# Bruneau River Subbasin Assessment and Total Maximum Daily Loads

2015 Addendum

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2015 Addendum

**October 2015**

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# Acknowledgments

Cover Photo: Clover Creek (East Fork Bruneau River) by Jessica De Varona (DEQ) taken on September 26, 2006.

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# Abbreviations, Acronyms, and Symbols

| | |
|---|---|
| **§303(d)** | Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section |
| **AU** | assessment unit |
| **BAG** | basin advisory group |
| **BMP** | best management practice |
| **C** | Celsius |
| **CAFO** | concentrated animal feeding operation |
| **CFR** | Code of Federal Regulations |
| **CGP** | Construction General Permit |
| **DEQ** | Department of Environmental Quality |
| **DMA** | designated management agency |
| **DMR** | discharge monitoring report |
| **EPA** | United States Environmental Protection Agency |
| **IDAPA** | Refers to citations of Idaho administrative rules |
| **kWh** | kilowatt-hour |
| **LA** | load allocation |
| **LC** | load capacity |
| **m** | meter |
| **mi** | mile |
| **MOS** | margin of safety |
| **NB** | natural background |
| **NPDES** | National Pollutant Discharge Elimination System |
| **NREL** | National Renewable Energy Laboratory |
| **PNV** | potential natural vegetation |
| **SWPPP** | Stormwater Pollution Prevention Plan |
| **TMDL** | total maximum daily load |
| **US** | United States |
| **USC** | United States Code |
| **WAG** | watershed advisory group |
| **WLA** | wasteload allocation |

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# Executive Summary

The federal Clean Water Act 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 Clean Water Act, 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 Clean Water Act establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every 2 years and is included as the list of Category 5 waters in the Integrated Report. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards.

This document addresses three water bodies in the Bruneau River subbasin—the lower Bruneau River, Clover Creek, and Jacks Creek—that have been placed in Category 5 of Idaho's most recent federally approved Integrated Report (DEQ 2014). This document only addresses the temperature TMDLs for these three streams and for three of their major contributors, upper Bruneau River, Little Jacks and Big Jacks Creeks (Figure A). For more information about these watersheds and the subbasin as a whole, see the *Bruneau Subbasin Assessment and Total Maximum Daily Loads of the §303(d) Water Bodies* (DEQ 2000).

This TMDL analysis has been developed to comply with Idaho's TMDL schedule. The 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. Wasteload allocations are provided for two aquaculture facilities along Jacks Creek.

## Subbasin at a Glance

The Bruneau River subbasin (hydrologic unit code 17050102) is located in southwestern Idaho south of Mountain Home. The river itself runs north from the Idaho-Nevada border to C.J. Strike Reservoir on the Snake River. Listed on Idaho's 1998 §303(d) list for temperature pollution were the Bruneau River below Hot Creek and Jacks Creek (Figure A).

The US Environmental Protection Agency (EPA) added to Idaho's 1998 §303(d) list of impaired streams that exceeded Idaho's temperature criteria. In the Bruneau River subbasin, Clover Creek (i.e., East Fork Bruneau River) was among those EPA additions (Figure A).

The 4th-order segment of Buck Flat Draw was erroneously added to the 2002 §303(d) list. This reach has never been assessed by the Idaho Department of Environmental Quality (DEQ), nor does any temperature data exist suggesting it is impaired for temperature. DEQ recommends moving this reach to Category 3 in the next Integrated Report as unassessed.

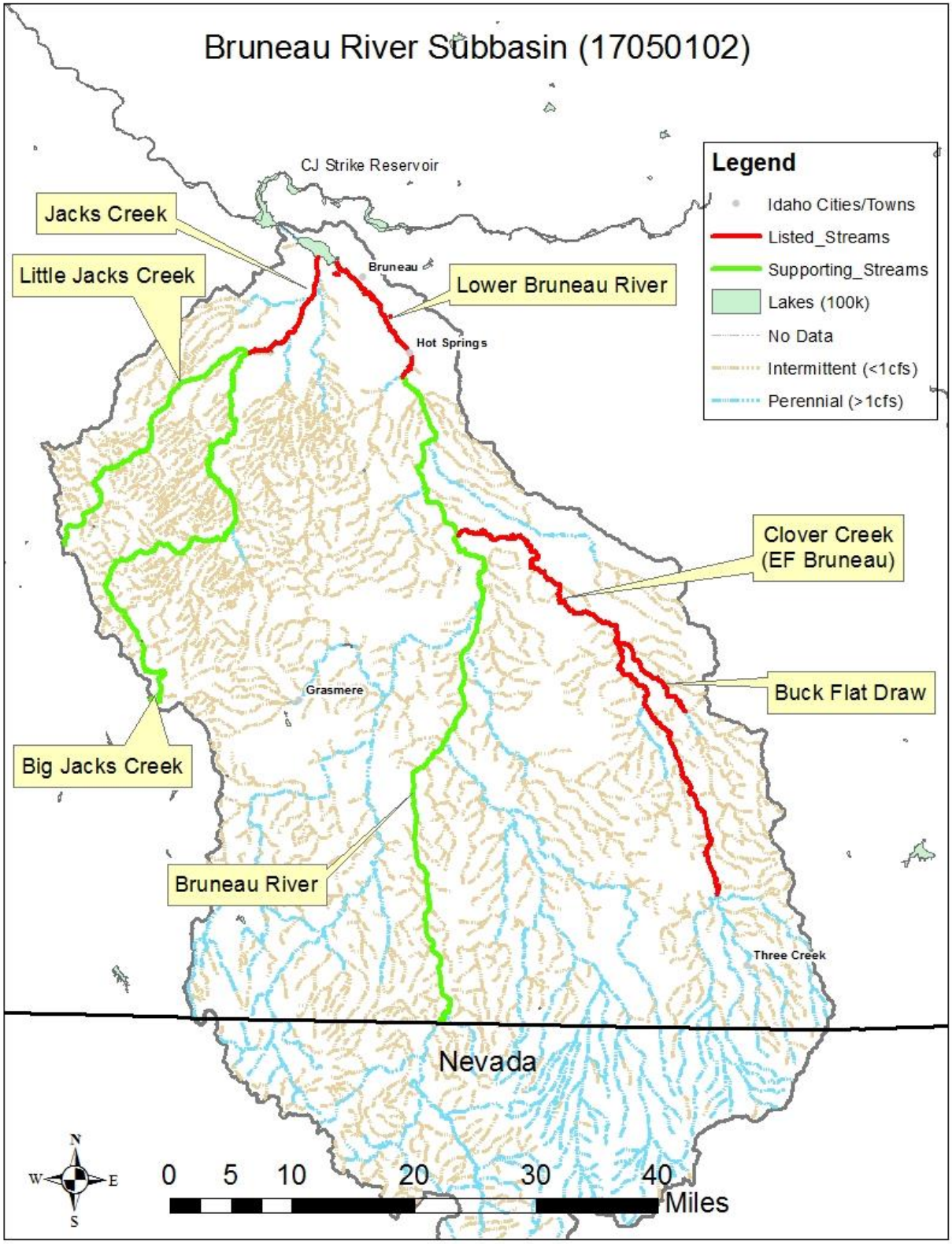


**Figure A. Subbasin at a glance.**

## Key Findings

Three water bodies (four assessment units) were placed on the 1998 §303(d) list of impaired waters for reasons associated with temperature criteria violations (Tables A and B). Temperature TMDLs were developed for these three streams. The analysis also looked at heat loading from contributing tributaries. Temperature wasteload allocations were also developed for two aquaculture facilities on Jacks Creek.

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

| Stream | Pollutant(s) |
|---|---|
| Bruneau River | Temperature |
| Jacks Creek, including Little and Big Jacks Creeks | Temperature |
| Clover Creek | Temperature |

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

| Water Body / Assessment Unit | Pollutant | TMDL(s) Completed | Recommended Changes to §303(d) List | Justification |
|---|---|---|---|---|
| Bruneau River ID17050102SW009_06 | Temperature | Yes | Move to Category 4a | Excess solar load from lack of shade |
| Clover Creek ID17050102SW028_05 ID17050102SW028_04 | Temperature | Yes | Move to Category 4a | Excess solar load from lack of shade |
| Jacks Creek ID17050102SW002_05 | Temperature | Yes | Move to Category 4a | Excess solar load from lack of shade |
| Buck Flat Draw ID17050102SW035_04 | Temperature | No | Move to Category 3 | This reach has never been assessed by DEQ. No temperature data exist suggesting impairment. Erroneously listed in 2002. |

Effective shade targets were established for the Bruneau River and four of its major tributaries (Jacks Creek, Big Jacks Creek, Little Jacks Creek, and Clover Creek) based on the concept of maximum shading under potential natural vegetation resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation then partially field verified with Solar Pathfinder data.

The majority of the Bruneau River and Clover Creek are meeting shade targets by virtue of their location in deep canyons where access is very limited and topographical shade is high. Several locations experienced disturbance in agricultural/grazing areas outside of canyons (e.g., Jacks Creek and lower Bruneau River). The listed segment of the Bruneau River (from Hot Creek to C.J. Strike Reservoir) was the only portion of the river to lack shade. Jacks Creek had significant lack of shade. Both streams have significant geothermal sources affecting their temperatures. Buck Flat Draw has never been assessed by DEQ in any of its 1st-, 2nd-, 3rd-, or 4th-order reaches. No data exist to suggest it is impaired by temperature in the 2002 §303(d)-listed 4th-

order segment. DEQ recommends moving the 4th-order assessment unit to Category 3 of the next Integrated Report until an assessment of beneficial uses occurs.

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. This analysis suggests that the Bruneau River subbasin by and large has significant areas meeting shade targets due to its extreme inaccessibility and topographic shade. And only a few areas show need for riparian improvements.

Two geothermally influenced point sources were also evaluated for temperature wasteload allocations in this TMDL analysis. The two aquaculture facilities (named Ace Development, Inc. or IDG-130123, and Arraina, Inc. or IDG-130122) discharge approximately 30% of their effluent under summer irrigation conditions to Jacks Creek. Effluent temperatures average 2.5 °C warmer than Jacks Creek during the summer months and can result in 0.8 °C rise in stream temperature after mixing. Wasteload allocations were established such that stream temperatures would rise only 0.15 °C after discharge from each facility. The wasteload allocation requires that effluent temperatures not exceed 25.4 °C. If the temperature regimes of these facilities change, the possibility of wasteload allocations for these two facilities may need to be revisited.

## Public Participation

A draft of the TMDL was presented to the Southwest Basin Advisory Group in 2012 at which time they advised us to pursue temperature sampling for the Jacks Creek aquaculture facilities and make a determination regarding beneficial uses support and temperature wasteload allocations. The BAG concurred at that time to move forward and publish the document for public comment upon completion. The general public will be able to comment on this draft document during the public comment period.

# Introduction

This document addresses four water bodies comprising five assessment units in the Bruneau River subbasin that have been placed in Category 5 of Idaho's most recent federally approved Integrated Report (DEQ 2014). The purpose of this total maximum daily load (TMDL) addendum is to characterize and document pollutant loads within the Bruneau River subbasin. The first portion of this document presents key characteristics or updated information for the subbasin assessment, which is divided into four major sections: subbasin characterization (section 1), water quality concerns and status (section 2), pollutant source inventory (section 3), and a summary of past and present pollution control efforts (section 4). While the subbasin assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up-to-date and accurate.

The subbasin assessment is used to develop a TMDL for each pollutant of concern for the Bruneau River subbasin. The TMDL (section 5) is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (40 CFR Part 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant. Effective shade targets were established for four AUs based on the concept of maximum shading under potential natural vegetation (PNV) resulting in natural background temperatures. Wasteload allocations for two aquaculture facilities along Jacks Creek are also provided.

This total maximum daily load (TMDL) is an addendum to the *Bruneau Subbasin Assessment and Total Maximum Daily Loads of the §303(d) Water Bodies* (DEQ 2000). That document does not follow the TMDL template adopted for use for all Idaho TMDL documents since 2001 that combines a subbasin assessment with a TMDL determination. This addendum, however, is based on the original subbasin assessment and characteristics from the 2000 subbasin assessment and TMDL.

## Regulatory Requirements

This document was prepared in compliance with both federal and state regulatory requirements. The federal government, through the United States Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. The Idaho Department of Environmental Quality (DEQ) implements the Clean Water Act in Idaho, while EPA oversees Idaho and certifies the fulfillment of Clean Water Act requirements and responsibilities.

Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act, in 1972. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 USC §1251). The act and the programs it has generated have changed over the years as experience and perceptions of water quality have changed. The Clean Water Act has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to

ensure “swimmable and fishable” conditions. These goals relate water quality to more than just chemistry.

The Clean Water Act 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 Clean Water Act, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation’s waters whenever possible. DEQ must review those standards every 3 years, and EPA must approve Idaho’s water quality standards. Idaho adopts water quality standards to protect public health and welfare, enhance water quality, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

Section 303(d) of the Clean Water Act establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a “§303(d) list”) of impaired waters. Currently, this list is published every 2 years as the list of Category 5 waters in Idaho’s Integrated Report. For waters identified on this list, states and tribes must develop a TMDL for the pollutants, set at a level to achieve water quality standards.

DEQ monitors waters, and for those not meeting water quality standards, DEQ must establish a TMDL for each pollutant impairing the waters. However, some conditions that impair water quality do not require TMDLs. EPA considers certain unnatural conditions—such as flow alteration, human-caused lack of flow, or habitat alteration—that are not the result of discharging a specific pollutant as “pollution.” TMDLs are not required for water bodies impaired by pollution, rather than a specific pollutant. A TMDL is only required when a pollutant can be identified and in some way quantified.

