Wildhorse River—1st and 2nd order, including all of Crooked River	ID17050201SW015_02	Temperature	Yes	Assess potential to move to Category 2	Meets solar load targets but exceeds numeric temperature criteria
Wildhorse River—4th order	ID17050201SW015_04	Temperature	Yes	Assess potential to move to Category 2	Meets solar load targets but exceeds numeric temperature criteria
Bear Creek—1st and 2nd order (includes 1-2 order Lick Creek)	ID17050201SW016_02	Temperature	Yes	Remain in Category 4a	Excess solar load from a lack of existing shade
Lick Creek—3rd order and all of Deer Creek	ID17050201SW016_03	Temperature	Yes	Remain in Category 4a	Excess solar load from a lack of existing shade
Lick and Bear Creeks—4th order	ID17050201SW016_04	Temperature	Yes	Remain in Category 4a	Excess solar load from a lack of existing shade

Public Participation

Throughout this process, local experience and participation have been and will continue to be invaluable in identifying water quality issues and implementing reduction strategies appropriate on a local scale. The public committee, known as the Weiser River Watershed Advisory Group, was involved in the TMDL assessment documented in this 5-year review.

1 Introduction

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 (DEQ 2014). 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.

Idaho Code §39-3611(7) requires a 5-year cyclic review process for Idaho TMDLs:

> The director shall review and reevaluate each TMDL, supporting subbasin assessment, implementation plan(s) and all available data periodically at intervals of no greater than five (5) years. Such reviews shall include the assessments required by section 39-3607, Idaho Code, and an evaluation of the water quality criteria, instream targets, pollutant allocations, assumptions and analyses upon which the TMDL and subbasin assessment were based. If the members of the watershed advisory group, with the concurrence of the basin advisory group, advise the director that the water quality standards, the subbasin assessment, or the implementation plan(s) are not attainable or are inappropriate based upon supporting data, the director shall initiate the process or processes to determine whether to make recommended modifications. The director shall report to the legislature annually the results of such reviews.

To meet the intent and purpose of Idaho Code §39-3611(7), this report documents reviews of the approved *Wildhorse River Subbasin Assessment and Total Maximum Daily Load* (DEQ 2007) and *Wildhorse River Watershed Total Maximum Daily Load Implementation Plan for Agriculture* (ISWCC 2010) and considers the most current and applicable information in conformance with Idaho Code §39-3607, evaluates the appropriateness of the TMDL to current watershed conditions, evaluates the implementation plan, and consults with the watershed advisory group (WAG). An evaluation of the recommendations presented is provided. Final decisions for TMDL modifications are decided by the Idaho Department of Environmental Quality (DEQ) director. Approval of TMDL modifications is decided by the US Environmental Protection Agency (EPA), with consultation by DEQ.

1.1 Assessment Units

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

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

2 TMDL Review and Status

This document is a 5-year review of the temperature TMDLs contained in the Wildhorse River TMDL (DEQ 2007). The five water bodies examined are separated into five AUs within the Wildhorse River watershed (i.e., Wildhorse River, Crooked River, Bear Creek, Lick Creek, and Deer Creek) (Table 1). These TMDLs were approved in 2007.

The Idaho Soil and Water Conservation Commission (ISWCC), Adams Soil and Water Conservation District, Weiser River Soil Conservation District, and Natural Resources Conservation Service (NRCS) developed the *Wildhorse River Watershed Total Maximum Daily Load Implementation Plan for Agriculture* (ISWCC 2010).

A complete list Idaho's subbasin assessments, TMDLs, and implementation plans can be accessed at *https://www.deq.idaho.gov/water-quality/surface-water/tmdls/table-of-sbas-tmdls.aspx*.

Table 1. Assessment unit recommended changes to next Integrated Report.

Assessment Unit Name	Assessment Unit Number	Pollutant	TMDL Approval Year	Recommended Changes to Next Integrated Report	Justification
Wildhorse River—1st and-2nd order and all of Crooked River	ID17050201SW015_02	Temperature	2007	Assess potential to move to Category 2	Meets solar load targets but exceeds numeric temperature criteria
Wildhorse River—4th order	ID17050201SW015_04	Temperature	2007	Assess potential to move to Category 2	Meets solar load targets but exceeds numeric temperature criteria
Bear Creek—1st and 2nd order (includes 1-2 order Lick Creek)	ID17050201SW016_02	Temperature	2007	Remain in Category 4a	Excess solar load from a lack of existing shade
Lick Creek—3rd order and all of Deer Creek	ID17050201SW016_03	Temperature	2007	Remain in Category 4a	Excess solar load from a lack of existing shade
Lick and Bear Creeks—4th order	ID17050201SW016_04	Temperature	2007	Remain in Category 4a	Excess solar load from a lack of existing shade

Table 1 summarizes the TMDLs for each AU/pollutant combination. The Wildhorse River TMDL (DEQ 2007) identifies the effective shade calculations based on a 6-month period from April through September, which 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. Spring salmonid spawning typically occurs between March 15 and July 15. Fall salmonid spawning begins in September. Late July and early August typically represent a period of highest stream temperatures. Solar gains can begin early in the spring and affect not only the highest temperatures reached later on in the summer but also solar loads affect salmonid spawning temperatures in spring and fall. Thus, solar load in these streams is evaluated from spring (April) to early fall (September).

2.1 Pollutant Targets

To restore "full support of designated beneficial uses" (Idaho Code §39.3611), we used a potential natural vegetation (PNV) approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and for temperature TMDLs, the natural level of shade and channel width become the TMDL target. The instream temperature that results from attaining these conditions is consistent with the water quality standards, even if it exceeds numeric temperature criteria. Appendix A provides further discussion of water quality standards and natural background provisions.

2.2 Control and Monitoring Points

2.2.1 Monitoring Points

Solar load capacities and allocations were ground-truthed in the watershed during the period of full leaf-out (August) in 2014. PNV was ground-truthed using a Solar Pathfinder at two separate sites in each of the water bodies (Crooked River, Bear Creek, and Lick Creek). Water temperature at the base, middle, and near the top of each AU was sampled continuously at 15-minute intervals between May and October 2014.

2.2.2 Load Capacity

Load capacity (i.e., target load) is the maximum load each water body can accommodate and still meet the water quality standards "with season variations and a margin of safety which takes into account any lack of knowledge..." (CWA §303(d)(C)). Likely sources of uncertainty include lack of knowledge of assimilative capacity, uncertain relation of selected targets to beneficial uses, and variability in target measurement. No further shade can be removed from the stream by any activity without exceeding its load capacity. Load capacity for these stream segments was determined by evaluating the natural shading from natural vegetation at full potential.

In determining loads, DEQ accounts for natural load and includes a margin of safety (MOS) to address uncertainty that may result from a variety of sources. These loads are iterative, meaning that if further monitoring shows that targets need to be adjusted, then those adjustments will be made. Background load will be evaluated on an ongoing basis to ensure adequate characterization.

2.2.3 Load Allocation

Load allocations are stream segment-specific and dependent upon the target load for a given segment. In section 3.3, Table 7 through Table 13 show the target shade and corresponding target summer load. This target load (i.e., load capacity) is necessary to achieve background conditions.

2.2.4 Water Diversion

Stream temperature may be affected by water diversions for water-right purposes. Flow diversion 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. Flow loss in the channel also affects the ability of the near-stream environment to support shade-producing vegetation, resulting in an increase in solar load to the channel.

Although these water temperature effects may occur, nothing in the 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 as follows:

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

Additionally, Idaho water quality standards indicate the following:

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

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

2.2.5 Wasteload Allocation

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

2.2.6 Construction Stormwater

The CWA requires construction site operators to obtain permit coverage to discharge stormwater to a water body or municipal storm sewer. 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.

In Idaho, EPA has issued a general permit for stormwater discharges from construction sites. 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. Operators 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.

When a stream is in Category 5 of the Integrated Report (DEQ 2014) and DEQ develops a TMDL, 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 or new TMDLs will also be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement appropriate BMPs.

Typically, operators must follow specific requirements to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for postconstruction stormwater management. Sediment is usually the main pollutant of concern in stormwater from construction sites. Applying 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.

2.2.7 Margin of Safety

Although the best available techniques and information are applied, uncertainty arises in the selection of water quality targets, load capacity, and estimates of existing loads and can be attributed to a number of sources including incomplete knowledge or understanding of the system and incomplete or variable data. MOS is essentially a reduction in load capacity that is identified before allocation to any sources.

MOS in this case is considered implicit in the design. Because the target is essentially background conditions, loads (shade levels) are allocated to lands adjacent to these streams at natural background levels. Because shade levels are established at natural background or system potential levels, it is unrealistic to set shade targets at higher, or more conservative, levels. Additionally, existing shade levels are reduced to the next lower 10% shade class, which likely underestimates actual shade in the load analysis. Although the load analysis used in the 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.

2.2.8 Seasonal Variation

The 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 period when the combination of increasing air and water temperatures coincides with increasing solar inputs and increasing vegetative shade. The critical time period is June, when spring salmonid spawning is occurring, July and August, when maximum temperatures 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.

3 Beneficial Use Status

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

Existing uses under the CWA are “those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.” Designated uses are specifically listed for water bodies in the Idaho water quality standards (IDAPA 58.01.02.100 and .02.109-.02.160 in addition to citations for existing and presumed uses).

Undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called “presumed uses,” DEQ will apply the numeric cold water aquatic life criteria and primary or secondary contact recreation criteria to undesignated waters.

3.1 Beneficial Uses

Water quality standards under the CWA consist of three main components: designated beneficial uses, water quality criteria that are established to protect designated beneficial uses, and antidegradation policies and procedures. Water quality criteria can be either numeric limits for individual pollutants and conditions, or narrative descriptions of desired conditions.

Surface water beneficial use classifications are intended to protect surface water uses. DEQ designates beneficial uses for selected water bodies as outlined in IDAPA 58.01.02.140. All surface waters within the state are designated for agricultural and industrial water supply, wildlife habitat, and aesthetics. Waters without specific beneficial use designations are defined as undesignated waters.

IDAPA 58.01.02.101.01 states: “...undesignated waters shall be protected for beneficial uses, which includes all recreational use in and on the water and the protection and propagation of fish, shellfish and wildlife wherever attainable.” Therefore, in the case where waters are undesignated, DEQ presumes that most waters in Idaho will support cold water aquatic life and, depending on the characteristics of the water body, primary or secondary contact recreation (IDAPA 58.01.02.101.01a). Cold water aquatic life use support determination procedures, apply to undesignated, perennial waters to protect these presumptive uses. If an undesignated surface water body is intermittent, then aquatic community indexes cannot be applied; however, numeric criteria do apply to intermittent waters during periods of optimal flow (IDAPA 58.01.02.070.06).

Additionally, under the CWA, any uses that existed or were presumed to exist in a water body in November 1975 are required to be protected as existing uses. The designation of existing uses for protection generally applies to segments where beneficial uses are not formally designated.

Wildhorse River is designated for salmonid spawning, cold water aquatic life, and primary contact recreation. The designated uses are shown in Table 2. Bull Trout critical habitat is designated on the streams listed below but only for nonfederal lands that have greater than 1/2 mile of river frontage.

Table 2 gives a complete listing of all designated and statewide beneficial uses for the listed water bodies.

Table 2. Beneficial uses of TMDL water bodies.

Assessment Unit Name	Assessment Unit Number	Beneficial Uses	Type of Use
Wildhorse River—1st and 2nd order and all of Crooked River	ID17050201SW015_02	Cold water aquatic life, salmonid spawning (including Bull Trout in upper reaches), and secondary contact recreation	Designated
Wildhorse River—4th order	ID17050201SW015_04	Cold water aquatic life, salmonid spawning (including Bull Trout in upper reaches), and secondary contact recreation	Designated
Bear Creek—1st and 2nd order (includes 1-2 order Lick Creek)	ID17050201SW016_02	Cold water aquatic life, salmonid spawning (including Bull Trout in upper reaches) ,and secondary contact recreation	Designated
Lick Creek—3rd order and all of Deer Creek	ID17050201SW016_03	Cold water aquatic life, salmonid spawning, and secondary contact recreation	Designated
Lick and Bear Creeks—4th order	ID17050201SW016_04	Cold water aquatic life, salmonid spawning, and secondary contact recreation	Designated

Note: Wherever attainable, surface waters within the state are designated for agricultural and industrial water supply, wildlife habitat, and aesthetics (IDAPA 58.01.02.100.03-05).

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

Table 3 includes the most common numeric criteria used in TMDLs; Figure 1 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

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

Parameter	Primary Contact Recreation	Secondary Contact Recreation	Cold Water Aquatic Life	Salmonid Spawning[a]
Water Quality Standards: IDAPA 58.01.02.250–251				
Bacteria				
Geometric mean	<126 *E. coli*/100 mL[b]	<126 *E. coli*/100 mL	—	—
Single sample	≤406 *E. coli*/100 mL	≤576 *E. coli*/100 mL	—	—
pH	—	—	Between 6.5 and 9.0	Between 6.5 and 9.5
Dissolved oxygen (DO)	—	—	DO exceeds 6.0 milligrams/liter (mg/L)	**Water Column DO**: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater **Intergravel DO**: DO exceeds 5.0 mg/L for a 1-day minimum and exceeds 6.0 mg/L for a 7-day average
Temperature[c]	—	—	22 °C or less daily maximum; 19 °C or less daily average **Seasonal Cold Water**: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average **Bull Trout**: Not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June–August; not to exceed 9 °C daily average in September and October
Turbidity	—	—	Turbidity shall not exceed background by more than 50 nephelometric turbidity units (NTU) instantaneously or more than 25 NTU for more than 10 consecutive days.	—
Ammonia	—	—	Ammonia not to exceed calculated concentration based on pH and temperature.	—
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131				
Temperature	—	—	—	7-day moving average of 10 °C or less maximum daily temperature for June–September

[a] During spawning and incubation periods for inhabiting species
[b] *Escherichia coli* per 100 milliliters
[c] Temperature exemption: Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the 7-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.