# 1 Subbasin Assessment—Subbasin Characterization

The Bruneau River subbasin, HUC 17050102, is characterized by dry, open, and highly accessible plateaus contrasted by confined and relatively inaccessible canyons through which the majority of water in the subbasin flows. Numerous geothermal springs and “artesian” upwellings dominate the landscape in the northernmost portions of the 4th-order HUC, in particularly in areas adjacent to Jacks Creek and in nearby stream courses (Figure 1). While most of the region is used for rangeland, irrigated agriculture and ranching dominate near the small communities of Grand View and Bruneau. Hay, pasture, potatoes, sugar beets, and grain are grown. Two warmwater fish farms adjacent to Jacks Creek have been in continuous operation, one as far back as the early 1970s. Geothermal spring seeps have been tapped for irrigation since the 1940s. Geothermal springs and seeps have also influenced stream temperatures through their natural mixing with streamflow for decades. For additional information please see the Bruneau subbasin assessment and total maximum daily load (DEQ 2000).

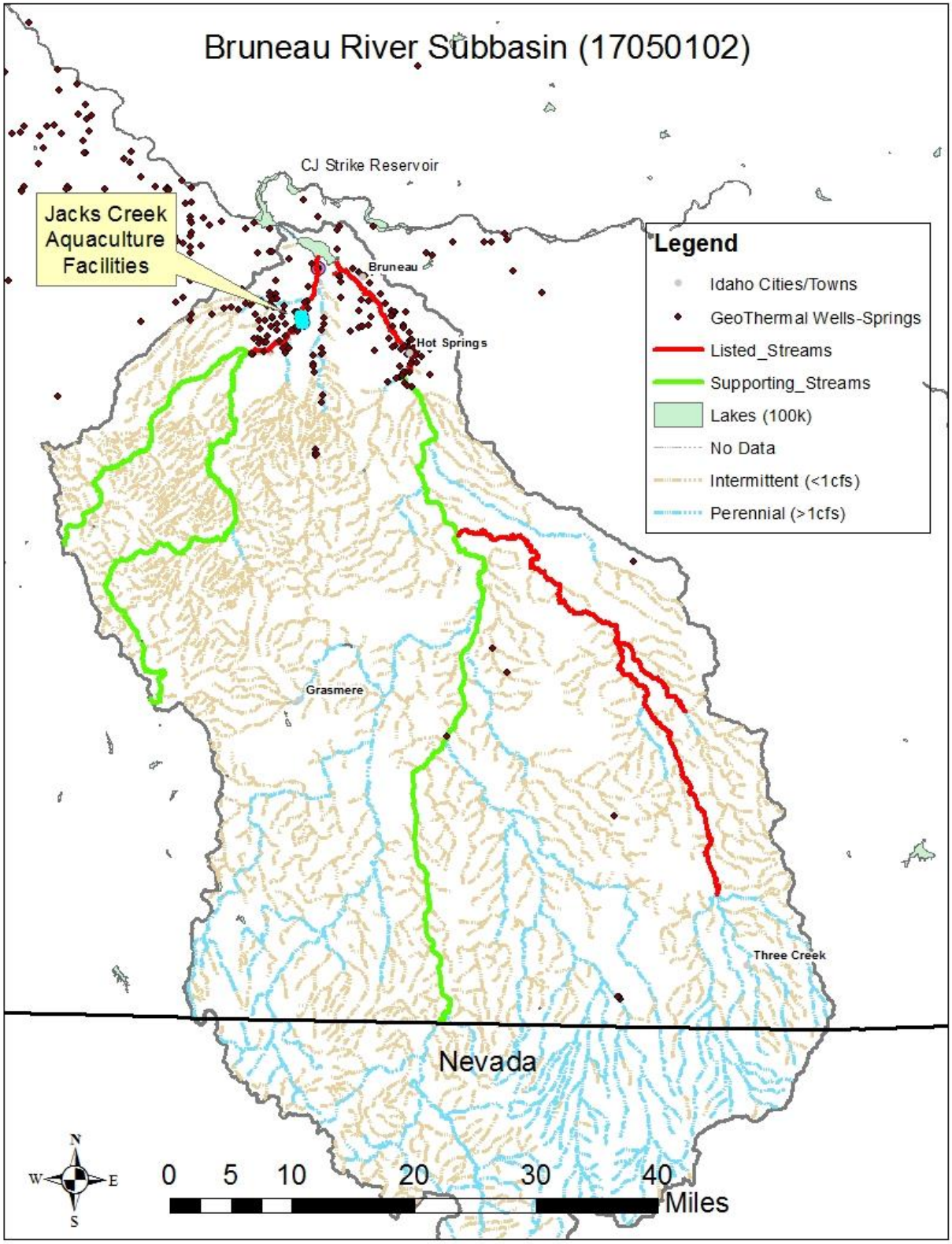


**Figure 1. Bruneau River subbasin.**

# 2 Subbasin Assessment—Water Quality Concerns and Status

## 2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

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

### 2.1.1 Assessment Units

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

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

### 2.1.2 Listed Waters

Table 1 shows the pollutants listed and the basis for listing for each §303(d)-listed AU in the subbasin (i.e., AUs in Category 5 of the Integrated Report).

**Table 1. Bruneau River subbasin §303(d)-listed assessment units in the subbasin.**

| Assessment Unit Name | Assessment Unit Number | Listed Pollutants | Listing Basis |
|---|---|---|---|
| Bruneau River | ID17050102SW009_06 | Temperature | 1998 §303(d) list— |
| Clover Creek | ID17050102SW028_04<br>ID17050102SW028_05 | Temperature | 1998 §303(d) list—EPA addition |
| Jacks Creek | ID17050102SW002_05 | Temperature | 1998 §303(d) list— |
| Buck Flat Draw | ID17050102SW035_04 | Temperature | Erroneously listed in 2002, never assessed |

Macroinvertebrate data collected for Jacks Creek indicated that the species composition is dominated by temperature tolerant species. Redband trout have been found throughout the Bruneau HUC and have evolved in high desert stream systems where warmer water temperatures predominate. Along the Bruneau River and in the Jacks Creek area, in particularly, warm water springs, and seeps influence the thermal regime of the stream year round. No trout have been found by DEQ in Jacks Creek or lower Bruneau River; seasonal cool and warm water species have been found.

## 2.2 Applicable Water Quality Standards and Beneficial Uses

Idaho water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as described briefly in the following paragraphs. The *Water Body Assessment Guidance* (Grafe et al. 2002) provides a more detailed description of beneficial use identification for use assessment purposes.

Beneficial uses include the following:

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

### 2.2.1 Existing Uses

Existing uses under the Clean Water Act are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards" (40 CFR 131.3). The existing instream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.051.01). Existing uses need to be protected, whether or not the level of water quality to fully support the uses currently exists.

Designated uses under the Clean Water Act are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained" (40 CFR 131.3). Designated uses are simply uses officially recognized by the state. In Idaho, these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Multiple uses often apply to the same water; in this case, water quality must be sufficiently maintained to meet the most sensitive use (designated or existing). Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are described in the Idaho water quality standards (IDAPA 58.01.02.100) and specifically listed by water body in sections 110–160.

### 2.2.2 Undesignated Surface Waters

In Idaho, due to a change in scale of cataloging waters in 2000, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations (IDAPA 58.01.02.110–160). These undesignated surface waters ultimately need to be designated for appropriate uses. In the interim, and absent information on existing uses, DEQ presumes most of these waters will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called *presumed uses*, DEQ applies the cold water and recreation use criteria to undesignated waters. If in addition to *presumed uses*, an additional existing use (e.g., salmonid spawning) exists, then the additional numeric criteria for

salmonid spawning would also apply (e.g., intergravel dissolved oxygen, temperature) because of the requirement to protect water quality for that existing use. However, if some other use that requires less stringent criteria for protection (such as seasonal cold water aquatic life) is found to be an existing use, then a use designation (rulemaking) is needed before that use can be applied in lieu of cold water criteria.

### 2.2.3 Beneficial Uses in the Subbasin

The Bruneau River subbasin has designated, undesignated, and existing uses (as shown in Table 2). The uses range from cold water aquatic life, salmonid spawning and primary contact recreation, to drinking water supply specifically in Clover Creek and seasonal cold and primary contact recreation. Buck Flat Draw is undesignated and has not been assessed. Jacks Creek has an existing use of seasonal cold that has not yet been designated in Idaho's water quality standards. The seasonal cold use has existed for several decades predating the Clean Water Act Amendments effective date of November 1975.

**Table 2. Bruneau River subbasin beneficial uses of §303(d)-listed streams.**

| Assessment Unit Name | Assessment Unit Number | Beneficial Uses[a] | Type of Use |
|---|---|---|---|
| Bruneau River | ID17050102SW009_06 | CW, SS, PCR | Designated |
| Clover Creek | ID17050102SW028_04<br>ID17050102SW028_05 | CW, SS, PCR, DWS | Designated |
| Jacks Creek | ID17050102SW002_05 | SC, PCR | Undesignated, SC existing prior to November 1975 |
| Buck Flat Draw | ID17050102SW035_04 | | Undesignated |

[a] Cold water (CW), salmonid spawning (SS), seasonal cold (SC) primary contact recreation (PCR), domestic water supply (DWS)

### 2.2.4 Water Quality Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of water quality criteria, which include *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity, and *narrative* criteria for pollutants such as sediment and nutrients (IDAPA 58.01.02.250–251) (Table 3). For more about temperature criteria and natural background provisions relevant to the PNV-style temperature TMDL approach, see Appendix A.

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

| Parameter | Primary Contact Recreation | Secondary Contact Recreation | Cold Water Aquatic Life | Salmonid Spawning[a] |
|---|---|---|---|---|
| ***Water Quality Standards: IDAPA 58.01.02.250–251*** | | | | |
| **Bacteria** | | | | |
| Geometric mean | <126 *E. coli*/100 mL[b] | <126 *E. coli*/100 mL | — | — |
| Single sample | ≤406 *E. coli*/100 mL | ≤576 *E. coli*/100 mL | — | — |
| **pH** | — | — | Between 6.5 and 9.0 | Between 6.5 and 9.5 |
| **Dissolved oxygen (DO)** | — | — | DO exceeds 6.0 milligrams/liter (mg/L) | **Water Column DO**: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater<br>**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<br>**Seasonal Cold Water**: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average (not EPA approved for use under the CWA per the "Alaska Rule", see www.deq.idaho.gov/epa-actions-on-proposed-standards for use of Idaho's original Seasonal Cold Water Standard. | 13 °C or less daily maximum; 9 °C or less daily average<br>**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.

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.050.02. The procedure relies heavily upon biological parameters and is presented in detail in the *Water Body Assessment Guidance* (Grafe et al. 2002). This guidance requires DEQ to use the most complete data available to make beneficial use support status determinations (Figure 2).

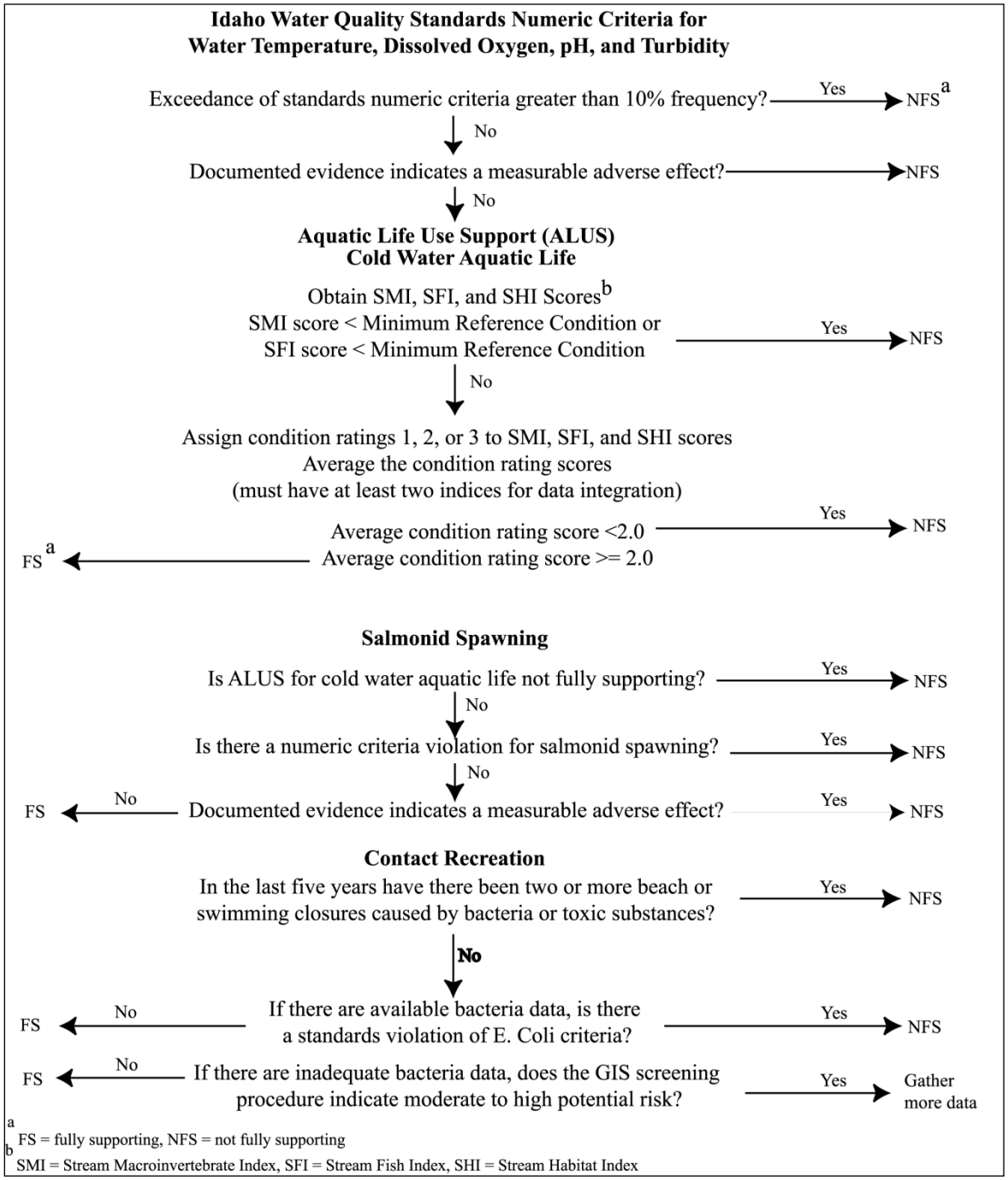


**Figure 2. Steps and criteria for determining support status of beneficial uses in wadeable streams (Grafe et al. 2002).**

## 2.3 Summary and Analysis of Existing Water Quality Data

There has been extensive temperature monitoring throughout the subbasin in wilderness river corridors and in Jacks Creek associated with the aquaculture facilities there. Temperature profiles for the many continuous recording loggers examined are located in Appendix B. The latest monitoring effort (2012–2014) involves continuous temperature monitoring throughout the Bruneau River and in Jacks Creek associated with aquaculture facilities. Recent logger data is presented in Figures B-20 through B-35. Here we present maximum temperature statistics from the latest monitoring effort (2012–2014) for the purposes of comparison among locations and to relevant water quality standards.

Temperature profiles from continuously monitoring data loggers were obtained for five locations in Bruneau River, one location in Clover Creek (East Fork Bruneau), four locations in Jacks Creek, and two locations in aquaculture facility effluent (Figures 3 and 4). Temperature profiles were also obtained from the US Geological Survey (USGS) gage station on the Bruneau River near Hot Springs (13168500). Maximum temperature statistics for each logger in the Bruneau River system are shown in Table 4. Temperature data from Jacks Creek will be described in section 5.4.5 on wasteload allocations for aquaculture facilities.

Temperature loggers in the Bruneau River are in wilderness areas and deep canyons where little disturbance occurs. Temperatures in the Bruneau River are considered natural temperatures, as the region does not lack shade primarily because steep canyon walls provide more than is necessary to meet riparian plant community target shade values. Temperature statistics for the Bruneau River show that natural water temperatures are very high. Maximum daily average temperatures (MDAT) are 25–26 °C in the river above Jarbidge River, decrease to 24–25 °C on the way to Indian Hot Springs below Jarbidge River, increase again to 28 °C after the Indian Hot Springs add more heat, then decline again to about 25.5 °C near Clover Creek. Clover Creek may not be cooler water as is reflected in the statistics (MDAT = 20 °C). Sampling here ended on June 30, 2014, when the logger was exposed to air. If Clover Creek is cooler, its effect is not apparent in the 2014 Bruneau River data above and below (Robertson Trail) Clover Creek because temperatures stay constant. Temperatures at the USGS station show the river has increased again several degrees before entering the agricultural valley below Hot Springs. This is likely due to the abundant geothermal sources in the lower valley, some of which occur in the vicinity of the USGS station (Figure 1).

Bruneau River temperatures throughout its length exceed cold water aquatic life (CWAL) and salmonid spawning (SS) temperature criteria by many degrees suggesting that these use designations are incorrect. Bruneau River temperatures at the coolest location above Indian Hot Springs exceeds CWAL criteria 80–86% of the time and exceed SS fall and spring criteria 74–93% of the time. This area exceeds seasonal CWAL criteria 15–55% of the time.

**Table 4. Maximum temperature statistics for data loggers and USGS data in the Bruneau subbasin.**

| Location | MDMT | MWMT | MDAT | MWAT | year |
|---|---|---|---|---|---|
| Bruneau River ab Jarbridge River | 27.9 | 26.9 | 24.9 | 24 | 2012 |
| Bruneau River ab Jarbridge River | 29.7 | 28.3 | 26.1 | 25.2 | 2013 |
| Bruneau River ab Jarbridge River | 30.6 | 29 | 25.9 | 24.6 | 2014 |
| Bruneau River ab Indian Hot Springs | 29.6 | 28.9 | 24.4 | 23.7 | 2012 |
| Bruneau River ab Indian Hot Springs | 29.1 | 28.4 | 24.1 | 23.4 | 2013 |
| Bruneau River ab Indian Hot Springs | 30.1 | 28.6 | 24.9 | 23.9 | 2014 |
| Bruneau River bl Indian Hot Springs | 32.1 | 31.6 | 28.3 | 28 | 2012 |
| Bruneau River bl Indian Hot Springs | 31.6 | 30.7 | 28.1 | 27.8 | 2013 |
| Bruneau River bl Indian Hot Springs | 32.3 | 31.2 | 28.3 | 27.9 | 2014 |
| Bruneau River ab Clover Cr (EF Bruneau) | 28 | 27.1 | 25.5 | 24.6 | 2014 |
| Clover Cr (EF Bruneau) at mouth | 25.5 | 23.1 | 20 | 19.5 | 2014 |
| Bruneau River ab Robertson Trail | 28.9 | 28.1 | 25.6 | 24.5 | 2014 |
| Bruneau River USGS nr Hot Springs | 28.8 | | 26.3 | | 2008 |
| Bruneau River USGS nr Hot Springs | 27.6 | | 24.9 | | 2009 |
| Bruneau River USGS nr Hot Springs | 28.3 | | 25.4 | | 2010 |
| Bruneau River USGS nr Hot Springs | 28.2 | | 25 | | 2011 |
| Bruneau River USGS nr Hot Springs | 31.7 | | 27.7 | | 2012 |
| Bruneau River USGS nr Hot Springs | 30.4 | | 27.7 | | 2013 |
| Bruneau River USGS nr Hot Springs | 30.5 | | 27 | | 2014 |

MDMT = maximum daily maximum temperature,
MWMT = maximum weekly maximum temperature
MDAT = maximum daily average temperature
MWAT = maximum weekly average temperature.

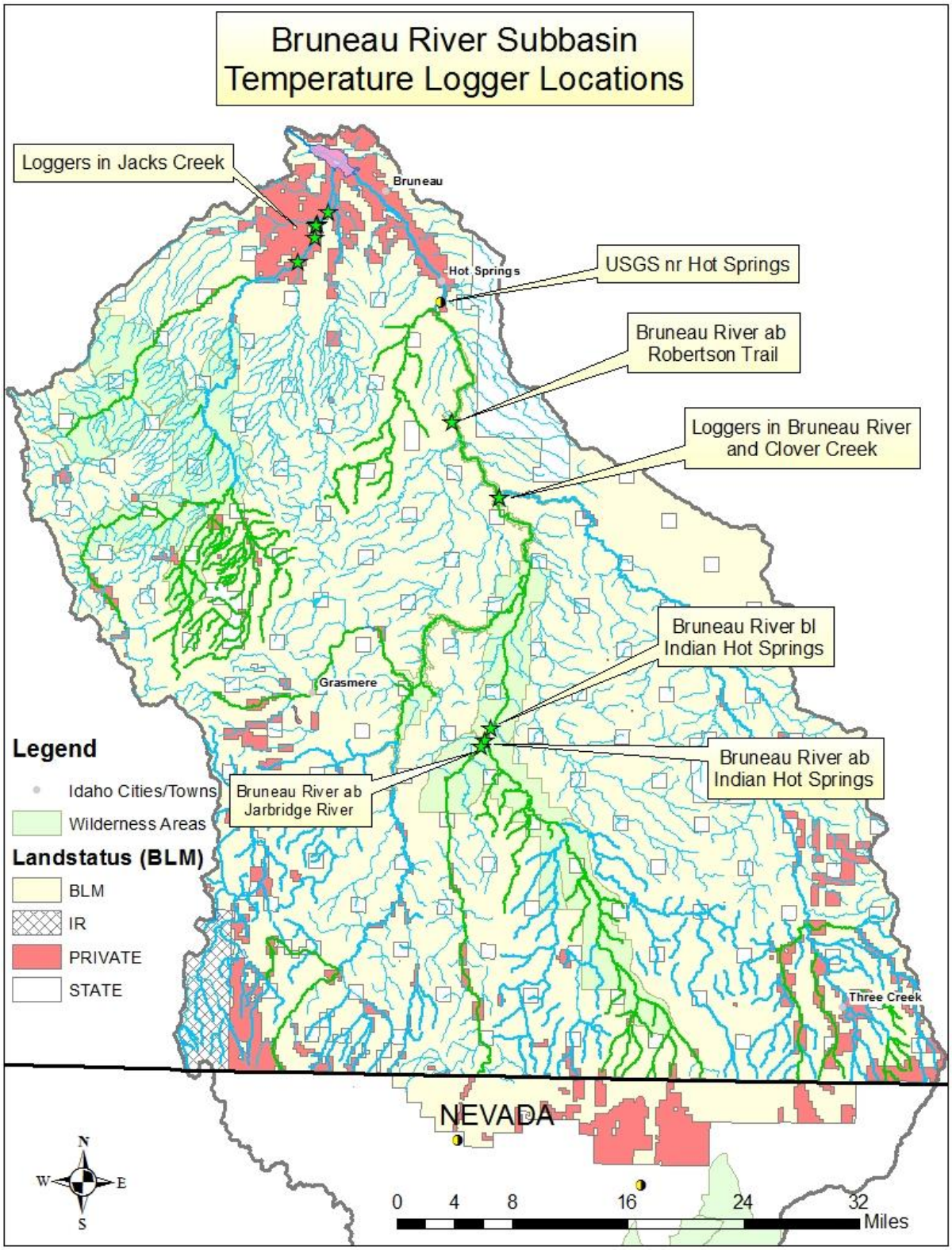


**Figure 3. Temperature logger locations within the Bruneau River subbasin.**

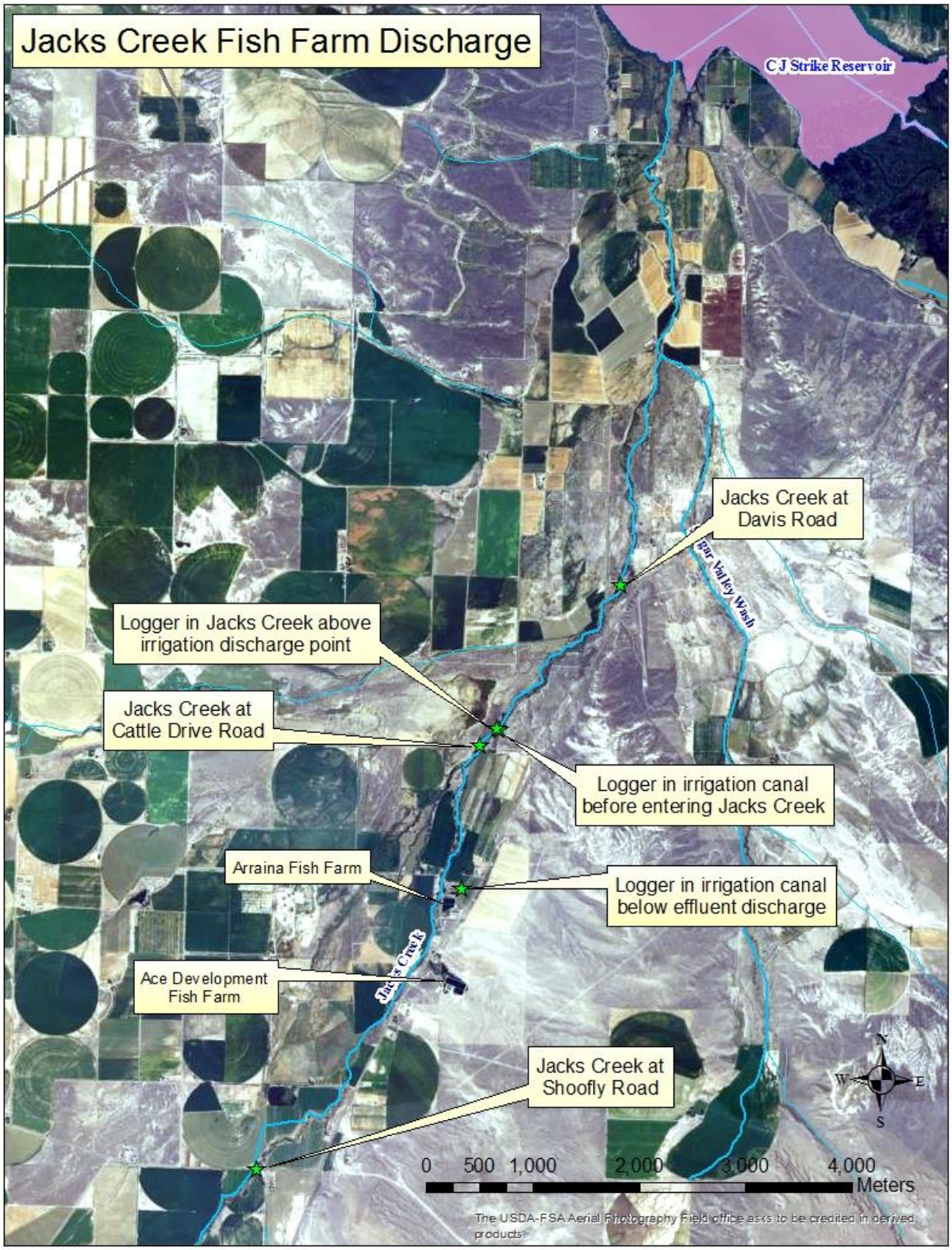


**Figure 4. Temperature logger locations within the Jacks Creek area.**

### 2.3.1 Status of Beneficial Uses

The pollutant(s) impacting beneficial uses and applicable water quality criteria are described in Table 5 based on the 2012 Integrated Report.