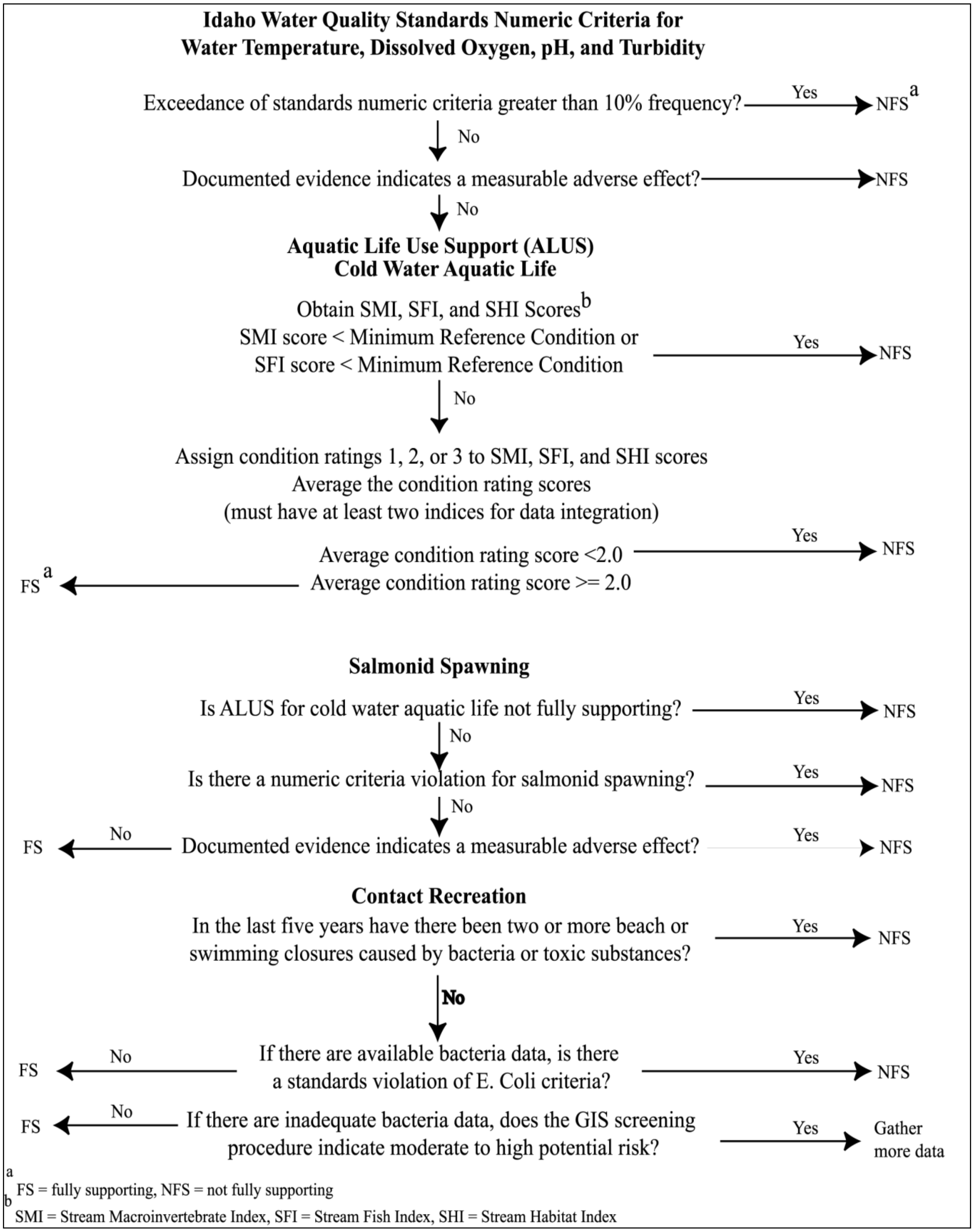

Figure 1. Determination steps and criteria for determining support status of beneficial uses in wadeable streams (Grafe et al. 2002).

3.1.1 Temperature

Temperature is a water quality factor essential to the life cycle of fish and other aquatic species. Different temperature regimes also result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or cold water aquatic community is present. Many factors, natural and human caused, affect stream temperatures. Natural factors include altitude, aspect, climate, weather, riparian vegetation (shade), and channel morphology (width and depth).

Human-influenced factors include heated discharges (such as those from point sources), riparian alteration, channel alteration, and flow alteration.

Elevated stream temperatures can be harmful to fish at all life stages, especially if they occur in combination with other habitat limitations such as low dissolved oxygen or poor food supply. Acceptable temperature ranges vary for different species of fish, with coldwater species being the least tolerant of high water temperatures. Consistently high temperatures can result in reduced body weight, reduced oxygen exchange, increased susceptibility to disease, and reduced reproductive capacity in adult fish. Acutely high temperatures can result in death if they persist for an extended length of time. Juvenile fish are even more sensitive to temperature variations than adult fish and can experience negative impacts at a lower value than adults, resulting in lower growth rates.

3.2 Changes to Subbasin Characteristics

The Wildhorse River headwaters originate in forested land at the southern end of the Seven Devils Mountains, which form the eastern border of Hells Canyon. The river flows southwesterly out of these mountains and enters the Snake River between Brownlee Dam and Oxbow Reservoir. This portion of the Snake River forms the border between Idaho and Oregon. Although some of the southerly tributaries flow out of Washington County, the mainstem is located solely in the southern portion of Adams County. No towns and very few inhabitants are located on the Wildhorse River. The unincorporated community of Bear is located in the Wildhorse River watershed.

The Wildhorse River watershed is predominately forested with a lesser amount as private ranch land. Little, if any, change has occurred to land use or human population since the Wildhorse River TMDL (DEQ 2007).

Due to very little change within the watershed since 2007, refer to the Wildhorse River TMDL for detailed descriptions of AU characteristics (DEQ 2007).

3.3 Summary and Analysis of Current Water Quality Data

3.3.1 Potential Natural Vegetation

3.3.1.1 Methods

Effective shade targets were established for five AUs based on maximum shading under PNV resulting in natural background temperatures.

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

Load capacity can be summarized by the following equation:

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

Where:

LC = load capacity
MOS = margin of safety
NB = natural background
LA = load allocation
WLA = wasteload allocation

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

The load capacity must be based on critical conditions—the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determining critical conditions can be more complicated than it may appear on the surface.

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

3.3.1.1.1 Instream Water Quality Targets

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

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

3.3.1.1.2 Factors Controlling Water Temperature in Streams

Several important factors contribute heat to a stream, including ground water temperature, air temperature, and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most controllable. The parameters that affect the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology (i.e., structure) affects riparian vegetation density and water storage in the alluvial aquifer. Riparian vegetation and channel morphology are the factors influencing shade that are most likely to have been influenced by anthropogenic activities and can be most readily corrected and addressed by a TMDL.

Riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. However, depending on how much vertical elevation surrounds the stream, vegetation further away from the riparian corridor can also provide shade. We can measure 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 with other optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and stream aspect.

In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream and can be measured using a densiometer or estimated visually either on site or using aerial photography. All of these methods provide information about how much of the stream is covered and how much is exposed to direct solar radiation.

3.3.1.1.3 Potential Natural Vegetation for Temperature TMDLs

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

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

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

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

3.3.1.1.4 Existing Shade Estimates

Existing shade was estimated for five AUs from visual interpretation of 2013 aerial photos. Estimates of existing shade based on plant type and density were marked out as stream segments on a 1:100,000 or 1:250,000 hydrography taking into account natural breaks in vegetation density. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. Each segment was assigned a single value representing the bottom of a 10% shade class (adapted from the cumulative watershed effects process, IDL 2000). For example, if shade for a particular stream segment was estimated somewhere between 50% and 59%, we assigned a 50% shade class to that segment. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and stream width. Streams where the banks and water are clearly visible are usually in low shade classes (10%, 20%, or 30%). Streams with dense forest or heavy brush where no portion of the stream is visible are usually in high shade classes (70%, 80%, or 90%). More open canopies where portions of the stream may be visible usually fall into moderate shade classes (40%, 50%, or 60%).

Visual estimates made from aerial photos are strongly influenced by canopy cover and do not always 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 the 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, and man-made structures).

3.3.1.1.5 Solar Pathfinder Field Verification

The accuracy of the aerial photo interpretations was field verified with a Solar Pathfinder at six sites in 2014. 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 segment, ten traces are taken at systematic or random intervals along the length of the stream in question.

At each sampling location, the Solar Pathfinder was placed in the middle of the stream at about the bank-full water level. Ten traces were taken following the manufacturer's instructions (i.e., orient to south and level). Systematic sampling was used because it is easiest to accomplish without biasing the sampling location. For each sampled segment, the sampler started at a unique location, such as 50 to 100 meters from a bridge or fence line, and proceeded upstream or downstream taking additional traces at fixed intervals (e.g., every 50 meters, 50 paces, etc.). Alternatively, one can randomly locate points of measurement by generating random numbers to be used as interval distances.

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

The accuracy of the 2013 aerial photo interpretations were field verified with a Solar Pathfinder with 60 traces taken at six sites on three of the four water bodies. These data showed that the original 2013 interpretation generally overestimated shade with a mean difference of 8% ± 6% (mean ± 95% CI (confidence interval)). Both sites on Bear Creek were overestimated by one 10% shade class as was one site on Lick Creek. Two sites showed that the aerial interpretation was accurate. One site on Crooked River was overestimated by two shade classes (Table 4).

Table 4. Pathfinder results for the 2013 aerial interpretation.

aerial class	pathfinder actual	pathfinder class	delta		Site Name
80	72	70	10		Bear 1
70	61.4	60	10		Bear 2
90	72.4	70	20		Crooked 1
60	69.6	60	0		Crooked 2
50	51.5	50	0		Lick 1
60	55	50	10		Lick 2
			8	average	
			7.53	std dev	
			6.02	95%CI	

3.3.1.1.6 Target Shade Determination

PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in Idaho (Shumar and De Varona 2009). A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, shade decreases as vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width.

3.3.1.1.7 Natural Bank-full Widths

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

Since, existing bank-full width may not be discernible from aerial photo interpretation and may not reflect natural bank-full widths, this parameter must be estimated from available information. We used regional curves for the major basins in Idaho, developed from data compiled by Diane Hopster of the Idaho Department of Lands, to estimate natural bank-full width (Figure 2).

For each stream evaluated in the load analysis, natural bank-full width was estimated based on the drainage area of the Payette/Weiser curve from Figure 2. Although estimates from other curves were examined (i.e., Upper Snake), the Payette/Weiser curve was ultimately chosen because of its proximity to the Wildhorse River watershed and overall similarity in climate and geology. Existing width data should also be evaluated and compared to these curve estimates if such data are available. However, for the Wildhorse River watershed, only a few Beneficial Use Reconnaissance Program (BURP) sites exist, and bank-full width data from those sites represent only spot data (e.g., only three measured widths in a reach just several hundred meters long) that are not always representative of the stream as a whole.

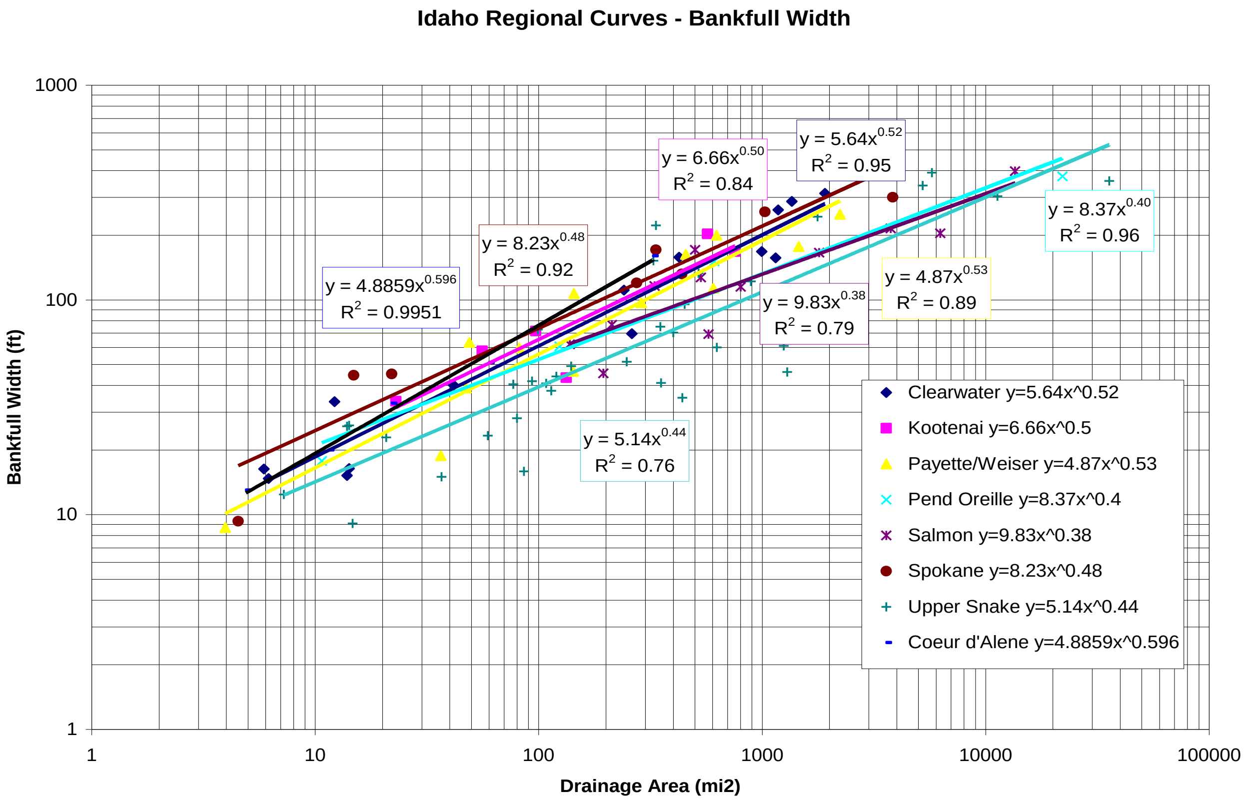

Figure 2. Bank-full width as a function of drainage area.

In general, we found BURP bank-full width data to agree with natural bank-full width estimates from the Payette/Weiser basin curve and chose not to make natural widths any smaller than these Payette/Weiser basin estimates. Natural bank-full width estimates for each stream in this analysis are presented in Table 5. The load analysis tables (section 3.3.1.3, Table 7 through Table 13) contain a natural bank-full width and an existing bank-full width for every stream segment in the analysis based on the bank-full width results presented here. Existing widths and natural widths are the same in load tables when there are no data to support making them differ.

Table 5. Bank-full widths (meters) as estimated by the Payette/Weiser regional hydrologic curve.

Location	area (sq mi)	Payette/Weiser (m)	measurements (m)
Bear Creek @ mouth	89.6	16	11
Bear Cr ab Lick Cr	31.6	9	9
Bear Cr bl Lick Cr	75.4	15	13
Bear Cr @ Huckleberry CG	17.3	7	5
Bear Cr bl Mickey Cr	7.12	4	9
Lick Cr @ mouth	43.8	11	10
Lick Cr bl HooHoo Gulch	15.2	6	6
Lick Cr bl Cold Spring Cr	7.9	4	unk
Crooked River @ mouth	23.4	8	11
Crooked River @ pathfinder 2	18.4	7	7
Crooked River @ pathfinder 1	8.3	5	3
Wildhorse River @ mouth	176.8	23	15
Wildhorse River bl Emery Cr	145.8	21	13
Wildhorse River @ Bear/Crooked	113.1	18	13

3.3.1.1.8 Design Conditions

The Wildhorse River originates at the confluence of Crooked River and Bear Creek, and then flows generally southwest through Snake River canyon country emptying into the Snake River just below Brownlee Dam. Bear Creek and its tributary Lick Creek originate in Blue Mountain Ecoregion highlands just south of the Seven Devils Mountains and flow south-southwest to Wildhorse River. Crooked River originates on the north face of Cuddy Mountain and flows predominantly north before turning west to join Bear Creek, which then forms the Wildhorse River. All of these tributaries to Wildhorse River originate in mixed conifer forests of Douglas fir (*Psuedotsuga menziesii*), grand fir (*Abies grandis*), ponderosa pine (*Pinus ponderosa*), and subalpine fir (*Abies lasiocarpa*) typical of the Blue Mountain Ecoregion. As the streams descend in elevation, their riparian community tends to become more deciduous shrub dominated, first with a conifer/shrub mix and then with a community that is mostly deciduous shrubs. The riparian community along the Wildhorse River in canyon country is predominantly deciduous trees and shrubs.

3.3.1.1.9 Shade Curve Selection

To determine PNV shade targets for Wildhorse River, Crooked River, Bear Creek, and Lick Creek, effective shade curves from the Southwest Idaho Forest Ecogroup (Boise, Payette, and Sawtooth National Forests) and Southern Idaho Nonforest Vegetation Types were examined (Table 6) (Shumar and De Varona 2009). These curves were produced using vegetation community modeling of Idaho plant communities. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. For Wildhorse River and its tributaries, curves for the most similar vegetation type were selected for shade target determinations. Crooked River, Bear Creek, and Lick Creek originate in warm, dry subalpine fir (PVG 7) and grand fir (PVGs 5 and 6), with occasional narrow strips of hydric subalpine fir (PVG 9). As streams progress downslope, valleys become wider and shrubs tend to dominate the near-shore plant community while the nearby forest still provides some shade. We have developed specific hybrid shade curves by mixing attributes of both forest types and alder nonforest type to produce conifer/meadow mix shade curves. Once valleys become wide enough and of lower gradient, shrubs tend to dominate the riparian plant community. We have selected the alder and the Geyer willow/sedge nonforest types to represent these shrub-dominated areas. Lower Wildhorse River tends to be dominated by deciduous trees and shrubs. We are unclear on exact species make-up for these communities. They may contain a variety of trees including white alder, water birch, aspen, and occasional cottonwoods. Willows and other shrubs are also likely components. We have chosen to have shade targets represented by the water birch nonforest type on lower Wildhorse River. Water birch is a smaller deciduous tree consistent with white alder and aspen in size.

Table 6. Shade curves used to derive targets for the various stream.

Southwest Idaho Forest Ecogroup Types	Conifer/meadow mix types	Southern Idaho Nonforest Types
PVG 2—warm, dry Douglas fir/moist ponderosa pine	PVG 2/alder	Alder
PVG 5—dry grand fir	PVG 5/alder	Geyer willow/sedge
PVG 6—moist grand fir	PVG 6/alder	Water birch
PVG 7—warm, dry subalpine fir	—	Sandbar willow
PVG 9—hydric subalpine fir	—	—
PVG 10—persistent lodgepole pine	—	—

3.3.1.2 Load Capacity

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

We obtained solar load data from flat-plate collectors at the NREL weather stations in Boise, Idaho, and Pendleton, Oregon. The solar load data used in this TMDL analysis are spring/summer averages (i.e., an average load for the 6-month period from April through September). As such, load capacity calculations are also based on this 6-month period, which coincides with the time of year when stream temperatures are increasing, deciduous vegetation is in leaf, and fall spawning is occurring. During this period, temperatures may affect beneficial uses such as spring and fall salmonid spawning and cold water aquatic life criteria may be exceeded during summer months. Late July and early August typically represent the period of highest stream temperatures. However, solar gains can begin early in the spring and affect not only the highest temperatures reached later in the summer but also salmonid spawning temperatures in spring and fall.

Table 7 through Table 13 and Figure 3 and Figure 4 show the PNV shade targets and existing loads. The tables also show corresponding target summer loads (in kilowatt-hours per square meter per day [kWh/m^2/day] and kilowatt-hours per day [kWh/day]) that serve as the load capacities for the streams. Existing and target loads in kWh/day can be summed for the entire stream or portion of stream examined in a single load analysis table. These total loads are shown at the bottom of their respective columns in each table. Because load calculations involve stream segment area calculations, the segments channel width, which typically only has one or two significant figures, dictates the level of significance of the corresponding loads. One significant figure in the resulting load can create rounding errors when existing and target loads are subtracted. The totals row of each load table represents total loads with two significant figures in an attempt to reduce apparent rounding errors.

The AU with the largest target load (i.e., load capacity) was Wildhorse River (ID17050201SW015_04) with 1.5 million kWh/day (Table 8). The smallest target load was in Lick Creek (ID17050201SW016_02) with 12,000 kWh/day (Table 10).

3.3.1.3 Estimates of Existing Pollutant Loads

Regulations allow that loads "...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 area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

Existing loads in the temperature TMDL come from existing shade estimates as determined from aerial photo interpretations. Currently, no permitted point sources exist in the affected AUs. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat-plate collector at the NREL weather stations. Existing shade data are presented in Table 7 through Table 13. Like load capacities (target loads), existing loads in Table 7 through Table 13 are presented on an area basis ($kWh/m^2/day$) and as a total load (kWh/day). Existing loads in kWh/day are also summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target and existing load is also summed for the entire table. Should existing load exceed target load, this difference becomes the excess load (i.e., lack of shade) to be discussed next in the load allocation section and as depicted in the lack-of-shade figures (Figure 5).

The AU with the largest existing load was Wildhorse River (ID17050201SW015_04) with 1.2 million kWh/day (Table 8). The smallest existing load was in Lick Creek (ID17050201SW016_02) with 43,000 kWh/day (Table 10).

Note: Significant figures are controlled by the lowest level in the calculation, typically that of the channel width. Some rounding errors may result.

Table 7. Existing and target solar loads for Crooked River (ID17050201SW015_02).

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
015_02	Crooked River	1	570	PVG 7	96%	0.24	1	600	100	90%	0.61	1	600	400	300	-6%
015_02	Crooked River	2	1800	PVG 9	97%	0.18	1	2,000	400	90%	0.61	1	2,000	1,000	600	-7%
015_02	Crooked River	3	890	PVG 10	96%	0.24	1	900	200	90%	0.61	1	900	500	300	-6%
015_02	Crooked River	4	2900	PVG 6	95%	0.30	2	6,000	2,000	90%	0.61	2	6,000	4,000	2,000	-5%
015_02	Crooked River	5	1600	PVG 7	94%	0.36	3	5,000	2,000	90%	0.61	3	5,000	3,000	1,000	-4%
015_02	Crooked River	6	1600	PVG 6	94%	0.36	3	5,000	2,000	90%	0.61	3	5,000	3,000	1,000	-4%
015_02	Crooked River	7	210	PVG 5	84%	0.97	4	800	800	90%	0.61	4	800	500	(300)	0%
015_02	Crooked River	8	490	PVG 6	91%	0.55	4	2,000	1,000	80%	1.22	4	2,000	2,000	1,000	-11%
015_02	Crooked River	9	1300	PVG 6	91%	0.55	4	5,000	3,000	70%	1.82	4	5,000	9,000	6,000	-21%
015_02	Crooked River	10	1400	PVG 6	84%	0.97	5	7,000	7,000	70%	1.82	5	7,000	10,000	3,000	-14%
015_02	Crooked River	11	900	PVG 6	84%	0.97	5	5,000	5,000	60%	2.43	5	5,000	10,000	5,000	-24%
015_02	Crooked River	12	460	alder	50%	3.04	5	2,000	6,000	80%	1.22	5	2,000	2,000	(4,000)	0%
015_02	Crooked River	13	920	alder	43%	3.47	6	6,000	20,000	60%	2.43	6	6,000	10,000	(10,000)	0%
015_02	Crooked River	14	350	alder	43%	3.47	6	2,000	7,000	50%	3.04	6	2,000	6,000	(1,000)	0%
015_02	Crooked River	15	150	alder	43%	3.47	6	900	3,000	60%	2.43	6	900	2,000	(1,000)	0%
015_02	Crooked River	16	140	alder	43%	3.47	6	800	3,000	50%	3.04	6	800	2,000	(1,000)	0%
015_02	Crooked River	17	240	alder	43%	3.47	6	1,000	3,000	30%	4.26	6	1,000	4,000	1,000	-13%
015_02	Crooked River	18	180	alder	43%	3.47	6	1,000	3,000	20%	4.86	6	1,000	5,000	2,000	-23%
015_02	Crooked River	19	890	alder	43%	3.47	6	5,000	20,000	50%	3.04	6	5,000	20,000	0	0%
015_02	Crooked River	20	1100	PVG 6/alder	44%	3.40	7	8,000	30,000	60%	2.43	7	8,000	20,000	(10,000)	0%
015_02	Crooked River	21	330	Geyer willow	35%	3.95	7	2,000	8,000	30%	4.26	7	2,000	9,000	1,000	-5%
015_02	Crooked River	22	130	Geyer willow	35%	3.95	7	900	4,000	20%	4.86	7	900	4,000	0	-15%
015_02	Crooked River	23	220	alder	38%	3.77	7	2,000	8,000	40%	3.65	7	2,000	7,000	(1,000)	0%
015_02	Crooked River	24	1000	PVG 5	65%	2.13	7	7,000	10,000	70%	1.82	7	7,000	10,000	0	0%
015_02	Crooked River	25	3920	PVG 2/alder	38%	3.77	8	30,000	100,000	70%	1.82	8	30,000	50,000	(50,000)	0%
							Totals		250,000					190,000	-54,000	

Table 8. Existing and target solar loads for Wildhorse River (ID17050201SW015_04).