**Table 5. Status of beneficial uses and causes of impairment.**

| Stream Name / AU | IR 2012 Category | Beneficial Uses | | | | | Causes of Impairment |
|---|---|---|---|---|---|---|---|
| | | CWAL | SS | PCR | SCR | DWS | |
| BR / ID17050102SW009_06 | 4a, 5 | X | X | X | | | TP, Temp, HA |
| CC / ID17050102SW028_04 | 4a, 5 | X | X | X | | X | *E. coli*, Temp |
| CC / ID17050102SW028_05 | 4a, 5 | X | X | X | | X | *E. coli*, Temp |
| JC / ID17050102SW002_05 | 4a, 4c, 5 | X | | | X | | *E. coli*, TP, Temp, TSS, Sed/Silt, Low Qalt |
| BFD / ID17050102SW035_04 | 5 | X | | | | | Temp |

*Notes*: AU = assessment unit, BR = Bruneau River, CC = Clover Creek, JC = Jacks Creek, BFD = Buck Flat Draw, IR = Integrated Report, CWAL = cold water aquatic life, SS = salmonid spawning, PCR = primary contact recreation, SCR = secondary contact recreation, DWS = domestic water supply, TP = total phosphorus, Temp = water temperature, HA = habitat assessments, TSS = total suspended solids, Sed/Silt = sedimentation/siltation, Qalt = low flow alteration.

### 2.3.2 Assessment Unit Summary

A summary of the data analysis, literature review, and field investigations and a list of conclusions for AUs included in Category 5 of the 2012 Integrated Report follows. This section includes changes that will be documented in the next Integrated Report once the TMDLs in this document have been approved by EPA.

**ID17050102SW002_05, Jacks Creek – Little Jacks Cr to CJ Strike Reservoir**

- Listed for temperature. Jacks Creek has approved TMDLs for *E. coli*, TP, sediment/TSS.
- Jacks Creek at the point where Little Jacks Creek and Big Jacks Creek converge generally has no water except for occasional wet year spring runoff. Jacks Creek gains water throughout its reach, first from agricultural runoff and then by geothermal springs and seeps. The two aquaculture facilities on middle Jacks Creek are artesian-type geothermal wells that provide the bulk of the flow to Jacks Creek. Jacks Creek temperature regime best fits a seasonal cold aquatic life community. According to BURP assessments, no salmonids or cottids have been encountered in Jacks Creek.
- Jacks Creek lacks riparian shade which will be necessary to maintain a seasonal cold temperature regime and is included in the present temperature TMDL. We recommend this AU move to Category 4a upon approval of the temperature TMDL.

**ID17050102SW004_05, Big Jacks Creek – upper 5th order**

- Listed for combined biota/habitat bioassessments.
- This AU of Big Jacks Creek has had very mixed results from BURP assessments. Of the eight BURP sites in the AU, four have passing scores, three have failing scores, and one site was dry at the time of the visit. A 2003 temperature logger indicates there may be impairment from temperature. The AU was included in the present temperature TMDL as a potential source load to Jacks Creek. The TMDL showed the Big Jacks Creek does not

carry excess solar load as a result of the shading provided by canyon walls. Temperature does appear to be the source of impairment.
- Remain in Category 5 for further investigations.

**ID17050102SW009_06**, **Bruneau River – 6th order (Hot Creek to mouth)**

- Listed for temperature. This AU has an approved TMDL for TP.
- This AU of the Bruneau River is the last section of river before it enters CJ Strike Reservoir. It is the only portion of the Bruneau River that is outside of the deep basalt canyon and has a broad floodplain for agriculture. This AU is lined with significant number of geothermal sources and has a temperature regime more suitable to seasonal cold aquatic life. According to BURP assessments, no salmonids or cottids have been encountered. The AU lacks shade necessary to support a seasonal cold community and was included in the present temperature TMDL.
- We recommend this AU move to Category 4a upon approval of the temperature TMDL.

**ID17050102SW014_04**, **Sheep Creek – 4th order**

- Listed for combined biota/habitat bioassessments.
- This AU of Sheep Creek has had very mixed results from BURP assessments. Of the six BURP sites in the AU, two have passing scores, three have failing scores, and one site was dry at the time of the visit. Macroinvertebrate scores have been strong at all sites, but habitat scores have been lacking. Fish data collected in 1997 show no salmonids or cottids.
- Remain in Category 5 for further investigations.

**ID17050102SW015_02L**, **Grasmere Reservoir**

- Listed for mercury.
- Remain in Category 5 for further investigation.

**ID17050102SW016_02**, **Marys Creek – 1st and 2nd order**

- Listed for combined biota/habitat bioassessments.
- This AU of Marys Creek has had very mixed results from BURP assessments. Of the four BURP sites in the AU, one has passing scores, one has failing scores, and two sites were dry at the time of the visit.
- Remain in Category 5 for further investigations.

**ID17050102SW016_04**, **Marys Creek – 4th order**

- Listed for combined biota/habitat bioassessments.
- Of the five BURP sites in the AU, four had failing scores and one was dry at the time of the visit. Two of the failing BURP sites had strong macroinvertebrate and habitat scores, but poor fish scores. These poor fish scores resulted from no salmonids or cottids present, suggesting that the aquatic life community may be more consistent with a seasonal cold use.
- Remain in Category 5 for further investigations.

**ID17050102SW017_02**, **Bull Creek – 1st and 2nd order tributaries**

- Listed for combined biota/habitat bioassessments.

- There were two BURP sites within the AU, both had strong macroinvertebrate scores, one had strong habitat scores as well. Both had failing fish scores because of no salmonids or cottids.
- Remain in Category 5 for further investigations.

**ID17050102SW018_02**, **Pole Creek – 1st and 2nd order**

- Listed for combined biota/habitat bioassessments.
- This AU of Pole Creek has had very mixed results from BURP assessments. Of the 11 BURP sites in the AU, 4 have passing scores, 3 have failing scores, 3 sites were dry at the time of the visit, and 1 was inaccessible.
- Remain in Category 5 for further investigations.

**ID17050102SW019_02, Cat Creek – 1st and 2nd order**

- Listed for combined biota/habitat bioassessments.
- This AU had one BURP site in 1998 that failed all three metrics for macroinvertebrates, fish and habitat.
- Remain in Category 5 for further investigations.

**ID17050102SW022_02, Cougar Creek – 1st and 2nd order**

- Listed for sediment.
- This AU has not been visited through the BURP assessment process.
- Remain in Category 5 for further investigations.

**ID17050102SW022_03, Cougar Creek – 3rd order**

- Listed for sediment.
- This AU has not been visited through the BURP assessment process.
- Remain in Category 5 for further investigations.

**ID17050102SW023_02, Dorsey Creek – 1st and 2nd order**

- Listed for combined biota/habitat bioassessments.
- This AU had three BURP sites, two of which showed failing scores and the third was dry at the time of visit.
- Remain in Category 5 for further investigations.

**ID17050102SW025_02, Poison Creek – 1st and 2nd order**

- Listed for sediment.
- This AU has not been visited through the BURP assessment process.
- Remain in Category 5 for further investigations.

**ID17050102SW025_03, Poison Creek – 3rd order**

- Listed for sediment.
- This AU had three visitations through the BURP process; all three were dry at the time of visit.
- Remain in Category 5 for further investigations.

**ID17050102SW028_04**, **Clover Creek – 4th order (Deadwood Creek to Buck Flat Draw)**

- Listed for temperature. Clover Creek has an approved TMDL for *E. coli* in 1998.
- This AU had three BURP sites all with passing scores as a result of strong macroinvertebrate scores. No fish were collect. The temperature listing is from EPA additions to the original 1998 list. The AU was included in the present temperature TMDL. The TMDL showed that Clover Creek does not carry excess solar load as a result of the shading provided by canyon walls. Temperature does appear to be the source of impairment.
- We recommend this AU move to Category 4a upon approval of the temperature TMDL.

**ID17050102SW028_05**, **Clover Creek (East Fork Bruneau River) – 5th order**

- Listed for temperature. Clover Creek has an approved TMDL for *E. coli* in 1998.
- This AU had three BURP sites, two with failing scores as a result of poor fish and habitat scores, and one site that was dry at visitation. There were no salmonids or cottids encountered. The temperature listing is from EPA additions to the original 1998 list. The AU was included in the present temperature TMDL. The TMDL showed that Clover Creek does not carry excess solar load as a result of the shading provided by canyon walls. Temperature does appear to be the source of impairment.
- We recommend this AU move to Category 4a upon approval of the temperature TMDL.

**ID17050102SW030_02, Buck Flat Draw – 1st and 2nd order**

- Listed for combined biota/habitat bioassessments.
- This AU had two BURP sites, one with failing scores and one that was dry at the time of visitation. Although the one site had failing scores, it did have salmonids present.
- Remain in Category 5 for further investigations.

**ID17050102SW033_03**, **Deer Creek – 3rd order**

- Listed for combined biota/habitat bioassessments.
- This AU had two BURP sites, one with a failing score in 1997 and one with a passing score in 2011. The 2011 site appears to have had abundant salmonids.
- Remain in Category 5 for further investigations.

**ID17050102SW034_02**, **Deadwood Creek – 1st and 2nd order**

- Listed for combined biota/habitat bioassessments.
- This AU of Deadwood Creek has had very mixed results from BURP assessments. Of the four BURP sites in the AU, two have passing scores, one has failing scores, and one site was dry at the time of the visit.
- Remain in Category 5 for further investigations.

**ID17050102SW035_04, Buck Flat Draw – 4th order**

- Listed for temperature.
- This AU is a dry valley with no surface channel to conduct water above ground. Water emerges as seeps in a pasture within 250 m of Clover Creek. This AU should not have been listed.
- We recommend that this AU be delisted for temperature and placed into Category 3.

# 3 Subbasin Assessment—Pollutant Source Inventory

Pollution within the Bruneau River subbasin is primarily from nutrients, sediment, bacteria, and temperature. Load allocations were established for all pollutants except temperature in the *Bruneau Subbasin Assessment and Total Maximum Daily Loads of the 303(d) Water Bodies* approved by EPA in March 2001 (DEQ 2000). Load allocations and wasteload allocations for temperature are established in this document.

## 3.1 Point Sources

There are three National Pollutant Discharge Elimination System (NPDES) permitted point sources listed in EPA's Permit Compliance System (PCS) database in the Bruneau River subbasin: two aquaculture facilities along Jacks Creek (Ace Development, IDG130123, and Arraina, Inc., IDG130122) and one feedlot with a discharge point listed as Jacks Creek via the South Side Canal (Bruneau Cattle Company, IDG010063).

Under the concentrated animal feeding operation (CAFO) general NPDES permit, these permitted facilities are only allowed to discharge in the event of a 25-year/24-hour storm event. Therefore, under normal conditions, CAFO facilities would not have any discharges to surface water, and a wasteload allocation for temperature is not needed for the above referenced CAFO facility.

The two aquaculture facilities partially discharge to Jacks Creek under normal conditions. In the 2007 Jacks Creek TMDL modification of the Bruneau River TMDL (Buhidar 2007, Appendix C, page 29), DEQ was able to demonstrate that about 85% of the fish farm effluent is reused as cropland irrigation and seldom reaches Jacks Creek. Since 2007, changes have occurred on the flow design of the facility due to changes in irrigation and aquaculture management. DEQ has since determined that approximately 30% of the discharge from each facility enters Jacks Creek during the summer. The remaining 70% of the effluent is utilized for irrigation water on agricultural fields associated with the Bruneau Cattle Company and Harley Ranches. Both aquaculture facilities use artesian geothermal well water, which has been in place since the 1940s.

The Ace Development, Inc., aquaculture facility is owned by the J.R. Simplot Company and was previously leased by SeaPac of Idaho (Filer, Idaho) since February 1, 2011. It is currently (as of September 22, 2015) not being leased by SeaPac of Idaho and does not have an operator-of-record to lease the facility. The Arraina, Inc., aquaculture facility is owned by Sherry and Craig Christiansen, Jacks Creek Ranch, and Harley Ranches and was previously leased by SeaPac of Idaho (Filer, Idaho) since February 1, 2011. It is currently (as of September 22, 2015) being leased by Best Sea Foods since SeaPac of Idaho no longer is leasing it.

There are no known Multi-Sector General Permits or industrial stormwater permittees discharging to the temperature impaired waterbodies. This is a rural agricultural area and there are no municipal separate storm sewer systems.

There is also no Bruneau Wastewater Treatment Plant facility that discharges to any receiving water in the Bruneau area. The Bruneau Water and Sewer District treats its municipal waste under a municipal wastewater reuse permit (LA-000129-02; Class D Municipal Wastewater) that

uses a facultative treatment/storage lagoon, chlorine disinfection, and slow rate land application. Its application season is from March 15 through October 31. Its most recent permit certification was in 2009 and was administered by the DEQ Boise Regional Office. (See http://www.deq.idaho.gov/permitting/issued-permits.aspx?records=100&type=Wastewater+Reuse&sort=nameAscending for further information.) (DEQ 2008)

## 3.2 Nonpoint Sources

Nonpoint sources of heat that affect stream temperature include geothermal sources and riparian plant community disturbance. Streams that have they natural riparian plant communities disturbed or removed as a result of human activities result in less shade and increased warming due to sun exposure. Listing temperature data are presented in Appendix B, Figures B-6 through B-19. Recent monitoring data are also in Appendix B, Figures B-21 through B-35.

## 3.3 Pollutant Transport

Pollutant transport refers to the pathway by which pollutants move from the pollutant source to cause a problem or water quality violation in the receiving water body. Because this TMDL is based on natural riparian shade, which is equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, in order to reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Therefore, load allocations are stream segment specific and dependent upon the target load for a given segment. This target load (i.e., load capacity) is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL is dependent 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.

# 4 Subbasin Assessment—Summary of Past and Present Pollution Control Efforts

In 2009 the Bruneau River Soil and Water Conservation District (BRSWCD) was awarded a 319 grant to help implement the Bruneau/Grand View Ground Water Quality (GWQ) Management Plan.

The expected outcome of the Bruneau/Grand View GWQ- Nitrate Priority Areas (NPA) is to reduce excessive leaching of nitrates past the crop root zone by implementing nutrient management planning (NMP) with producers through the following process: using U of I soil sampling methodology in accordance with the NRCS Nutrient Management Standard 590, sending the samples to a North American Proficiency Testing-Performance Assessment Program (NAPT-PAP) certified lab to perform the soils analysis for quality assurance, and to base soil amendment recommendations on the University of Idaho Fertilizer Guides. Although the project focus will be on nutrient management, irrigation water management will play a significant role through the monitoring of crop water use and soil moisture status on selected fields. The

information gained from cooperating landowners will be used as an educational tool for all irrigators in the project area to demonstrate the feasibility and advantages of increasing water application efficiencies and irrigating to meet crop demands. For further information, see the Bruneau/Grand View Nitrate Priority Areas at https://www.deq.idaho.gov/media/470805-bruneau_grand_view_nitrate_priority_areas_gw_plan.pdf (DEQ 2008) and the Owyhee County GWQ Improvement and Drinking Water Source Protection Plan at http://www.deq.idaho.gov/media/473984-_water_data_reports_ground_water_owyhee_co_gwq_dwsp_plan.pdf (DEQ 2010) .

The BGWIPA focus was on reducing the nitrogen loading from crop fertilization, crop plow down, and manure storage sites throughout the project area. These nitrogen sources have been listed as major nitrate sources in the Bruneau/Grand View area according to DEQ (Nitrogen Loading Evaluation, Appendix A in DEQ 2008). SWCC/BRSWCD planned to track progress toward nitrogen reductions by evaluating nutrient management plans through soil tests, crop yields, and fertilizer inputs. In addition, irrigation water management of participating landowners will be evaluated so that nutrient amendments are kept within the crop root zone. Project reporting was respected as to landowners' privacy and only amounts were to be reported with no associated participant names unless a participant provides permission to do so.

Subwatersheds involved in the project included the following:

- 170501021604 Halfway Gulch
- 170501021605 Lower Sugar Creek
- 170501021606 Little Valley-Jacks Creek
- 170501021703 Seventy One Gulch-Bruneau River
- 170501021704 Wilkins Gulch-Bruneau River

BMPs anticipated to be installed to reduce/control nitrogen leaching included the following: composting facility, irrigation water management, nutrient management, and a waste storage facility.

In 2005, the Bruneau River SCD and Clover Flats Ranch received a grant for a fencing project to reduce bacteria from grazing and livestock that enters Clover Creek, a tributary to the Bruneau River. A mile of fencing was expected to be installed.

## 4.1 Water Quality Monitoring

Currently there is limited water quality monitoring that has occurred with the exception of additional BURP sites established within the entire watershed and temperature monitoring by DEQ in various streams. The Bureau of Land Management is embarking upon Multiple Indicator Monitoring (MIM), which evaluates stream cover and stream channel attributes using qualitative and quantitative indicators. DEQ expects to conduct a 5-year review in the future, at which time an analysis of recent water quality data gathered by various agencies will be reviewed and summarized.

# 5 Total Maximum Daily Loads

A TMDL prescribes an upper limit (i.e., load capacity) on discharge of a pollutant from all sources so as to ensure water quality standards are met. It further allocates this load capacity among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation, and nonpoint sources, each of which receives a load allocation. Natural background contributions, when present, are considered part of the load allocation but are often 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 (40 CFR Part 130) require a margin of safety be a part of the TMDL. Practically, the margin of safety and natural background are both reductions in the load capacity available for allocation to pollutant sources.

Load capacity can be summarized by the following equation:

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

Where:

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

The equation is written in this order because it represents the logical order in which a load analysis is conducted. First, the load capacity is determined. Then the load capacity is broken down into its components. After the necessary margin of safety and natural background, if relevant, are 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 a pollutant discharged over some period of time and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques

limit more accurate estimates, as is the case in this temperature TMDL. For certain pollutants whose effects are long term, such as temperature, the US Environmental Protection Agency (EPA) allows for seasonal or annual loads.

## 5.1 Instream Water Quality Targets

For the Bruneau River subbasin temperature TMDLs, we utilized 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 the natural level of shade and channel width become the target of the TMDL. The instream temperature that results from attaining these conditions is consistent with the water quality standards, even if it exceeds numeric temperature criteria. See Appendix A for further discussion of water quality standards and background provisions.

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

### 5.1.1 Factors Controlling Water Temperature in Streams

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

Riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. However, depending on how much vertical elevation also surrounds the stream, vegetation further away from the riparian corridor can 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 the stream is covered and how much is exposed to direct solar radiation.

### 5.1.2 Potential Natural Vegetation for Temperature TMDLs

PNV along a stream is that riparian plant community that could grow to an overall mature state, although some level of natural disturbance is usually included in the development and use of shade targets. Vegetation can be removed by disturbance either naturally (e.g., wildfire, disease/old age, wind damage, wildlife grazing) or anthropogenically (e.g., domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade-producing vegetation. 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) 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 station collecting these data. In this case, we used the station in Boise, Idaho. 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 (see 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.

#### *5.1.2.1 Existing Shade Estimates*

Existing shade was estimated for the streams from visual interpretation of aerial photos. Estimates of existing shade based on plant type and density were marked out on a 1:100,000 or 1:250,000 hydrography; taking into account natural breaks in vegetation density. 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 the 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 were partially field verified with a Solar Pathfinder, which measures effective shade and takes into consideration other physical features that block the sun from hitting the stream surface (e.g., hillsides, canyon walls, terraces, man-made structures).

### Solar Pathfinder Field Verification

The accuracy of the aerial photo interpretations was field verified with a Solar Pathfinder at 14 sites. 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 aerial photo interpretations was field verified with 83 Solar Pathfinder traces at 14 sites, most of which were not on streams in this analysis. We used the results from other streams in the area to calibrate our estimates when reevaluating the original aerial photo interpretation. The average difference between the aerial photo interpretation of existing shade and field measurements of shade was 3% ± 5.4 (mean ± 95% confidence interval). Aerial photo interpretations were off by one 10% shade class at eight sites, were off by two classes at two sites, and were accurate at four sites. Because the average difference was reasonably low and most differences were within one 10% shade class with similar chances of being high or low (six sites had higher than expected values and four sites had lower than expected values), we decided not to change the original aerial photo interpretations for streams in this analysis (we did however, change specific pathfinder site interpretations to match results). Thus, it is likely that existing shade presented in this document is within one or two 10% shade classes of actual shade values.

#### *5.1.2.2 Target Shade Determination*

PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in Idaho (see Shumar and De Varona 2009). To determine shade targets for the Bruneau River and tributaries, effective shade curves for a number of plant communities (yellow willow, sandbar willow, Pacific willow, juniper, and sagebrush/grass) were examined. These curves were produced using vegetation community modeling of Idaho plant communities (see Shumar and De Varona 2009) and show the relationship between effective shade and stream width. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width.

**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 shallow. 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 5).

For each stream evaluated in the load analysis, natural bank-full width was estimated based on the drainage area of the Upper Snake Basin curve from Figure 5. The Upper Snake Basin curve was chosen because of its proximity to the Bruneau River subbasin. Existing width data should also be evaluated and compared to these curve estimates if such data are available. Width estimates for the Bruneau River at the Nevada border and at its mouth were estimated from aerial photographs. If the stream's existing width was wider than predicted by the Upper Snake Basin curve in Figure 5, then the Figure 5 estimate of bank-full width was used in the loading analysis for natural bank-full width. If existing width was smaller, then existing width was used in the loading analysis for natural bank-full width.

In most cases, existing bank-full widths were smaller than estimates based on the drainage area (as indicated by the green color in Table 6). This finding is consistent with many dry rangeland areas where the precipitation is low; perhaps considerably lower than when the drainage area was formed. Therefore, existing bank-full widths were used as natural widths in this analysis.

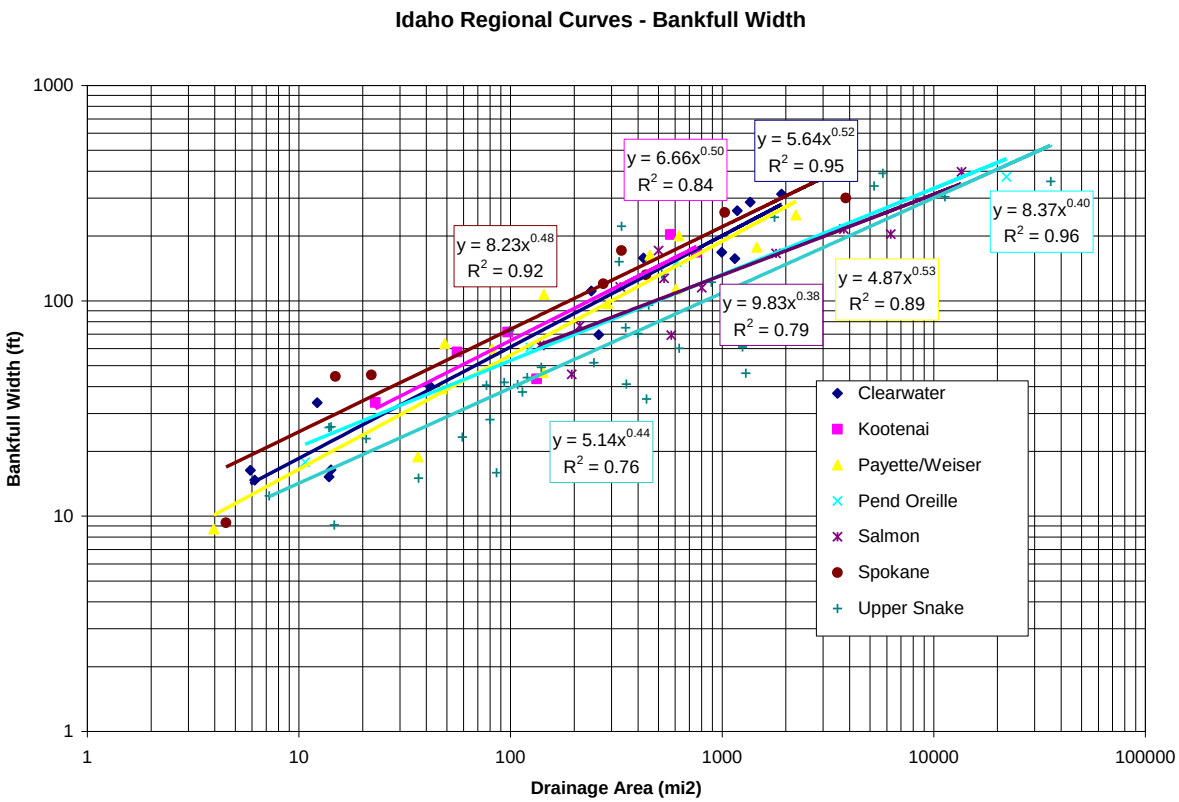


**Figure 5. Bank-full width as a function of drainage area.**

**Table 6. Bank-full width estimates based on the Upper Snake Basin (US) drainage area regional curve and existing measurements.**

| Location | area (sq mi) | US (m) | existing (m) |
|---|---|---|---|
| Bruneau R. @ mouth | 2760 | 51 | ~35 |
| Bruneau R. @ gage nr Hot Spr. | 2690 | 51 | 32 |
| Bruneau R. bl Clover Creek | 2370 | 48 | |
| Bruneau R. ab Clover Creek | 1860 | 43 | |
| Bruneau R. bl Sheep Creek | 1800 | 42 | |
| Bruneau R. ab Sheep Creek | 1200 | 35 | |
| Bruneau R bl Jarbridge R. | 1030 | 33 | |
| Bruneau R. ab Jarbridge R. | 560 | 25 | |
| Bruneau R. @ ID/NV border | 437 | 23 | ~15 |
| Clover Cr. (EF Bruneau) @ mouth | 510 | 24 | 13.1 |
| Clover Cr. bl Three Creek confluence | 222 | 17 | 11.8 |
| Jacks Cr. @ mouth | 596 | 26 | 15.7 |
| Big Jacks Cr. @ L.Jacks confluence | 244 | 18 | |
| Big Jacks Cr. @ Owyhee Front | 226 | 17 | 7.9 |
| Big Jacks Cr. bl Wickahoney Cr. | 174 | 15 | 7.7 |
| Big Jacks Cr. ab Wickahoney Cr. | 115 | 13 | |
| Little Jacks Cr. @ B.Jack confluence | 104 | 12 | |
| Little Jacks Cr. @ Owyhee Front | 75 | 10 | 4.6 |
| green = low existing | | | |

*Note*: square miles (sq mi); meter (m).