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
015_04	Wldhorse River	1	130	PVG 2/alder	26%	4.50	13	1,700	7,600	20%	4.86	13	1,700	8,300	700	-6%
015_04	Wldhorse River	2	180	PVG 2/alder	26%	4.50	13	2,300	10,000	30%	4.26	13	2,300	9,800	(200)	0%
015_04	Wldhorse River	3	260	PVG 2/alder	26%	4.50	13	3,400	15,000	40%	3.65	13	3,400	12,000	(3,000)	0%
015_04	Wldhorse River	4	250	PVG 2/alder	26%	4.50	13	3,300	15,000	20%	4.86	13	3,300	16,000	1,000	-6%
015_04	Wldhorse River	5	320	PVG 2/alder	26%	4.50	13	4,200	19,000	30%	4.26	13	4,200	18,000	(1,000)	0%
015_04	Wldhorse River	6	230	PVG 2/alder	26%	4.50	13	3,000	13,000	40%	3.65	13	3,000	11,000	(2,000)	0%
015_04	Wldhorse River	7	140	PVG 2/alder	26%	4.50	13	1,800	8,100	30%	4.26	13	1,800	7,700	(400)	0%
015_04	Wldhorse River	8	250	PVG 2/alder	26%	4.50	13	3,300	15,000	20%	4.86	13	3,300	16,000	1,000	-6%
015_04	Wldhorse River	9	150	PVG 2/alder	26%	4.50	13	2,000	9,000	40%	3.65	13	2,000	7,300	(1,700)	0%
015_04	Wldhorse River	10	100	PVG 2/alder	26%	4.50	13	1,300	5,800	50%	3.04	13	1,300	4,000	(1,800)	0%
015_04	Wldhorse River	11	100	PVG 2/alder	26%	4.50	13	1,300	5,800	30%	4.26	13	1,300	5,500	(300)	0%
015_04	Wldhorse River	12	85	PVG 2/alder	26%	4.50	13	1,100	4,900	10%	5.47	13	1,100	6,000	1,100	-16%
015_04	Wldhorse River	13	140	PVG 2/alder	26%	4.50	13	1,800	8,100	50%	3.04	13	1,800	5,500	(2,600)	0%
015_04	Wldhorse River	14	130	PVG 2/alder	26%	4.50	13	1,700	7,600	30%	4.26	13	1,700	7,200	(400)	0%
015_04	Wldhorse River	15	290	PVG 2/alder	26%	4.50	13	3,800	17,000	40%	3.65	13	3,800	14,000	(3,000)	0%
015_04	Wldhorse River	16	320	PVG 2/alder	26%	4.50	13	4,200	19,000	30%	4.26	13	4,200	18,000	(1,000)	0%
015_04	Wldhorse River	17	390	PVG 5/alder	28%	4.38	13	5,100	22,000	40%	3.65	13	5,100	19,000	(3,000)	0%
015_04	Wldhorse River	18	130	PVG 5/alder	28%	4.38	13	1,700	7,400	30%	4.26	13	1,700	7,200	(200)	0%
015_04	Wldhorse River	19	150	alder	22%	4.74	13	2,000	9,500	20%	4.86	13	2,000	9,700	200	-2%
015_04	Wldhorse River	20	230	PVG 5/alder	28%	4.38	13	3,000	13,000	40%	3.65	13	3,000	11,000	(2,000)	0%
015_04	Wldhorse River	21	600	alder	22%	4.74	13	7,800	37,000	30%	4.26	13	7,800	33,000	(4,000)	0%
015_04	Wldhorse River	22	97	alder	22%	4.74	13	1,300	6,200	20%	4.86	13	1,300	6,300	100	-2%
015_04	Wldhorse River	23	460	alder	22%	4.74	13	6,000	28,000	40%	3.65	13	6,000	22,000	(6,000)	0%
015_04	Wldhorse River	24	390	alder	22%	4.74	13	5,100	24,000	30%	4.26	13	5,100	22,000	(2,000)	0%
015_04	Wldhorse River	25	450	alder	22%	4.74	13	5,900	28,000	40%	3.65	13	5,900	22,000	(6,000)	0%
015_04	Wldhorse River	26	380	water birch	26%	4.50	13	4,900	22,000	30%	4.26	13	4,900	21,000	(1,000)	0%
015_04	Wldhorse River	27	420	water birch	26%	4.50	13	5,500	25,000	40%	3.65	13	5,500	20,000	(5,000)	0%
015_04	Wldhorse River	28	170	water birch	26%	4.50	13	2,200	9,900	20%	4.86	13	2,200	11,000	1,100	-6%
015_04	Wldhorse River	29	160	water birch	26%	4.50	13	2,100	9,400	30%	4.26	13	2,100	8,900	(500)	0%
015_04	Wldhorse River	30	180	water birch	26%	4.50	13	2,300	10,000	20%	4.86	13	2,300	11,000	1,000	-6%
015_04	Wldhorse River	31	750	water birch	24%	4.62	14	11,000	51,000	30%	4.26	14	11,000	47,000	(4,000)	0%
015_04	Wldhorse River	32	290	water birch	24%	4.62	14	4,100	19,000	40%	3.65	14	4,100	15,000	(4,000)	0%
015_04	Wldhorse River	33	160	water birch	24%	4.62	14	2,200	10,000	20%	4.86	14	2,200	11,000	1,000	-4%
015_04	Wldhorse River	34	150	water birch	24%	4.62	14	2,100	9,700	40%	3.65	14	2,100	7,700	(2,000)	0%
015_04	Wldhorse River	35	210	water birch	24%	4.62	14	2,900	13,000	30%	4.26	14	2,900	12,000	(1,000)	0%
015_04	Wldhorse River	36	320	water birch	24%	4.62	14	4,500	21,000	40%	3.65	14	4,500	16,000	(5,000)	0%
015_04	Wldhorse River	37	180	water birch	24%	4.62	14	2,500	12,000	20%	4.86	14	2,500	12,000	0	-4%

Table 8 (cont.). Existing and target solar loads for Wildhorse River (ID17050201SW015_04).

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
015_04	Wldhorse River	38	580	water birch	24%	4.62	14	8,100	37,000	40%	3.65	14	8,100	30,000	(7,000)	0%
015_04	Wldhorse River	39	160	water birch	24%	4.62	14	2,200	10,000	30%	4.26	14	2,200	9,400	(600)	0%
015_04	Wldhorse River	40	450	water birch	24%	4.62	14	6,300	29,000	40%	3.65	14	6,300	23,000	(6,000)	0%
015_04	Wldhorse River	41	180	water birch	24%	4.62	14	2,500	12,000	20%	4.86	14	2,500	12,000	0	-4%
015_04	Wldhorse River	42	200	water birch	24%	4.62	14	2,800	13,000	30%	4.26	14	2,800	12,000	(1,000)	0%
015_04	Wldhorse River	43	200	water birch	24%	4.62	14	2,800	13,000	40%	3.65	14	2,800	10,000	(3,000)	0%
015_04	Wldhorse River	44	210	water birch	24%	4.62	14	2,900	13,000	20%	4.86	14	2,900	14,000	1,000	-4%
015_04	Wldhorse River	45	180	water birch	24%	4.62	14	2,500	12,000	50%	3.04	14	2,500	7,600	(4,400)	0%
015_04	Wldhorse River	46	310	water birch	24%	4.62	14	4,300	20,000	30%	4.26	14	4,300	18,000	(2,000)	0%
015_04	Wldhorse River	47	130	water birch	24%	4.62	14	1,800	8,300	50%	3.04	14	1,800	5,500	(2,800)	0%
015_04	Wldhorse River	48	350	water birch	24%	4.62	14	4,900	23,000	20%	4.86	14	4,900	24,000	1,000	-4%
015_04	Wldhorse River	49	190	water birch	24%	4.62	14	2,700	12,000	40%	3.65	14	2,700	9,800	(2,200)	0%
015_04	Wldhorse River	50	310	water birch	24%	4.62	14	4,300	20,000	30%	4.26	14	4,300	18,000	(2,000)	0%
015_04	Wldhorse River	51	240	water birch	24%	4.62	14	3,400	16,000	40%	3.65	14	3,400	12,000	(4,000)	0%
015_04	Wldhorse River	52	270	water birch	24%	4.62	14	3,800	18,000	30%	4.26	14	3,800	16,000	(2,000)	0%
015_04	Wldhorse River	53	400	water birch	24%	4.62	14	5,600	26,000	40%	3.65	14	5,600	20,000	(6,000)	0%
015_04	Wldhorse River	54	98	water birch	24%	4.62	14	1,400	6,500	30%	4.26	14	1,400	6,000	(500)	0%
015_04	Wldhorse River	55	180	water birch	24%	4.62	14	2,500	12,000	40%	3.65	14	2,500	9,100	(2,900)	0%
015_04	Wldhorse River	56	380	water birch	24%	4.62	14	5,300	24,000	20%	4.86	14	5,300	26,000	2,000	-4%
015_04	Wldhorse River	57	350	water birch	24%	4.62	14	4,900	23,000	30%	4.26	14	4,900	21,000	(2,000)	0%
015_04	Wldhorse River	58	140	water birch	23%	4.68	15	2,100	9,800	20%	4.86	15	2,100	10,000	200	-3%
015_04	Wldhorse River	59	120	water birch	23%	4.68	15	1,800	8,400	40%	3.65	15	1,800	6,600	(1,800)	0%
015_04	Wldhorse River	60	84	water birch	23%	4.68	15	1,300	6,100	20%	4.86	15	1,300	6,300	200	-3%
015_04	Wldhorse River	61	330	water birch	23%	4.68	15	5,000	23,000	40%	3.65	15	5,000	18,000	(5,000)	0%
015_04	Wldhorse River	62	170	water birch	23%	4.68	15	2,600	12,000	20%	4.86	15	2,600	13,000	1,000	-3%
015_04	Wldhorse River	63	170	water birch	23%	4.68	15	2,600	12,000	50%	3.04	15	2,600	7,900	(4,100)	0%
015_04	Wldhorse River	64	500	water birch	23%	4.68	15	7,500	35,000	40%	3.65	15	7,500	27,000	(8,000)	0%
015_04	Wldhorse River	65	360	water birch	23%	4.68	15	5,400	25,000	30%	4.26	15	5,400	23,000	(2,000)	0%
015_04	Wldhorse River	66	160	water birch	23%	4.68	15	2,400	11,000	50%	3.04	15	2,400	7,300	(3,700)	0%
015_04	Wldhorse River	67	360	water birch	23%	4.68	15	5,400	25,000	40%	3.65	15	5,400	20,000	(5,000)	0%
015_04	Wldhorse River	68	470	water birch	23%	4.68	15	7,100	33,000	30%	4.26	15	7,100	30,000	(3,000)	0%
015_04	Wldhorse River	69	350	water birch	23%	4.68	15	5,300	25,000	40%	3.65	15	5,300	19,000	(6,000)	0%
015_04	Wldhorse River	70	170	water birch	23%	4.68	15	2,600	12,000	30%	4.26	15	2,600	11,000	(1,000)	0%
015_04	Wldhorse River	71	1500	water birch	23%	4.68	15	23,000	110,000	40%	3.65	15	23,000	84,000	(26,000)	0%
015_04	Wldhorse River	72	1650	water birch	23%	4.68	15	25,000	120,000	50%	3.04	15	25,000	76,000	(44,000)	0%
015_04	Wldhorse River	73	960	water birch	23%	4.68	15	14,000	66,000	40%	3.65	15	14,000	51,000	(15,000)	0%
015_04	Wldhorse River	74	80	sandbar willow	20%	4.86	15	1,200	5,800	10%	5.47	15	1,200	6,600	800	-10%
015_04	Wldhorse River	75	110	sandbar willow	20%	4.86	15	1,700	8,300	0%	6.08	15	1,700	10,000	1,700	-20%
							Totals		1,500,000					1,200,000	-220,000	

Table 9. Existing and target solar loads for Bear Creek (ID17050201SW016_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
016_02	Bear Creek	1	1500	PVG 7	96%	0.24	1	2,000	500	90%	0.61	1	2,000	1,000	500	-6%
016_02	Bear Creek	2	390	PVG 7	95%	0.30	2	800	200	80%	1.22	2	800	1,000	800	-15%
016_02	Bear Creek	3	65	PVG 7	95%	0.30	2	100	30	10%	5.47	2	100	500	500	-85%
016_02	Bear Creek	4	130	PVG 6	95%	0.30	2	300	90	80%	1.22	2	300	400	300	-15%
016_02	Bear Creek	5	830	PVG 5	94%	0.36	2	2,000	700	90%	0.61	2	2,000	1,000	300	-4%
016_02	Bear Creek	6	600	PVG 9	96%	0.24	3	2,000	500	90%	0.61	3	2,000	1,000	500	-6%
016_02	Bear Creek	7	500	PVG 9	96%	0.24	3	2,000	500	80%	1.22	3	2,000	2,000	2,000	-16%
016_02	Bear Creek	8	880	PVG 6	94%	0.36	3	3,000	1,000	90%	0.61	3	3,000	2,000	1,000	-4%
016_02	Bear Creek	9	740	PVG 7	91%	0.55	4	3,000	2,000	80%	1.22	4	3,000	4,000	2,000	-11%
016_02	Bear Creek	10	510	PVG 9	94%	0.36	4	2,000	700	70%	1.82	4	2,000	4,000	3,000	-24%
016_02	Bear Creek	11	880	PVG 7	91%	0.55	4	4,000	2,000	60%	2.43	4	4,000	10,000	8,000	-31%
016_02	Bear Creek	12	300	PVG 7	84%	0.97	5	2,000	2,000	50%	3.04	5	2,000	6,000	4,000	-34%
016_02	Bear Creek	13	180	PVG 7	84%	0.97	5	900	900	70%	1.82	5	900	2,000	1,000	-14%
016_02	Bear Creek	14	740	PVG 7	84%	0.97	5	4,000	4,000	50%	3.04	5	4,000	10,000	6,000	-34%
016_02	Bear Creek	15	1200	PVG 7	84%	0.97	5	6,000	6,000	60%	2.43	5	6,000	10,000	4,000	-24%
016_02	Bear Creek	16	700	PVG 7	78%	1.34	6	4,000	5,000	70%	1.82	6	4,000	7,000	2,000	-8%
016_02	Bear Creek	17	750	PVG 7	78%	1.34	6	5,000	7,000	60%	2.43	6	5,000	10,000	3,000	-18%
016_02	Bear Creek	18	920	PVG 6	72%	1.70	7	6,000	10,000	60%	2.43	7	6,000	10,000	0	-12%
016_02	Bear Creek	19	370	PVG 6/alder	44%	3.40	7	3,000	10,000	50%	3.04	7	3,000	9,000	(1,000)	0%
016_02	Bear Creek	20	330	PVG 6/alder	44%	3.40	7	2,000	7,000	40%	3.65	7	2,000	7,000	0	-4%
016_02	Bear Creek	21	130	PVG 6/alder	44%	3.40	7	900	3,000	50%	3.04	7	900	3,000	0	0%
016_02	Bear Creek	22	180	PVG 6/alder	44%	3.40	7	1,000	3,000	30%	4.26	7	1,000	4,000	1,000	-14%
016_02	Bear Creek	23	630	PVG 6/alder	44%	3.40	7	4,000	10,000	20%	4.86	7	4,000	20,000	10,000	-24%
016_02	Bear Creek	24	610	alder	38%	3.77	7	4,000	20,000	10%	5.47	7	4,000	20,000	0	-28%
016_02	Bear Creek	25	100	alder	38%	3.77	7	700	3,000	20%	4.86	7	700	3,000	0	-18%
016_02	Bear Creek	26	88	alder	38%	3.77	7	600	2,000	0%	6.08	7	600	4,000	2,000	-38%
016_02	Bear Creek	27	430	alder	38%	3.77	7	3,000	10,000	10%	5.47	7	3,000	20,000	10,000	-28%
016_02	Bear Creek	28	290	alder	38%	3.77	7	2,000	8,000	20%	4.86	7	2,000	10,000	2,000	-18%
016_02	Bear Creek	29	210	alder	34%	4.01	8	2,000	8,000	20%	4.86	8	2,000	10,000	2,000	-14%

Table 9 (cont.). Existing and target solar loads for Bear Creek (ID17050201SW016_02).

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
016_02	Bear Creek	30	310	alder	34%	4.01	8	2,000	8,000	10%	5.47	8	2,000	10,000	2,000	-24%
016_02	Bear Creek	31	180	alder	34%	4.01	8	1,000	4,000	0%	6.08	8	1,000	6,000	2,000	-34%
016_02	Bear Creek	32	100	alder	34%	4.01	8	800	3,000	30%	4.26	8	800	3,000	0	-4%
016_02	Bear Creek	33	400	alder	34%	4.01	8	3,000	10,000	10%	5.47	8	3,000	20,000	10,000	-24%
016_02	Bear Creek	34	220	alder	34%	4.01	8	2,000	8,000	0%	6.08	8	2,000	10,000	2,000	-34%
016_02	Bear Creek	35	330	alder	34%	4.01	8	3,000	10,000	20%	4.86	8	3,000	10,000	0	-14%
016_02	Bear Creek	36	62	alder	34%	4.01	8	500	2,000	0%	6.08	8	500	3,000	1,000	-34%
016_02	Bear Creek	37	420	alder	34%	4.01	8	3,000	10,000	20%	4.86	8	3,000	10,000	0	-14%
016_02	Bear Creek	38	90	alder	34%	4.01	8	700	3,000	0%	6.08	8	700	4,000	1,000	-34%
016_02	Bear Creek	39	260	alder	34%	4.01	8	2,000	8,000	20%	4.86	8	2,000	10,000	2,000	-14%
016_02	Bear Creek	40	110	alder	34%	4.01	8	900	4,000	40%	3.65	8	900	3,000	(1,000)	0%
016_02	Bear Creek	41	230	Geyer willow	31%	4.20	8	2,000	8,000	30%	4.26	8	2,000	9,000	1,000	-1%
016_02	Bear Creek	42	350	Geyer willow	31%	4.20	8	3,000	10,000	40%	3.65	8	3,000	10,000	0	0%
016_02	Bear Creek	43	230	Geyer willow	31%	4.20	8	2,000	8,000	30%	4.26	8	2,000	9,000	1,000	-1%
016_02	Bear Creek	44	130	Geyer willow	31%	4.20	8	1,000	4,000	20%	4.86	8	1,000	5,000	1,000	-11%
016_02	Bear Creek	45	260	Geyer willow	31%	4.20	8	2,000	8,000	30%	4.26	8	2,000	9,000	1,000	-1%
016_02	Bear Creek	46	170	Geyer willow	31%	4.20	8	1,000	4,000	10%	5.47	8	1,000	5,000	1,000	-21%
016_02	Bear Creek	47	530	Geyer willow	29%	4.32	9	5,000	20,000	20%	4.86	9	5,000	20,000	0	-9%
016_02	Bear Creek	48	110	Geyer willow	29%	4.32	9	1,000	4,000	0%	6.08	9	1,000	6,000	2,000	-29%
016_02	Bear Creek	49	140	Geyer willow	29%	4.32	9	1,000	4,000	30%	4.26	9	1,000	4,000	0	0%
016_02	Bear Creek	50	240	Geyer willow	29%	4.32	9	2,000	9,000	20%	4.86	9	2,000	10,000	1,000	-9%
016_02	Bear Creek	51	1330	Geyer willow	29%	4.32	9	10,000	40,000	30%	4.26	9	10,000	40,000	0	0%
016_02	Bear Creek	52	140	Geyer willow	29%	4.32	9	1,000	4,000	20%	4.86	9	1,000	5,000	1,000	-9%
016_02	Bear Creek	53	310	Geyer willow	29%	4.32	9	3,000	10,000	30%	4.26	9	3,000	10,000	0	0%
016_02	Bear Creek	54	200	Geyer willow	29%	4.32	9	2,000	9,000	20%	4.86	9	2,000	10,000	1,000	-9%
016_02	Bear Creek	55	230	Geyer willow	29%	4.32	9	2,000	9,000	30%	4.26	9	2,000	9,000	0	0%
016_02	Bear Creek	56	130	Geyer willow	29%	4.32	9	1,000	4,000	20%	4.86	9	1,000	5,000	1,000	-9%
016_02	Bear Creek	57	130	Geyer willow	29%	4.32	9	1,000	4,000	30%	4.26	9	1,000	4,000	0	0%
016_02	Bear Creek	58	390	Geyer willow	29%	4.32	9	4,000	20,000	20%	4.86	9	4,000	20,000	0	-9%
016_02	Bear Creek	59	360	Geyer willow	29%	4.32	9	3,000	10,000	30%	4.26	9	3,000	10,000	0	0%
							Totals		390,000					480,000	95,000	

Table 10. Existing and target solar loads for Lick Creek (ID17050201SW016_02).

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
016_02	Lick Creek	1	1400	PVG 7	96%	0.24	1	1,000	200	90%	0.61	1	1,000	600	400	-6%
016_02	Lick Creek	2	1500	PVG 5	95%	0.30	1	2,000	600	90%	0.61	1	2,000	1,000	400	-5%
016_02	Lick Creek	3	2300	PVG 6	95%	0.30	2	5,000	2,000	80%	1.22	2	5,000	6,000	4,000	-15%
016_02	Lick Creek	4	1900	PVG 9	96%	0.24	3	6,000	1,000	80%	1.22	3	6,000	7,000	6,000	-16%
016_02	Lick Creek	5	770	PVG 9	94%	0.36	4	3,000	1,000	80%	1.22	4	3,000	4,000	3,000	-14%
016_02	Lick Creek	6	1100	PVG 7	91%	0.55	4	4,000	2,000	70%	1.82	4	4,000	7,000	5,000	-21%
016_02	Lick Creek	7	470	PVG 7	84%	0.97	5	2,000	2,000	60%	2.43	5	2,000	5,000	3,000	-24%
016_02	Lick Creek	8	590	PVG 7	84%	0.97	5	3,000	3,000	50%	3.04	5	3,000	9,000	6,000	-34%
016_02	Lick Creek	9	290	PVG 9	92%	0.49	5	1,000	500	50%	3.04	5	1,000	3,000	3,000	-42%
							Totals		12,000					43,000	31,000	

Table 11. Existing and target solar loads for Lick Creek (ID17050201SW016_03).

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
016_03	Lick Creek	1	270	PVG 2	50%	3.04	6	2,000	6,000	40%	3.65	6	2,000	7,000	1,000	-10%
016_03	Lick Creek	2	540	PVG 6	78%	1.34	6	3,000	4,000	50%	3.04	6	3,000	9,000	5,000	-28%
016_03	Lick Creek	3	380	PVG 6	78%	1.34	6	2,000	3,000	70%	1.82	6	2,000	4,000	1,000	-8%
016_03	Lick Creek	4	810	PVG 6	78%	1.34	6	5,000	7,000	50%	3.04	6	5,000	20,000	10,000	-28%
016_03	Lick Creek	5	900	PVG 6	72%	1.70	7	6,000	10,000	70%	1.82	7	6,000	10,000	0	-2%
016_03	Lick Creek	6	740	PVG 6/alder	44%	3.40	7	5,000	20,000	30%	4.26	7	5,000	20,000	0	-14%
016_03	Lick Creek	7	420	PVG 6/alder	44%	3.40	7	3,000	10,000	40%	3.65	7	3,000	10,000	0	-4%
016_03	Lick Creek	8	93	PVG 6	68%	1.95	8	700	1,000	70%	1.82	8	700	1,000	0	0%
016_03	Lick Creek	9	110	PVG 6	68%	1.95	8	900	2,000	60%	2.43	8	900	2,000	0	-8%
016_03	Lick Creek	10	350	PVG 6/alder	40%	3.65	8	3,000	10,000	30%	4.26	8	3,000	10,000	0	-10%
016_03	Lick Creek	11	740	PVG 6/alder	40%	3.65	8	6,000	20,000	40%	3.65	8	6,000	20,000	0	0%
016_03	Lick Creek	12	750	PVG 2	43%	3.47	8	6,000	20,000	40%	3.65	8	6,000	20,000	0	-3%
							Totals		110,000					130,000	17,000	

Table 12. Existing and target solar loads for Bear Creek (ID17050201SW016_04).

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
016_04	Bear Creek	1	66	Geyer willow	26%	4.50	10	660	3,000	20%	4.86	10	660	3,200	200	-6%
016_04	Bear Creek	2	130	Geyer willow	26%	4.50	10	1,300	5,800	10%	5.47	10	1,300	7,100	1,300	-16%
016_04	Bear Creek	3	1150	Geyer willow	26%	4.50	10	12,000	54,000	30%	4.26	10	12,000	51,000	(3,000)	0%
016_04	Bear Creek	4	720	PVG 2	37%	3.83	10	7,200	28,000	40%	3.65	10	7,200	26,000	(2,000)	0%
016_04	Bear Creek	5	230	PVG 2	37%	3.83	10	2,300	8,800	30%	4.26	10	2,300	9,800	1,000	-7%
016_04	Bear Creek	6	130	PVG 2	37%	3.83	10	1,300	5,000	40%	3.65	10	1,300	4,700	(300)	0%
016_04	Bear Creek	7	790	PVG 2	37%	3.83	10	7,900	30,000	30%	4.26	10	7,900	34,000	4,000	-7%
016_04	Bear Creek	8	240	PVG 2	35%	3.95	11	2,600	10,000	40%	3.65	11	2,600	9,500	(500)	0%
016_04	Bear Creek	9	640	PVG 2	35%	3.95	11	7,000	28,000	30%	4.26	11	7,000	30,000	2,000	-5%
016_04	Bear Creek	10	270	PVG 2	35%	3.95	11	3,000	12,000	40%	3.65	11	3,000	11,000	(1,000)	0%
016_04	Bear Creek	11	2290	PVG 2	35%	3.95	11	25,000	99,000	30%	4.26	11	25,000	110,000	11,000	-5%
							Totals		280,000					300,000	13,000	

Table 13. Existing and target solar loads for Lick Creek (ID17050201SW016_04).