## Design Conditions

**Figure 6. Bruneau River canyon (photo credit: Peg Owens, Idaho Travel Council).**

The Bruneau River subbasin is canyon country, with extraordinarily deep basalt canyons (Figure 6). The Bruneau River, the Jarbidge River, Clover Creek (i.e., East Fork Bruneau River), and many associated tributaries are in deep canyons for much of their lengths in Idaho. The Bruneau River canyon can reach 244 meters (800 feet) deep in places, with most of the canyon exceeding 150 meters (500 feet) deep.

The Bruneau and Jarbidge Rivers emanate from the Jarbidge Mountains of Nevada and drain due north into Idaho. The streams coalesce into the Bruneau River before entering C.J. Strike Reservoir on the Snake River south of Mountain Home, Idaho. This hot, dry sagebrush desert and canyon country does not support much riparian plant growth along rivers and streams. Basalt canyon walls are close to streambanks, leaving little room for floodplains and riparian plant communities. Most riparian communities are narrow strips of shrubs and grasses. Larger shrubs and trees (cottonwoods and junipers) can be found at the mouth of Bruneau River and several other tributaries. Junipers occur along most of the upper Jarbidge River.

Developing shade targets for vegetation types in deep canyon country is difficult. In non-canyon areas, shade targets are logically based on vegetation types. In canyons, these vegetation type targets are inadequate to represent the additional shade provided by canyon walls.

## Shade Curve Selection

For the Bruneau River subbasin, the most logical and expected vegetation types were selected for shade target determinations. Shade curves used in this analysis are presented in Appendix B. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis.

The Bruneau River canyon is largely dominated by juniper and sandbar willow communities. In most canyons, the existing shade is higher than would be expected based on the riparian plant community because of canyon wall shade. The mouths of this river and Jacks Creek are on short floodplains out of the canyons and are surrounded by a complex of willows and cottonwood trees. We chose the Pacific willow community to represent these areas as that shade curve includes a mixture of cottonwood and willow as well as several other shrub species. Clover Creek is largely dominated by the low-elevation sandbar willow with some juniper locations along its canyon.

The Jacks Creek complex—which includes Big Jacks Creek, Little Jacks Creek, and Jacks Creek further to the west of the Bruneau River—is in very dry canyon country, and several portions of

stream channels are dry, open washes devoid of riparian vegetation. These streams typically originate as small channels in sagebrush/grass areas that transition to sandbar willow–dominated canyons. Lower Jacks Creek enters a lowland agricultural area before joining C.J. Strike Reservoir and, similar to the lower end of the Bruneau River, we have placed it into a Pacific willow community representing a mixture of cottonwoods and willows.

## 5.2 Load Capacity

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

We obtained solar load data from flat-plate collectors at the NREL weather station in Boise, Idaho. The solar load data used in this TMDL 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 salmonid 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 in the early spring and affect not only the highest temperatures reached later on in the summer but also salmonid spawning temperatures in spring and fall.

Tables 7–11 and Figure 7 show the PNV shade targets. The tables also show corresponding target summer loads (in kilowatt-hours per square meter per day [kWh/m$^2$/day] and kWh/day) that serve as the load capacities for the streams. Existing and target loads in kWh/day can be summed for the entire stream or portion of stream examined in a single load analysis table. These total loads are shown at the bottom of their respective columns in each table.

The Bruneau River is the largest stream examined in this TMDL, and as such has the largest load capacity (i.e., target load) at 14 million kWh/day (Table 7). By contrast Little Jacks Creek is the smallest stream with a load capacity of 370,000 kWh/day (Table 10).

## 5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR 130.2(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 this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations (Figure 8). Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat-plate collector at the NREL weather station in Boise. Existing shade data are presented in Tables 7–11. Like load capacities (target loads), existing loads in these tables are presented on an area basis (kWh/m$^2$/day) and as a total load (kWh/day). Existing loads in kWh/day are also summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target and existing load is also summed for the entire table. 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 Figure 9. The percent reduction shown in the final column of each table represents how much total excess load there is in relation to total existing load.

Existing heat loads vary from 13 million kWh/day on the Bruneau River (Table 7) to 420,000 kWh/day on Little Jacks Creek (Table 10). The following summarizes the previous paragraph.

Target Shade Load = TSL
Existing Shade Load = ESL
Difference = TSL − ESL

If, ESL > TSL
Then, Difference = Excess Load = Lack of Shade (Deficiency)

If, ESL = TSL
Then, Difference = Excess Load = the Same (Existing = Target)

If, ESL < TSL
Then, Difference = Excess Load = Abundance of Shade (Surplus)

**Table 7. Existing and target solar loads for Bruneau River.**

| 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 |
| 020_05 | Bruneau River | 1 | 1370 | sandbar willow | 29% | 4.53 | 10 | 14,000 | 63,000 | 30% | 4.47 | 10 | 14,000 | 63,000 | 0 | 0% |
| 020_05 | Bruneau River | 2 | 6120 | sandbar willow | 29% | 4.53 | 10 | 61,000 | 280,000 | 40% | 3.83 | 10 | 61,000 | 230,000 | (50,000) | 0% |
| 020_05 | Bruneau River | 3 | 2300 | sandbar willow | 29% | 4.53 | 10 | 23,000 | 100,000 | 30% | 4.47 | 10 | 23,000 | 100,000 | 0 | 0% |
| 020_05 | Bruneau River | 4 | 5380 | sandbar willow | 29% | 4.53 | 10 | 54,000 | 240,000 | 40% | 3.83 | 10 | 54,000 | 210,000 | (30,000) | 0% |
| 020_05 | Bruneau River | 5 | 8050 | juniper | 32% | 4.34 | 10 | 81,000 | 350,000 | 40% | 3.83 | 10 | 81,000 | 310,000 | (40,000) | 0% |
| 020_05 | Bruneau River | 6 | 1620 | sandbar willow | 29% | 4.53 | 10 | 16,000 | 72,000 | 40% | 3.83 | 10 | 16,000 | 61,000 | (11,000) | 0% |
| 020_05 | Bruneau River | 7 | 8440 | sandbar willow | 29% | 4.53 | 10 | 84,000 | 380,000 | 40% | 3.83 | 10 | 84,000 | 320,000 | (60,000) | 0% |
| 020_05 | Bruneau River | 8 | 4740 | juniper | 27% | 4.66 | 12 | 57,000 | 270,000 | 50% | 3.19 | 12 | 57,000 | 180,000 | (90,000) | 0% |
| 020_05 | Bruneau River | 9 | 3570 | sandbar willow | 25% | 4.79 | 12 | 43,000 | 210,000 | 40% | 3.83 | 12 | 43,000 | 160,000 | (50,000) | 0% |
| 020_05 | Bruneau River | 10 | 690 | sandbar willow | 25% | 4.79 | 12 | 8,300 | 40,000 | 40% | 3.83 | 12 | 8,300 | 32,000 | (8,000) | 0% |
| 020_05 | Bruneau River | 11 | 1900 | sandbar willow | 25% | 4.79 | 12 | 23,000 | 110,000 | 30% | 4.47 | 12 | 23,000 | 100,000 | (10,000) | 0% |
| 013_05 | Bruneau River | 1 | 2840 | sandbar willow | 17% | 5.30 | 18 | 51,000 | 270,000 | 20% | 5.10 | 18 | 51,000 | 260,000 | (10,000) | 0% |
| 013_05 | Bruneau River | 2 | 3430 | sandbar willow | 17% | 5.30 | 18 | 62,000 | 330,000 | 50% | 3.19 | 18 | 62,000 | 200,000 | (130,000) | 0% |
| 013_05 | Bruneau River | 3 | 750 | sandbar willow | 17% | 5.30 | 18 | 14,000 | 74,000 | 40% | 3.83 | 18 | 14,000 | 54,000 | (20,000) | 0% |
| 013_05 | Bruneau River | 4 | 580 | sandbar willow | 17% | 5.30 | 18 | 10,000 | 53,000 | 50% | 3.19 | 18 | 10,000 | 32,000 | (21,000) | 0% |
| 013_05 | Bruneau River | 5 | 1800 | sandbar willow | 17% | 5.30 | 18 | 32,000 | 170,000 | 40% | 3.83 | 18 | 32,000 | 120,000 | (50,000) | 0% |
| 013_05 | Bruneau River | 6 | 1580 | juniper | 19% | 5.17 | 18 | 28,000 | 140,000 | 50% | 3.19 | 18 | 28,000 | 89,000 | (51,000) | 0% |
| 013_05 | Bruneau River | 7 | 6700 | juniper | 19% | 5.17 | 18 | 120,000 | 620,000 | 50% | 3.19 | 18 | 120,000 | 380,000 | (240,000) | 0% |
| 013_05 | Bruneau River | 8 | 4340 | juniper | 19% | 5.17 | 18 | 78,000 | 400,000 | 40% | 3.83 | 18 | 78,000 | 300,000 | (100,000) | 0% |
| 013_06 | Bruneau River | 1 | 1380 | juniper | 15% | 5.42 | 22 | 30,000 | 160,000 | 50% | 3.19 | 22 | 30,000 | 96,000 | (64,000) | 0% |
| 013_06 | Bruneau River | 2 | 940 | sandbar willow | 14% | 5.49 | 22 | 21,000 | 120,000 | 40% | 3.83 | 22 | 21,000 | 80,000 | (40,000) | 0% |
| 013_06 | Bruneau River | 3 | 1790 | sandbar willow | 14% | 5.49 | 22 | 39,000 | 210,000 | 50% | 3.19 | 22 | 39,000 | 120,000 | (90,000) | 0% |
| 013_06 | Bruneau River | 4 | 6640 | sandbar willow | 14% | 5.49 | 22 | 150,000 | 820,000 | 40% | 3.83 | 22 | 150,000 | 570,000 | (250,000) | 0% |
| 013_06 | Bruneau River | 5 | 3230 | juniper | 15% | 5.42 | 22 | 71,000 | 390,000 | 50% | 3.19 | 22 | 71,000 | 230,000 | (160,000) | 0% |
| 013_06 | Bruneau River | 6 | 240 | juniper | 15% | 5.42 | 22 | 5,300 | 29,000 | 40% | 3.83 | 22 | 5,300 | 20,000 | (9,000) | 0% |
| 011_06 | Bruneau River | 1 | 2600 | juniper | 15% | 5.42 | 22 | 57,000 | 310,000 | 40% | 3.83 | 22 | 57,000 | 220,000 | (90,000) | 0% |
| 011_06 | Bruneau River | 2 | 7860 | juniper | 15% | 5.42 | 22 | 170,000 | 920,000 | 50% | 3.19 | 22 | 170,000 | 540,000 | (380,000) | 0% |
| 011_06 | Bruneau River | 3 | 1780 | juniper | 15% | 5.42 | 22 | 39,000 | 210,000 | 60% | 2.55 | 22 | 39,000 | 100,000 | (110,000) | 0% |
| 011_06 | Bruneau River | 4 | 1470 | juniper | 15% | 5.42 | 22 | 32,000 | 170,000 | 50% | 3.19 | 22 | 32,000 | 100,000 | (70,000) | 0% |
| 011_06 | Bruneau River | 5 | 3090 | juniper | 15% | 5.42 | 22 | 68,000 | 370,000 | 60% | 2.55 | 22 | 68,000 | 170,000 | (200,000) | 0% |
| 011_06 | Bruneau River | 6 | 1660 | juniper | 15% | 5.42 | 22 | 37,000 | 200,000 | 50% | 3.19 | 22 | 37,000 | 120,000 | (80,000) | 0% |
| 011_06 | Bruneau River | 7 | 4080 | juniper | 15% | 5.42 | 22 | 90,000 | 490,000 | 60% | 2.55 | 22 | 90,000 | 230,000 | (260,000) | 0% |
| 011_06 | Bruneau River | 8 | 4450 | juniper | 15% | 5.42 | 22 | 98,000 | 530,000 | 50% | 3.19 | 22 | 98,000 | 310,000 | (220,000) | 0% |
| 011_06 | Bruneau River | 9 | 1740 | sandbar willow | 13% | 5.55 | 24 | 42,000 | 230,000 | 30% | 4.47 | 24 | 42,000 | 190,000 | (40,000) | 0% |
| 011_06 | Bruneau River | 10 | 560 | sandbar willow | 11% | 5.68 | 28 | 16,000 | 91,000 | 20% | 5.10 | 28 | 16,000 | 82,000 | (9,000) | 0% |
| 009_06 | Bruneau River | 1 | 4520 | pacific willow | 24% | 4.85 | 28 | 130,000 | 630,000 | 10% | 5.74 | 28 | 130,000 | 750,000 | 120,000 | -14% |
| 009_06 | Bruneau River | 2 | 29480 | pacific willow | 22% | 4.98 | 30 | 880,000 | 4,400,000 | 0% | 6.38 | 30 | 880,000 | 5,600,000 | 1,200,000 | -22% |
| | | | | | | | *Totals* | | 14,000,000 | | | | | 13,000,000 | -1,700,000 | |

*Note*: All assessment unit (AU) numbers start with ID17050102SW in all load tables (Tables 7–11). Significant figures are controlled by the lowest level in the calculation, typically that of the channel width. Some rounding errors may result.