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
016_04	Lick Creek	1	250	PVG 2	40%	3.65	9	2,000	7,000	40%	3.65	9	2,000	7,000	0	0%
016_04	Lick Creek	2	400	PVG 2	40%	3.65	9	4,000	10,000	30%	4.26	9	4,000	20,000	10,000	-10%
016_04	Lick Creek	3	1100	Geyer willow	29%	4.32	9	10,000	40,000	20%	4.86	9	10,000	50,000	10,000	-9%
016_04	Lick Creek	4	1100	Geyer willow	26%	4.50	10	11,000	49,000	20%	4.86	10	11,000	54,000	5,000	-6%
016_04	Lick Creek	5	430	Geyer willow	26%	4.50	10	4,300	19,000	30%	4.26	10	4,300	18,000	(1,000)	0%
016_04	Lick Creek	6	650	Geyer willow	26%	4.50	10	6,500	29,000	10%	5.47	10	6,500	36,000	7,000	-16%
016_04	Lick Creek	7	130	Geyer willow	24%	4.62	11	1,400	6,500	0%	6.08	11	1,400	8,500	2,000	-24%
016_04	Lick Creek	8	870	Geyer willow	24%	4.62	11	9,600	44,000	10%	5.47	11	9,600	53,000	9,000	-14%
016_04	Lick Creek	9	160	Geyer willow	24%	4.62	11	1,800	8,300	20%	4.86	11	1,800	8,800	500	-4%
016_04	Lick Creek	10	300	Geyer willow	24%	4.62	11	3,300	15,000	10%	5.47	11	3,300	18,000	3,000	-14%
							Totals		230,000					270,000	46,000	

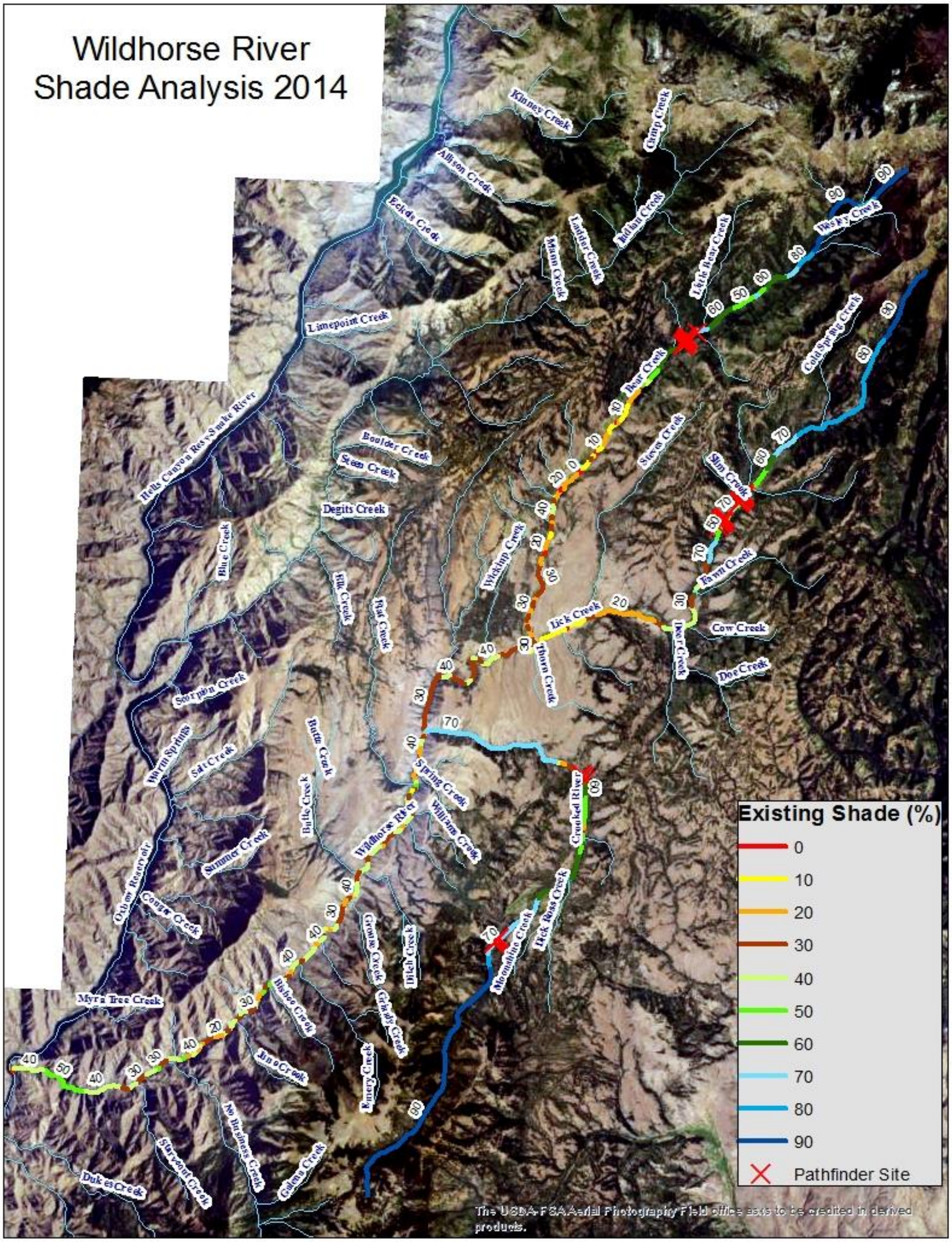

Figure 3. Existing shade estimated for the Wildhorse River watershed by aerial photo interpretation.

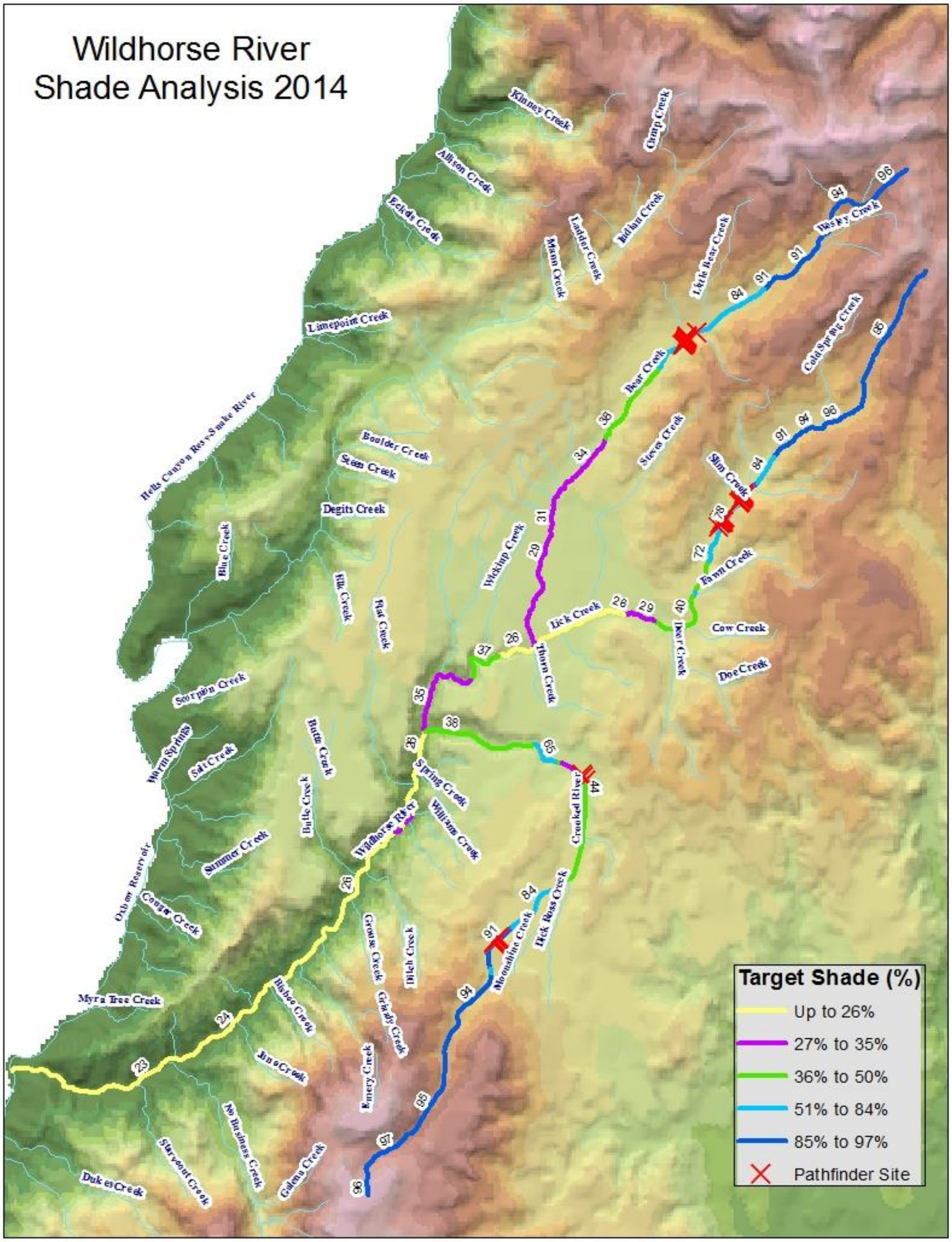

Figure 4. Target shade for the Wildhorse River watershed.

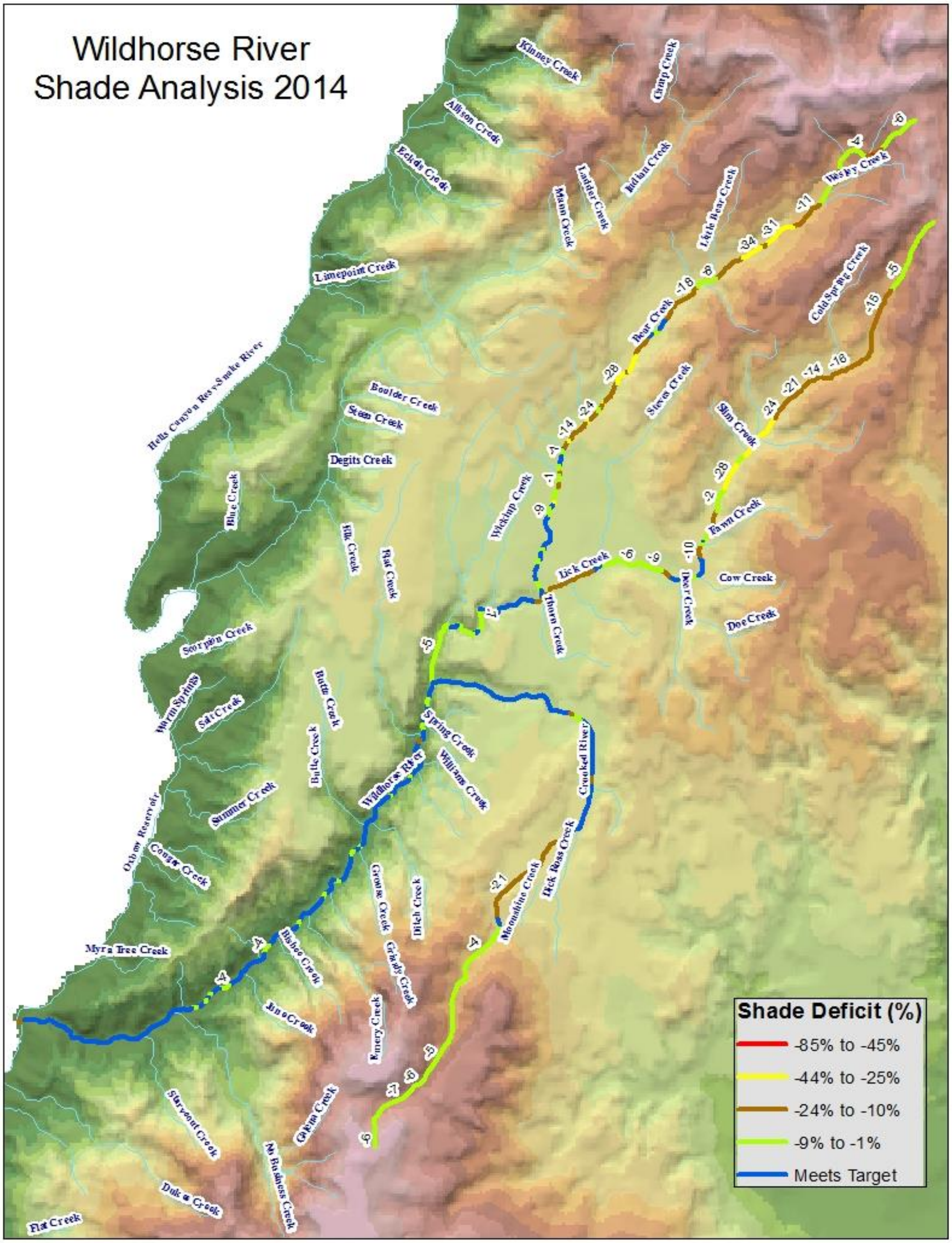

Figure 5. Shade deficit (difference between existing and target) for the Wildhorse River watershed.

3.3.1.4 Load Allocation

Because the TMDL is based on PNV, which is equivalent to background load, the load allocation is essentially the desire to achieve background conditions. However, 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. Therefore, load allocations are stream segment-specific and dependent upon the target load for a given segment. Table 7 through Table 13 show the target shade and corresponding target summer load. This target load (i.e., load capacity) is necessary to achieve background conditions. No further shade can be removed from the stream by any activity without exceeding its load capacity. Additionally, because the TMDL depends upon background conditions for achieving water quality standards, all tributaries to the waters examined here need to be in natural conditions to prevent excess heat loads to the system.

Table 14 shows the total existing, target, and excess loads and the average lack of shade for each water body examined. The size of a stream influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths. Table 14 lists the tributaries in order of their excess loads, from lowest to highest. Therefore, large tributaries tend to be listed last and small tributaries first.