**Table 8. Existing and target solar loads for Clover Creek (East Fork Bruneau River).**

| 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 |
| 028_04 | Clover Creek | 1 | 120 | sandbar willow | 25% | 4.79 | 12 | 1,400 | 6,700 | 20% | 5.10 | 12 | 1,400 | 7,100 | 400 | -5% |
| 028_04 | Clover Creek | 2 | 370 | yellow willow | 19% | 5.17 | 12 | 4,400 | 23,000 | 30% | 4.47 | 12 | 4,400 | 20,000 | (3,000) | 0% |
| 028_04 | Clover Creek | 3 | 1270 | yellow willow | 19% | 5.17 | 12 | 15,000 | 78,000 | 20% | 5.10 | 12 | 15,000 | 77,000 | (1,000) | 0% |
| 028_04 | Clover Creek | 4 | 800 | sandbar willow | 25% | 4.79 | 12 | 9,600 | 46,000 | 30% | 4.47 | 12 | 9,600 | 43,000 | (3,000) | 0% |
| 028_04 | Clover Creek | 5 | 3640 | juniper | 27% | 4.66 | 12 | 44,000 | 200,000 | 40% | 3.83 | 12 | 44,000 | 170,000 | (30,000) | 0% |
| 028_04 | Clover Creek | 6 | 1550 | sandbar willow | 25% | 4.79 | 12 | 19,000 | 91,000 | 30% | 4.47 | 12 | 19,000 | 85,000 | (6,000) | 0% |
| 028_04 | Clover Creek | 7 | 150 | sandbar willow | 25% | 4.79 | 12 | 1,800 | 8,600 | 40% | 3.83 | 12 | 1,800 | 6,900 | (1,700) | 0% |
| 028_04 | Clover Creek | 8 | 2140 | sandbar willow | 25% | 4.79 | 12 | 26,000 | 120,000 | 30% | 4.47 | 12 | 26,000 | 120,000 | 0 | 0% |
| 028_04 | Clover Creek | 9 | 2630 | sandbar willow | 25% | 4.79 | 12 | 32,000 | 150,000 | 30% | 4.47 | 12 | 32,000 | 140,000 | (10,000) | 0% |
| 028_04 | Clover Creek | 10 | 1470 | sandbar willow | 25% | 4.79 | 12 | 18,000 | 86,000 | 40% | 3.83 | 12 | 18,000 | 69,000 | (17,000) | 0% |
| 028_04 | Clover Creek | 11 | 6480 | sandbar willow | 25% | 4.79 | 12 | 78,000 | 370,000 | 30% | 4.47 | 12 | 78,000 | 350,000 | (20,000) | 0% |
| 028_04 | Clover Creek | 12 | 2750 | juniper | 27% | 4.66 | 12 | 33,000 | 150,000 | 40% | 3.83 | 12 | 33,000 | 130,000 | (20,000) | 0% |
| 028_04 | Clover Creek | 13 | 4810 | sandbar willow | 25% | 4.79 | 12 | 58,000 | 280,000 | 30% | 4.47 | 12 | 58,000 | 260,000 | (20,000) | 0% |
| 028_04 | Clover Creek | 14 | 640 | sandbar willow | 25% | 4.79 | 12 | 7,700 | 37,000 | 40% | 3.83 | 12 | 7,700 | 29,000 | (8,000) | 0% |
| 028_04 | Clover Creek | 15 | 710 | sandbar willow | 25% | 4.79 | 12 | 8,500 | 41,000 | 30% | 4.47 | 12 | 8,500 | 38,000 | (3,000) | 0% |
| 028_04 | Clover Creek | 16 | 2330 | sandbar willow | 25% | 4.79 | 12 | 28,000 | 130,000 | 30% | 4.47 | 12 | 28,000 | 130,000 | 0 | 0% |
| 028_04 | Clover Creek | 17 | 4620 | sandbar willow | 25% | 4.79 | 12 | 55,000 | 260,000 | 30% | 4.47 | 12 | 55,000 | 250,000 | (10,000) | 0% |
| 028_04 | Clover Creek | 18 | 2160 | juniper | 27% | 4.66 | 12 | 26,000 | 120,000 | 40% | 3.83 | 12 | 26,000 | 100,000 | (20,000) | 0% |
| 028_04 | Clover Creek | 19 | 1200 | sandbar willow | 25% | 4.79 | 12 | 14,000 | 67,000 | 30% | 4.47 | 12 | 14,000 | 63,000 | (4,000) | 0% |
| 028_04 | Clover Creek | 20 | 890 | sandbar willow | 25% | 4.79 | 12 | 11,000 | 53,000 | 30% | 4.47 | 12 | 11,000 | 49,000 | (4,000) | 0% |
| 028_04 | Clover Creek | 21 | 340 | sandbar willow | 25% | 4.79 | 12 | 4,100 | 20,000 | 20% | 5.10 | 12 | 4,100 | 21,000 | 1,000 | -5% |
| 028_04 | Clover Creek | 22 | 1040 | sandbar willow | 25% | 4.79 | 12 | 12,000 | 57,000 | 30% | 4.47 | 12 | 12,000 | 54,000 | (3,000) | 0% |
| 028_04 | Clover Creek | 23 | 2060 | sandbar willow | 23% | 4.91 | 13 | 27,000 | 130,000 | 30% | 4.47 | 13 | 27,000 | 120,000 | (10,000) | 0% |
| 028_04 | Clover Creek | 24 | 870 | sandbar willow | 23% | 4.91 | 13 | 11,000 | 54,000 | 10% | 5.74 | 13 | 11,000 | 63,000 | 9,000 | -13% |
| 028_04 | Clover Creek | 25 | 2450 | sandbar willow | 23% | 4.91 | 13 | 32,000 | 160,000 | 0% | 6.38 | 13 | 32,000 | 200,000 | 40,000 | -23% |
| 028_05 | Clover Creek | 1 | 390 | sandbar willow | 23% | 4.91 | 13 | 5,100 | 25,000 | 0% | 6.38 | 13 | 5,100 | 33,000 | 8,000 | -23% |
| 028_05 | Clover Creek | 2 | 3690 | sandbar willow | 23% | 4.91 | 13 | 48,000 | 240,000 | 10% | 5.74 | 13 | 48,000 | 280,000 | 40,000 | -13% |
| 028_05 | Clover Creek | 3 | 2390 | sandbar willow | 23% | 4.91 | 13 | 31,000 | 150,000 | 40% | 3.83 | 13 | 31,000 | 120,000 | (30,000) | 0% |
| 028_05 | Clover Creek | 4 | 1900 | sandbar willow | 23% | 4.91 | 13 | 25,000 | 120,000 | 40% | 3.83 | 13 | 25,000 | 96,000 | (24,000) | 0% |
| 028_05 | Clover Creek | 5 | 2540 | sandbar willow | 23% | 4.91 | 13 | 33,000 | 160,000 | 40% | 3.83 | 13 | 33,000 | 130,000 | (30,000) | 0% |
| 028_05 | Clover Creek | 6 | 2490 | sandbar willow | 23% | 4.91 | 13 | 32,000 | 160,000 | 20% | 5.10 | 13 | 32,000 | 160,000 | 0 | -3% |
| 028_05 | Clover Creek | 7 | 480 | sandbar willow | 23% | 4.91 | 13 | 6,200 | 30,000 | 20% | 5.10 | 13 | 6,200 | 32,000 | 2,000 | -3% |
| 028_05 | Clover Creek | 8 | 880 | sandbar willow | 23% | 4.91 | 13 | 11,000 | 54,000 | 30% | 4.47 | 13 | 11,000 | 49,000 | (5,000) | 0% |
| 028_05 | Clover Creek | 9 | 3790 | sandbar willow | 23% | 4.91 | 13 | 49,000 | 240,000 | 20% | 5.10 | 13 | 49,000 | 250,000 | 10,000 | -3% |
| 028_05 | Clover Creek | 10 | 310 | sandbar willow | 23% | 4.91 | 13 | 4,000 | 20,000 | 30% | 4.47 | 13 | 4,000 | 18,000 | (2,000) | 0% |
| 028_05 | Clover Creek | 11 | 1680 | sandbar willow | 23% | 4.91 | 13 | 22,000 | 110,000 | 40% | 3.83 | 13 | 22,000 | 84,000 | (26,000) | 0% |
| 028_05 | Clover Creek | 12 | 2120 | sandbar willow | 23% | 4.91 | 13 | 28,000 | 140,000 | 30% | 4.47 | 13 | 28,000 | 130,000 | (10,000) | 0% |
| 028_05 | Clover Creek | 13 | 280 | sandbar willow | 23% | 4.91 | 13 | 3,600 | 18,000 | 40% | 3.83 | 13 | 3,600 | 14,000 | (4,000) | 0% |
| 028_05 | Clover Creek | 14 | 1050 | sandbar willow | 23% | 4.91 | 13 | 14,000 | 69,000 | 10% | 5.74 | 13 | 14,000 | 80,000 | 11,000 | -13% |
| 028_05 | Clover Creek | 15 | 1460 | sandbar willow | 23% | 4.91 | 13 | 19,000 | 93,000 | 20% | 5.10 | 13 | 19,000 | 97,000 | 4,000 | -3% |
| 028_05 | Clover Creek | 16 | 7080 | sandbar willow | 23% | 4.91 | 13 | 92,000 | 450,000 | 30% | 4.47 | 13 | 92,000 | 410,000 | (40,000) | 0% |
| 028_05 | Clover Creek | 17 | 1560 | sandbar willow | 23% | 4.91 | 13 | 20,000 | 98,000 | 40% | 3.83 | 13 | 20,000 | 77,000 | (21,000) | 0% |
| 028_05 | Clover Creek | 18 | 6100 | juniper | 25% | 4.79 | 13 | 79,000 | 380,000 | 50% | 3.19 | 13 | 79,000 | 250,000 | (130,000) | 0% |
| | | | | | | | *Totals* | | 5,300,000 | | | | | 4,900,000 | -390,000 | |

**Table 9. Existing and target solar loads for Big Jacks Creek.**

| Segment Details | | | | | Target | | | | | Existing | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | Stream Name | Number (top to bottom) | Length (m) | Vegetation Type | Shade | Solar Radiation (kWh/m$^2$/day) | Segment Width (m) | Segment Area (m$^2$) | Solar Load (kWh/day) | Shade | Solar Radiation (kWh/m$^2$/day) | Segment Width (m) | Segment Area (m$^2$) | Solar Load (kWh/day) | Excess Load (kWh/day) | Lack of Shade |
| 004_02 | Big Jacks Creek | 1 | 3300 | grass meadow | 31% | 4.40 | 2 | 7,000 | 30,000 | 10% | 5.74 | 4 | 10,000 | 60,000 | 30,000 | -21% |
| 004_03 | Big Jacks Creek | 1 | 420 | grass meadow | 31% | 4.40 | 2 | 800 | 4,000 | 10% | 5.74 | 4 | 2,000 | 10,000 | 6,000 | -21% |
| 004_03 | Big Jacks Creek | 2 | 710 | water | 0% | 6.38 | 100 | 71,000 | 453,000 | 0% | 6.38 | 100 | 71,000 | 453,000 | 0 | 0% |
| 004_03 | Big Jacks Creek | 3 | 2080 | sandbar willow | 58% | 2.68 | 4 | 8,000 | 20,000 | 70% | 1.91 | 4 | 8,000 | 20,000 | 0 | 0% |
| 004_03 | Big Jacks Creek | 4 | 10550 | sandbar willow | 44% | 3.57 | 6 | 60,000 | 200,000 | 60% | 2.55 | 6 | 60,000 | 200,000 | 0 | 0% |
| 004_03 | Big Jacks Creek | 5 | 110 | sandbar willow | 39% | 3.89 | 7 | 800 | 3,000 | 50% | 3.19 | 7 | 800 | 3,000 | 0 | 0% |
| 004_04 | Big Jacks Creek | 1 | 2640 | sandbar willow | 39% | 3.89 | 7 | 20,000 | 80,000 | 50% | 3.19 | 7 | 20,000 | 60,000 | (20,000) | 0% |
| 004_04 | Big Jacks Creek | 2 | 3400 | sandbar willow | 39% | 3.89 | 7 | 20,000 | 80,000 | 40% | 3.83 | 7 | 20,000 | 80,000 | 0 | 0% |
| 004_04 | Big Jacks Creek | 3 | 6040 | sandbar willow | 35% | 4.15 | 8 | 50,000 | 200,000 | 30% | 4.47 | 8 | 50,000 | 200,000 | 0 | -5% |
| 004_05 | Big Jacks Creek | 1 | 4970 | sandbar willow | 35% | 4.15 | 8 | 40,000 | 200,000 | 40% | 3.83 | 8 | 40,000 | 200,000 | 0 | 0% |
| 004_05 | Big Jacks Creek | 2 | 830 | sandbar willow | 35% | 4.15 | 8 | 7,000 | 30,000 | 50% | 3.19 | 8 | 7,000 | 20,000 | (10,000) | 0% |
| 004_05 | Big Jacks Creek | 3 | 5190 | sandbar willow | 35% | 4.15 | 8 | 40,000 | 200,000 | 30% | 4.47 | 8 | 40,000 | 200,000 | 0 | -5% |
| 004_05 | Big Jacks Creek | 4 | 15460 | sandbar willow | 35% | 4.15 | 8 | 100,000 | 400,000 | 40% | 3.83 | 8 | 100,000 | 400,000 | 0 | 0% |
| 004_05 | Big Jacks Creek | 5 | 1020 | sandbar willow | 35% | 4.15 | 8 | 8,000 | 30,000 | 50% | 3.19 | 8 | 8,000 | 30,000 | 0 | 0% |
| 004_05 | Big Jacks Creek | 6 | 1950 | sandbar willow | 35% | 4.15 | 8 | 20,000 | 80,000 | 40% | 3.83 | 8 | 20,000 | 80,000 | 0 | 0% |
| 004_05 | Big Jacks Creek | 7 | 1790 | sandbar willow | 35% | 4.15 | 8 | 10,000 | 40,000 | 50% | 3.19 | 8 | 10,000 | 30,000 | (10,000) | 0% |
| | | | | | | | *Totals* | | 2,100,000 | | | | | 2,000,000 | -4,000 | |