Although the TMDL analysis focuses on total solar loads, it is important to note that differences between existing and target shade, as depicted in the lack-of-shade figure (Figure 5), are the key to successfully restoring these waters to achieving water quality standards. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts. Each load analysis table contains a column that lists the lack of shade on the stream segment. This value is derived from subtracting target shade from existing shade for each segment. Thus, stream segments with the largest lack of shade are in the worst shape. The average lack of shade derived from the last column in each load analysis table is also listed in Table 14 and provides a general level of comparison among streams.

Table 14. Total solar loads and average lack of shade for all waters.

Assessment Unit Name	Assessment Unit Number	Total Existing Load	Total Target Load	Excess Load	Percent Reduction (%)	Average Lack of Shade (%)
		(kWh/day)				
Wildhorse River	ID17050201SW015_04	1,200,000	1,500,000	0	—	2
Crooked River	ID17050201SW015_02	190,000	250,000	0	—	6
Bear Creek	ID17050201SW016_04	300,000	280,000	13,000	4	4
Lick Creek	ID17050201SW016_03	130,000	110,000	17,000	13	10
Lick Creek	ID17050201SW016_02	43,000	12,000	31,000	72	20
Lick Creek	ID17050201SW016_04	270,000	230,000	46,000	17	10
Bear Creek	ID17050201SW016_02	480,000	390,000	95,000	20	15

Notes: Load data are rounded to two significant figures, which may present rounding errors; kilowatt-hours per day (kWh/day).

For this 5-year review, the analysis of existing shade was enhanced by newer and better aerial imagery. The 2013 National Agricultural Imagery Program (NAIP) imagery has a resolution of 1/2 meter and 2011 NAIP imagery, although at 1-meter resolution, provides some of the clearest images we have seen to date. In addition to new imagery, the 5-year review analysis was enhanced by using target shade curves specifically developed from Idaho plant community data (Shumar and De Varona 2009). The Wildhorse River TMDL (DEQ 2007) borrowed target shade curves from Oregon, Washington, and California or other watersheds in Idaho, and were not specific enough about the vegetation actually growing in the Wildhorse River watershed.

The 5-year review analysis showed that the Wildhorse River and Crooked River AUs had no excess solar loads (Table 14) and were essentially meeting shade targets adequately (Figure 5). Bear Creek and Lick Creek AUs, however, continue to show excess solar loads and a lack of sufficient shade to meet target values. The 2nd-order AU of Bear Creek has the largest excess load at 95,000 kWh/day and a required reduction of 20%. The 4th-order AU of Bear Creek is in better condition primarily due to the canyon and has an average shade deficit of 4% consistent with existing shade in the same 10% class interval as shade targets. Of the three Lick Creek AUs, the 2nd-order AU requires the largest relative reduction at 72%. The 3rd- and 4th-order AUs of Lick Creek have required reductions of 13% and 17%, respectively.

A certain amount of excess load is potentially created by the existing shade/target shade difference inherent in the load analysis. Because existing shade is reported as a 10% shade class and target shade a unique integer between 0% and 100%, a difference exists between the two. For example, a particular stream segment has a target shade of 86% based on its vegetation type and natural bank-full width. If existing shade on that segment were at target level, it would be recorded as 80% in the load analysis because it falls into the 80% existing shade class. The difference is of 6%, which could be attributed to MOS.

The Wildhorse River TMDL (DEQ 2007) compared to the present analysis showed similar results for Bear and Lick Creeks (Table 15). Loads and required reductions are slightly less in 2014 as compared to 2007 for these two waters due to the improved habitat and improved analysis. Wildhorse and Crooked Rivers were considered lacking shade and having excess solar loads in 2007, whereas today we find existing solar loads better (less) than target loads. Shade deficits depicted in Figure 5 clearly show an abundance of reaches meeting target shade levels on these two water bodies. Crooked River lacks shade in the middle and upper reaches but that is apparently compensated by an abundance of shade in the lower canyon reach. These data suggest that shade restoration efforts should be directed towards Bear and Lick Creeks.

Table 15. Comparison analysis (2007 versus 2014) of total solar loads for all waters.

	TMDL Load (kWh/day) Comparison							
Stream	Existing Load 2007	Target Load 2007	Excess Load 2007	Reduction 2007	Existing Load 2014	Target Load 2014	Excess Load 2014	Reduction 2014
Bear Creek	939,015	780,523	158,492	17%	780,000	670,000	108,000	14%
Lick Creek	537,547	388,202	149,345	28%	450,000	350,000	93,000	21%
Crooked River	219,013	179,806	39,206	18%	190,000	250,000	0	0%
Wildhorse River	2,008,571	1,760,971	247,600	12%	1,200,000	1,500,000	0	0%

Notes: The 2014 load data are rounded to two significant figures, which may present rounding errors; kilowatt-hours per day (kWh/day). 2007 data *from Wildhorse River Subbasin Assessment and Total Maximum Daily Load* (DEQ 2007).

3.3.2 Water Temperature

Although target shade levels and solar loads under PNV (section 3.3.1.3) proved to be a better approach than inflexible numeric criteria in identifying whether instream temperatures given natural conditions are being met, especially in arid areas, water temperatures were measured at the top, middle, and most upper sections of each AU. Data logger locations are described in footnotes at the bottom of each table. Instream data loggers measured temperature at 15-minute intervals between mid-May and mid-October. Wildhorse and Crooked Rivers exceeded numeric temperature criteria for cold water aquatic life and salmonid spawning (Table 16 and Table 17, respectively). To add complexity, the instream temperature in Wildhorse River (Table 16) is due, in part, to inflow from tributaries (e.g., Bear and Lick Creeks) that are temperature impaired as well as the natural shading of vegetation that is already at full potential. The AU including Crooked River has no temperature-impaired tributaries flowing into it; therefore, we assume that instream temperature in this AU is a direct result of natural conditions and shading at full potential. Bear and Lick Creeks exceed cold water aquatic life and salmonid spawning temperature criteria (Table 18 and Table 19, respectively).

Table 16. Water temperatures (°C) in Wildhorse River, May–October 2014.

Site[a]	Month	Period	Mean	±SE	Max	Min	Daily Max ≥22[b]	Daily Mean ≥19[b]	Daily Max ≥13[c]	Daily Mean ≥9[c]
WB	May	Second half	8.2	0.2	12.6	3.9	0	0	0	1
WB	June	First half	10.7	0.2	15.3	5.9	0	0	11	14
WB	June	Second half	12.9	0.6	18.0	5.9	0	0	12	14
WB	July	First half	18.7	0.4	24.5	11.2	8	5	15	15
WB	July	Second half	19.0	0.3	23.3	13.8	10	9	NA	NA
WB	August	First half	18.9	0.2	23.0	15.3	6	8	NA	NA
WB	August	Second half	16.4	0.3	21.9	12.2	0	0	NA	NA
WB	September	First half	12.4	0.3	17.4	8.0	0	0	15	15
WB	September	Second half	13.6	0.2	17.4	10.9	0	0	13	15
WB	October	First half	10.0	0.3	13.2	7.6	0	0	1	6
WM	May	Second half	10.1	0.2	13.6	6.3	0	0	3	14
WM	June	First half	12.3	0.2	16.0	8.8	0	0	15	15
WM	June	Second half	11.0	0.4	16.6	8.3	0	0	2	4
WM	July	First half	19.5	0.3	23.3	15.9	4	4	7	7
WM	July	Second half	18.8	0.2	22.3	13.9	3	10	NA	NA
WM	August	First half	19.1	0.2	22.0	15.9	2	9	NA	NA
WM	August	Second half	17.2	0.3	20.8	13.4	0	0	NA	NA
WM	September	First half	14.2	0.3	17.5	10.2	0	0	15	15
WM	September	Second half	15.3	0.3	17.9	12.5	0	0	15	15
WM	October	First half	11.9	0.3	14.1	9.8	0	0	2	6

a. WB: Approximately 200 meters downstream of Crooked River and Bear Creek confluence, WM: mouth
b. Cold water aquatic life criterion
c. Salmonid spawning criterion
Notes: NA- Not Applicable

Table 17. Water temperatures (°C) in Crooked River, May–October 2014.

Site[a]	Month	Period	Mean	±SE	Max	Min	Daily Max ≥22[b]	Daily Mean ≥19[b]	Daily Max ≥13[c]	Daily Mean ≥9[c]
CL	May	Second half	7.8	0.2	13.5	3.5	0	0	1	1
CL	June	First half	11.9	0.3	18.5	6.6	0	0	14	15
CL	June	Second half	12.8	0.5	20.0	6.0	0	0	12	15
CL	July	First half	17.1	0.3	23.9	9.6	6	1	15	15
CL	July	Second half	16.7	0.3	21.9	9.7	0	0	NA	NA
CL	August	First half	16.5	0.3	21.5	11.2	0	0	NA	NA
CL	August	Second half	13.5	0.4	19.0	8.0	0	0	NA	NA
CL	September	First half	9.9	0.3	14.7	4.1	0	0	9	12
CL	September	Second half	12.0	0.3	16.0	8.2	0	0	11	15
CL	October	First half	8.4	0.3	12.4	4.8	0	0	0	2
CCD	May	Second half	9.3	0.2	13.7	4.9	0	0	4	9
CCD	June	First half	12.5	0.2	16.1	8.1	0	0	13	15
CCD	June	Second half	13.2	0.5	16.9	7.4	0	0	12	15
CCD	July	First half	17.7	0.3	22.2	11.9	1	2	15	15
CCD	July	Second half	17.4	0.3	21.1	12.6	0	0	NA	NA
CCD	August	First half	17.3	0.2	20.5	14.0	0	0	NA	NA
CCD	August	Second half	14.6	0.3	18.7	11.1	0	0	NA	NA
CCD	September	First half	10.7	0.3	14.0	6.9	0	0	5	13
CCD	September	Second half	12.6	0.2	15.2	10.3	0	0	11	15
CCD	October	First half	8.7	0.3	10.4	6.7	0	0	0	3

a. CL: Lafferty Campground, CCD: Above bridge at confluence with Wildhorse River
b. Cold water aquatic life criterion
c. Salmonid spawning criterion
Notes: NA- Not Applicable

Table 18. Water temperatures (°C) in Bear Creek, May–October 2014.

Site[a]	Month	Period	Mean	±SE	Max	Min	Daily Max ≥22[b]	Daily Mean ≥19[b]	Daily Max ≥13[c]	Daily Mean ≥9[c]
BH	May	Second half	4.7	0.1	7.7	2.8	0	0	0	0
BH	June	First half	6.3	0.1	11.0	3.9	0	0	0	0
BH	June	Second half	7.8	0.4	12.9	3.1	0	0	0	2
BH	July	First half	11.8	0.3	17.2	6.4	0	0	14	15
BH	July	Second half	12.1	0.2	16.6	7.2	0	0	NA	NA
BH	August	First half	12.7	0.2	16.7	9.3	0	0	NA	NA
BH	August	Second half	10.9	0.3	16.1	6.9	0	0	NA	NA
BH	September	First half	8.0	0.3	12.3	3.4	0	0	0	2
BH	September	Second half	10.0	0.2	13.6	7.0	0	0	3	14
BH	October	First half	6.4	0.4	9.6	3.6	0	0	0	0
BBU	May	Second half	6.4	0.1	9.5	3.9	0	0	0	0
BBU	June	First half	8.3	0.2	14.2	5.4	0	0	3	4
BBU	June	Second half	10.9	0.5	18.0	4.1	0	0	12	12
BBU	July	First half	17.2	0.5	24.9	8.5	9	2	15	15
BBU	July	Second half	18.2	0.2	24.1	10.8	11	2	NA	NA
BBU	August	First half	18.2	0.2	23.7	12.8	8	5	NA	NA
BBU	August	Second half	16.3	0.3	23.3	10.1	4	0	NA	NA
BBU	September	First half	12.7	0.3	19.2	5.8	0	0	15	15
BBU	September	Second half	13.9	0.3	19.3	9.6	0	0	14	15
BBU	October	First half	10.4	0.3	15.4	6.2	0	0	5	6
BC	May	Second half	8.2	0.2	12.6	3.8	0	0	0	1
BC	June	First half	10.5	0.2	15.2	5.7	0	0	11	14
BC	June	Second half	12.8	0.6	18.0	5.7	0	0	12	13
BC	July	First half	18.7	0.4	24.5	11.0	7	5	15	15
BC	July	Second half	19.0	0.3	23.1	13.8	10	10	NA	NA
BC	August	First half	19.0	0.2	22.9	15.4	4	8	NA	NA
BC	August	Second half	16.5	0.3	21.7	12.3	0	0	NA	NA
BC	September	First half	12.5	0.3	17.4	8.2	0	0	15	15
BC	September	Second half	13.7	0.2	17.5	11.0	0	0	13	15
BC	October	First half	10.1	0.3	13.3	7.7	0	0	1	6

a. BH: Huckleberry Campground, BBU: Bridge at main road to Bear (NR-002), BC: Above bridge at confluence with Wildhorse River
b. Cold water aquatic life criterion
c. Salmonid spawning
Notes: NA- Not Applicable

Table 19. Water temperatures (°C) in Lick Creek, May–October 2014.

Site[a]	Month	Period	Mean	±SE	Max	Min	Daily Max ≥22[b]	Daily Mean ≥19[b]	Daily Max ≥13[c]	Daily Mean ≥9[c]
LU	August	First half	15.5	0.3	21.1	11.5	0	0	9	9
LU	August	Second half	13.5	0.4	20.1	8.6	0	0	16	16
LU	September	First half	9.9	0.3	15.5	4.5	0	0	11	12
LU	September	Second half	11.9	0.3	16.8	8.6	0	0	11	15
LU	October	First half	7.9	0.4	12.2	4.6	0	0	0	1
D	May	Second half	8.6	0.3	13.7	4.3	0	0	4	6
D	June	First half	10.2	0.2	14.7	6.2	0	0	9	13
D	June	Second half	10.6	0.5	15.8	4.6	0	0	10	11
D	July	First half	15.6	0.4	21.7	8.5	0	0	15	15
D	July	Second half	15.5	0.3	20.5	9.4	0	0	NA	NA
D	August	First half	15.6	0.3	20.0	11.5	0	0	NA	NA
D	August	Second half	12.7	0.4	18.6	8.4	0	0	NA	NA
D	September	First half	9.0	0.3	13.9	3.7	0	0	5	8
D	September	Second half	11.3	0.3	15.2	8.2	0	0	10	15
D	October	First half	7.1	0.4	10.5	4.1	0	0	0	0
LBU	May	Second half	7.9	0.2	12.5	3.7	0	0	0	1
LBU	June	First half	11.0	0.3	16.4	5.9	0	0	12	14
LBU	June	Second half	12.7	0.6	20.4	5.4	0	0	12	13
LBU	July	First half	19.1	0.4	26.9	10.2	12	8	15	15
LBU	July	Second half	19.5	0.2	25.6	11.6	15	11	NA	NA
LBU	August	First half	19.0	0.3	24.8	13.5	8	7	NA	NA
LBU	August	Second half	16.3	0.4	23.5	10.2	4	0	NA	NA
LBU	September	First half	12.2	0.3	17.8	5.8	0	0	15	15
LBU	September	Second half	13.8	0.3	18.0	10.1	0	0	14	15
LBU	October	First half	10.4	0.4	14.2	6.9	0	0	2	6

a. LU: First bridge on road NF-143 when entering from south, D: Culvert as Deer Creek crosses road NF-143, LBU: Bridge at main road (NF-002)
b. Cold water aquatic life criterion
c. Salmonid spawning criterion
Notes: NA- Not Applicable

3.4 Beneficial Use Recommendations

All AUs are designated for primary contact recreation, salmonid spawning, and cold water aquatic life in addition to the statewide use designations of agricultural and industrial water supply, wildlife habitat, and aesthetics. The beneficial uses affected by water quality in these streams are summarized in Table 2.

Continued monitoring is necessary to ensure that the characterization of these watersheds is complete. Available information for cold water aquatic life use and salmonid spawning is limited and current data are needed.

Elevated solar loads of Bear and Lick Creeks contribute to impairment of downstream waters. Continuing the ongoing process of decreasing solar loads due natural events (tornado), possibly forestry practices, and livestock management will have the greatest impact towards attaining beneficial uses.

4 Review of Implementation Plan and Activities

The *Wildhorse River Watershed Total Maximum Daily Load Implementation Plan for Agriculture* (ISWCC 2010) was developed for DEQ by the Idaho Soil and Water Conservation Commission. The implementation plan provides guidance for the Adams Soil and Water Conservation District and Weiser River Soil Conservation District.

4.1 Planned Activities

Agricultural pollutant reductions will be achieved by on-farm conservation planning with individual operators and applying BMPs in agricultural critical areas. The implementation plan recommends BMPs needed to meet TMDL targets in the Wildhorse River watershed and suggests alternatives for reducing surface and ground water quality problems from agricultural-related activities.

4.2 Accomplished Activities

Some federally funded land treatment projects to benefit water quality have occurred since the origin of the TMDL and associated implementation plan; both are from DEQ §319-funded and other NRCS-approved projects. OX Ranch made improvements to streambank stability and installed several BMPs. DEQ provided §319 funding for projects that resulted in water quality improvements.

4.2.1 Wildhorse River Restoration–OX Ranch (2008–2012)

Three miles of the Lick Creek riparian area is fenced off and in a Conservation Reserve Program. Fish passage and fish screening projects were completed in the drainage as well as improvement to the Lick Creek ditch, which resulted in piping of the water instead of an open ditch. Eight-hundred feet of eroding streambank was stabilized with log revetments and willow pole/whip planting.

4.2.2 Additional Best Management Practices

In addition to §319 projects, the ISWCC and local landowners have been installing BMPs. The ISWCC provided data on BMPs that were installed in the subbasin from 2008–2014 (Table 20).

Table 20. Best management practices for the Wildhorse River watershed (2008–2014).

Best Management Practice	Practice Code	Unit	Program	2008	2009	2010	2011	2012	2013	2014
Irrigation water conveyance	460DD	Feet	EQIP	—	—	391	—	—	—	—
Irrigation water conveyance	460HH	Feet	EQIP	—	—	1,800	—	—	—	—
Structure for water control	587	NA	EQIP	—	—	2	—	—	—	—
Prescribed grazing	528	Acre	CTA-GENRL	11,921	—	6,598	35,673	37,355	—	—
Forest slash treatment	384	Acre	EQIP	14	19	—	—	—	—	—
Forest stand improvement	666	Acre	EQIP	—	154	—	—	—	—	—
Pond	378	NA	EQIP	1	—	—	—	—	—	—

Notes: Environmental Quality Incentives Program (EQIP); General Conservation Technical Assistance (CTA-GNERL); Not Applicable (NA)

4.3 Future Strategy

Implementation strategies for TMDLs produced using PNV-based shade and solar loads should incorporate the load analysis tables presented in this TMDL 5-year review (Table 7 through Table 13). These tables need to be updated, first to field verify the remaining existing shade levels and second to monitor progress toward achieving reductions and TMDL goals. Using the Solar Pathfinder to measure existing shade levels in the field is important to achieving both objectives. It is likely that further field verification will find discrepancies with reported existing shade levels in the load analysis tables. Due to the inexact nature of the aerial photo interpretation technique, these tables should not be viewed as complete until verified. Implementation strategies should include Solar Pathfinder monitoring to simultaneously field verify the TMDL and mark progress toward achieving desired load reductions.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or significant progress is not being made toward achieving the goals. Some reasons that individual stream segments do not meet shade targets include natural phenomena (e.g., beaver ponds, springs, wet meadows, and past natural disturbances) and/or historic land-use activities (e.g., logging, grazing, and mining). It is important that existing shade for each stream segment be field verified to determine if shade differences are real and result from activities that are controllable. Information within this 5-year review (maps and load analysis tables) should be used to guide and prioritize implementation investigations. The information provided in this review may need further adjustment to reflect new information and conditions in the future.

4.4 Planned Time Frame

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

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

4.4.1 Monitoring Strategy

Effective shade monitoring can take place on any segment throughout the Wildhorse River watershed and be compared to existing shade estimates seen in Figure 3 and described in Table 7 through Table 13. Those areas with the largest disparity between existing and target shade should be monitored with Solar Pathfinders to verify existing shade levels and determine progress toward meeting shade targets. Since many existing shade estimates have not been field verified, they may require adjustment during the implementation process. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade toward target levels. Ten equally spaced Solar Pathfinder measurements averaged together within that segment should suffice to determine new shade levels in the future.

5 Summary of Five-Year Review

5.1 Review Process

The ISWCC, OX Ranch, and other landowners have been working to improve water quality within the Wildhorse River watershed. The ISWCC consults with the Weiser River WAG, and through this process, on April 30, 2015, the Weiser River WAG was invited to review this 5-year review within a 3-month period and provide input and additional information.

The primary data sources were the Idaho Power, NRCS, ISWCC, and DEQ (Appendix B). Idaho Power provided temperature data for the mouth of the Wildhorse River. The ISWCC provided data on load reductions related to implementation projects, and NRCS and ISWCC provided information on installed BMPs. The Weiser River WAG also provided valuable insight into the status of the TMDL, ongoing water quality issues, and areas of improvement.

5.2 Changes in Subbasin

No major changes in land use, land conversion, or new industry, point sources, or nonpoint sources have occurred in the subbasin, and according to the local landowners, land use in regards to these activities remains relatively stable.

5.3 TMDL Analysis

Effective shade targets were established for five Wildhorse River water bodies (five AUs) based on the concept of maximum shading under PNV resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation and partially field verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02). A summary of assessment outcomes, including recommended changes to listing status in the next Integrated Report, is presented in Table 21.

The 5-year review analysis involved better aerial imagery, new and improved target settings based on Idaho plant communities, and instream water temperature data. A comparison of these new data with data presented in the Wildhorse River TMDL (DEQ 2007) showed that Wildhorse and Crooked Rivers are not sources of excess solar loads although both rivers still exceed numeric temperature criteria for cold water aquatic life and salmonid spawning. Target shade levels and solar loads under PNV proved to be a better approach than inflexible numeric criteria to identify whether instream temperatures given natural conditions are being met, especially in arid areas. To add complexity, the instream temperature in Wildhorse River is due, in part, to inflow from tributaries (e.g., Bear and Lick Creeks) that are temperature impaired as well as the natural shading of vegetation that is already at full potential. The AU that includes Crooked River (ID17050201SW015_02) has no temperature-impaired tributaries flowing into it; therefore, DEQ assumes that instream temperature in this AU is a direct result of natural conditions and shading at full potential. Bear and Lick Creeks continue to be sources of excess solar loads and also exceed cold water aquatic life and salmonid spawning temperature criteria. Shade restoration efforts in the Wildhorse River watershed should be directed at Bear and Lick Creeks in an effort to improve overall watershed stream temperatures. Target shade levels for individual stream segments should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts.

DEQ recommends assessing the potential to move Crooked River (ID17050201SW015_02) and Wildhorse River (ID17050201SW015_04) into Category 2 (Table 21).

Table 21. Summary of assessment outcomes.

Assessment Unit Name	Assessment Unit Number	Pollutant	TMDL Approval Year	Recommended Changes to Next Integrated Report	Justification
Wildhorse River—1st and-2nd order and all of Crooked River	ID17050201SW015_02	Temperature	2007	Assess potential to move to Category 2	Meets solar load targets but exceeds numeric temperature criteria
Wildhorse River—4th order	ID17050201SW015_04	Temperature	2007	Assess potential to move to Category 2	Meets solar load targets but exceeds numeric temperature criteria
Bear Creek—1st and 2nd order (includes 1-2 order Lick Creek)	ID17050201SW016_02	Temperature	2007	Remain in Category 4a	Excess solar load from a lack of existing shade
Lick Creek—3rd order and all of Deer Creek	ID17050201SW016_03	Temperature	2007	Remain in Category 4a	Excess solar load from a lack of existing shade
Lick and Bear Creeks—4th order	ID17050201SW016_04	Temperature	2007	Remain in Category 4a	Excess solar load from a lack of existing shade

5.4 Review of Beneficial Uses

A thorough review of beneficial use support is difficult because the data are lacking to support such an analysis; future data collection should be targeted to assess beneficial uses in conjunction with the TMDL.

5.5 Water Quality Criteria

Water quality criteria related to the temperature TMDLs have remained unchanged; however some tools to analyze PNV (e.g., aerial imagery) have improved. Although two AUs within the subbasin are meeting target solar loads, three have not. These AUs are expected to improve as BMPs continue to be implemented, contingent upon receiving §319 funding and sufficient time elapses for riparian shade to mature.

5.6 Watershed Advisory Group Consultation

Throughout this process, local experience and participation have been and will continue to be invaluable in identifying water quality issues and implementing reduction strategies appropriate on a local scale. The public committee, known as the Weiser River Watershed Advisory Group, was involved in the TMDL assessment documented in this 5-year review.

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GIS Coverages

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USDA – FSA Aerial Photography Field Office - 2013 National Agricultural Imagery Program (NAIP) 0.5m imagery

USDA – FSA Aerial Photography Field Office - 2011 National Agricultural Imagery Program (NAIP) 1.0m imagery

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 by species. For spring-spawning salmonids, the default spawning and incubation period recognized by the Idaho Department of Environmental Quality (DEQ) is generally March 15 to July 15 (Grafe et al. 2002). Fall spawning can occur as early as September 1 and continue with incubation into the following spring up to June 1. As per IDAPA 58.01.02.250.02.f.ii., the following water quality criteria need to be met during that time period:

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

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

Natural Background Provisions

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

> When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, there shall be no lowering of water quality from natural background conditions. Provided, however, that temperature may be increased above natural background conditions when allowed under Section 401. (IDAPA 58.01.02.200.09)

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

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Appendix B. Data Sources and Other Data

Table B-1. Data sources for the Wildhorse River and associated tributaries.

Water Body	Data Source	Type of Data	Collection Date
Wildhorse River watershed	DEQ Boise Regional Office	Solar Pathfinder effective shade and stream width	September 2014
Wildhorse River watershed	DEQ State Technical Services Office	Aerial photo interpretation of existing shade and stream width estimation	August–November 2014
Wildhorse River watershed	DEQ IDASA Database	Temperature	May–October 2014
Wildhorse River watershed	Idaho Power Company	Temperature	May–October 2014