**Table 10. Existing and target solar loads for Little Jacks Creek.**

| Segment Details | | | | | Target | | | | | Existing | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | Stream Name | Number (top to bottom) | Length (m) | Vegetation Type | Shade | Solar Radiation (kWh/m$^2$/day) | Segment Width (m) | Segment Area (m$^2$) | Solar Load (kWh/day) | Shade | Solar Radiation (kWh/m$^2$/day) | Segment Width (m) | Segment Area (m$^2$) | Solar Load (kWh/day) | Excess Load (kWh/day) | Lack of Shade |
| 003_02 | Little Jacks Creek | 1 | 1830 | grass meadow | 31% | 4.40 | 2 | 4,000 | 20,000 | 10% | 5.74 | 4 | 7,000 | 40,000 | 20,000 | -21% |
| 003_03 | Little Jacks Creek | 1 | 1260 | grass meadow | 31% | 4.40 | 2 | 3,000 | 10,000 | 10% | 5.74 | 4 | 5,000 | 30,000 | 20,000 | -21% |
| 003_03 | Little Jacks Creek | 2 | 630 | sandbar willow | 87% | 0.83 | 2 | 1,000 | 800 | 70% | 1.91 | 2 | 1,000 | 2,000 | 1,000 | -17% |
| 003_03 | Little Jacks Creek | 3 | 1750 | sandbar willow | 87% | 0.83 | 2 | 4,000 | 3,000 | 80% | 1.28 | 2 | 4,000 | 5,000 | 2,000 | -7% |
| 003_04 | Little Jacks Creek | 1 | 12230 | sandbar willow | 70% | 1.91 | 3 | 40,000 | 80,000 | 70% | 1.91 | 3 | 40,000 | 80,000 | 0 | 0% |
| 003_04 | Little Jacks Creek | 2 | 5360 | sandbar willow | 58% | 2.68 | 4 | 20,000 | 50,000 | 70% | 1.91 | 4 | 20,000 | 40,000 | (10,000) | 0% |
| 003_04 | Little Jacks Creek | 3 | 3480 | sandbar willow | 58% | 2.68 | 4 | 10,000 | 30,000 | 60% | 2.55 | 4 | 10,000 | 30,000 | 0 | 0% |
| 003_04 | Little Jacks Creek | 4 | 5220 | sandbar willow | 50% | 3.19 | 5 | 30,000 | 100,000 | 50% | 3.19 | 5 | 30,000 | 100,000 | 0 | 0% |
| 003_04 | Little Jacks Creek | 5 | 1890 | sandbar willow | 44% | 3.57 | 6 | 10,000 | 40,000 | 50% | 3.19 | 6 | 10,000 | 30,000 | (10,000) | 0% |
| 003_04 | Little Jacks Creek | 6 | 2270 | sandbar willow | 44% | 3.57 | 6 | 10,000 | 40,000 | 10% | 5.74 | 6 | 10,000 | 60,000 | 20,000 | -34% |
| | | | | | | | *Totals* | | 370,000 | | | | | 420,000 | 43,000 | |

**Table 11. Existing and target solar loads for Jacks Creek.**

| Segment Details | | | | | Target | | | | | Existing | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | Stream Name | Number (top to bottom) | Length (m) | Vegetation Type | Shade | Solar Radiation (kWh/m$^2$/day) | Segment Width (m) | Segment Area (m$^2$) | Solar Load (kWh/day) | Shade | Solar Radiation (kWh/m$^2$/day) | Segment Width (m) | Segment Area (m$^2$) | Solar Load (kWh/day) | Excess Load (kWh/day) | Lack of Shade |
| 002_05 | Jacks Creek | 1 | 630 | Pacific willow | 57% | 2.74 | 10 | 6,300 | 17,000 | 20% | 5.10 | 10 | 6,300 | 32,000 | 15,000 | -37% |
| 002_05 | Jacks Creek | 2 | 300 | Pacific willow | 57% | 2.74 | 10 | 3,000 | 8,200 | 40% | 3.83 | 10 | 3,000 | 11,000 | 2,800 | -17% |
| 002_05 | Jacks Creek | 3 | 860 | Pacific willow | 57% | 2.74 | 10 | 8,600 | 24,000 | 30% | 4.47 | 10 | 8,600 | 38,000 | 14,000 | -27% |
| 002_05 | Jacks Creek | 4 | 220 | Pacific willow | 57% | 2.74 | 10 | 2,200 | 6,000 | 0% | 6.38 | 10 | 2,200 | 14,000 | 8,000 | -57% |
| 002_05 | Jacks Creek | 5 | 640 | Pacific willow | 57% | 2.74 | 10 | 6,400 | 18,000 | 10% | 5.74 | 10 | 6,400 | 37,000 | 19,000 | -47% |
| 002_05 | Jacks Creek | 6 | 1580 | Pacific willow | 53% | 3.00 | 11 | 17,000 | 51,000 | 50% | 3.19 | 11 | 17,000 | 54,000 | 3,000 | -3% |
| 002_05 | Jacks Creek | 7 | 940 | Pacific willow | 53% | 3.00 | 11 | 10,000 | 30,000 | 40% | 3.83 | 11 | 10,000 | 38,000 | 8,000 | -13% |
| 002_05 | Jacks Creek | 8 | 270 | Pacific willow | 49% | 3.25 | 12 | 3,200 | 10,000 | 10% | 5.74 | 12 | 3,200 | 18,000 | 8,000 | -39% |
| 002_05 | Jacks Creek | 9 | 210 | Pacific willow | 49% | 3.25 | 12 | 2,500 | 8,100 | 40% | 3.83 | 12 | 2,500 | 9,600 | 1,500 | -9% |
| 002_05 | Jacks Creek | 10 | 380 | Pacific willow | 49% | 3.25 | 12 | 4,600 | 15,000 | 10% | 5.74 | 12 | 4,600 | 26,000 | 11,000 | -39% |
| 002_05 | Jacks Creek | 11 | 500 | Pacific willow | 49% | 3.25 | 12 | 6,000 | 20,000 | 20% | 5.10 | 12 | 6,000 | 31,000 | 11,000 | -29% |
| 002_05 | Jacks Creek | 12 | 310 | Pacific willow | 46% | 3.45 | 13 | 4,000 | 14,000 | 50% | 3.19 | 13 | 4,000 | 13,000 | (1,000) | 0% |
| 002_05 | Jacks Creek | 13 | 220 | Pacific willow | 46% | 3.45 | 13 | 2,900 | 10,000 | 30% | 4.47 | 13 | 2,900 | 13,000 | 3,000 | -16% |
| 002_05 | Jacks Creek | 14 | 1500 | Pacific willow | 46% | 3.45 | 13 | 20,000 | 69,000 | 40% | 3.83 | 13 | 20,000 | 77,000 | 8,000 | -6% |
| 002_05 | Jacks Creek | 15 | 320 | Pacific willow | 46% | 3.45 | 13 | 4,200 | 14,000 | 30% | 4.47 | 13 | 4,200 | 19,000 | 5,000 | -16% |
| 002_05 | Jacks Creek | 16 | 730 | Pacific willow | 41% | 3.76 | 15 | 11,000 | 41,000 | 30% | 4.47 | 15 | 11,000 | 49,000 | 8,000 | -11% |
| 002_05 | Jacks Creek | 17 | 930 | Pacific willow | 41% | 3.76 | 15 | 14,000 | 53,000 | 10% | 5.74 | 15 | 14,000 | 80,000 | 27,000 | -31% |
| 002_05 | Jacks Creek | 18 | 320 | Pacific willow | 41% | 3.76 | 15 | 4,800 | 18,000 | 40% | 3.83 | 15 | 4,800 | 18,000 | 0 | -1% |
| 002_05 | Jacks Creek | 19 | 660 | Pacific willow | 41% | 3.76 | 15 | 9,900 | 37,000 | 20% | 5.10 | 15 | 9,900 | 51,000 | 14,000 | -21% |
| 002_05 | Jacks Creek | 20 | 630 | Pacific willow | 41% | 3.76 | 15 | 9,500 | 36,000 | 40% | 3.83 | 15 | 9,500 | 36,000 | 0 | -1% |
| 002_05 | Jacks Creek | 21 | 150 | Pacific willow | 41% | 3.76 | 15 | 2,300 | 8,700 | 20% | 5.10 | 15 | 2,300 | 12,000 | 3,300 | -21% |
| 002_05 | Jacks Creek | 22 | 410 | Pacific willow | 41% | 3.76 | 15 | 6,200 | 23,000 | 0% | 6.38 | 15 | 6,200 | 40,000 | 17,000 | -41% |
| 002_05 | Jacks Creek | 23 | 1100 | Pacific willow | 41% | 3.76 | 15 | 17,000 | 64,000 | 10% | 5.74 | 15 | 17,000 | 98,000 | 34,000 | -31% |
| 002_05 | Jacks Creek | 24 | 1100 | Pacific willow | 41% | 3.76 | 15 | 17,000 | 64,000 | 20% | 5.10 | 15 | 17,000 | 87,000 | 23,000 | -21% |
| 002_05 | Jacks Creek | 25 | 1100 | Pacific willow | 41% | 3.76 | 15 | 17,000 | 64,000 | 0% | 6.38 | 15 | 17,000 | 110,000 | 46,000 | -41% |
| 002_05 | Jacks Creek | 26 | 150 | Pacific willow | 41% | 3.76 | 15 | 2,300 | 8,700 | 30% | 4.47 | 15 | 2,300 | 10,000 | 1,300 | -11% |
| 002_05 | Jacks Creek | 27 | 760 | Pacific willow | 41% | 3.76 | 15 | 11,000 | 41,000 | 0% | 6.38 | 15 | 11,000 | 70,000 | 29,000 | -41% |
| | | | | | | | *Totals* | | 770,000 | | | | | 1,100,000 | 320,000 | |

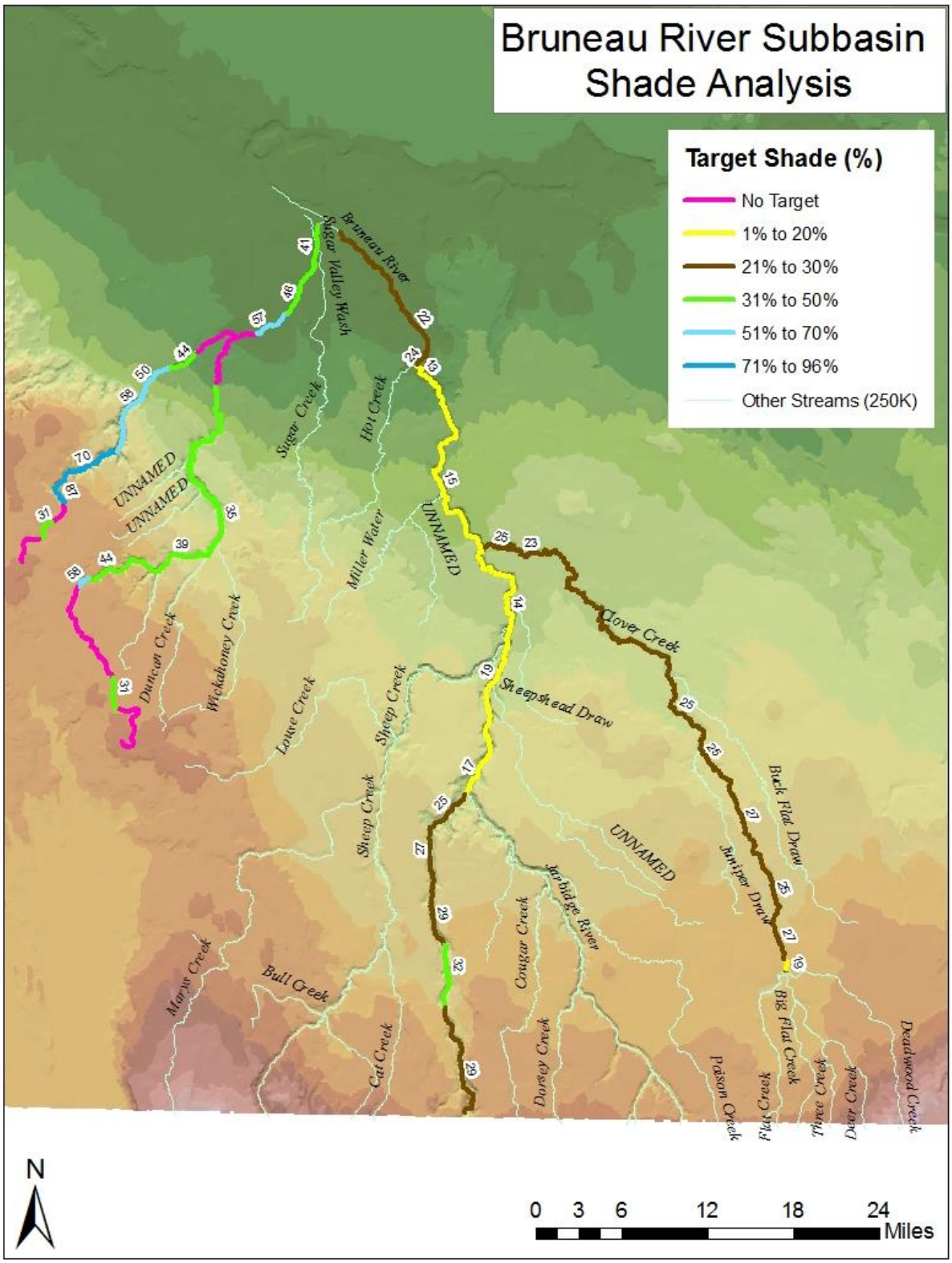


**Figure 7. Target shade for the Bruneau River subbasin.**

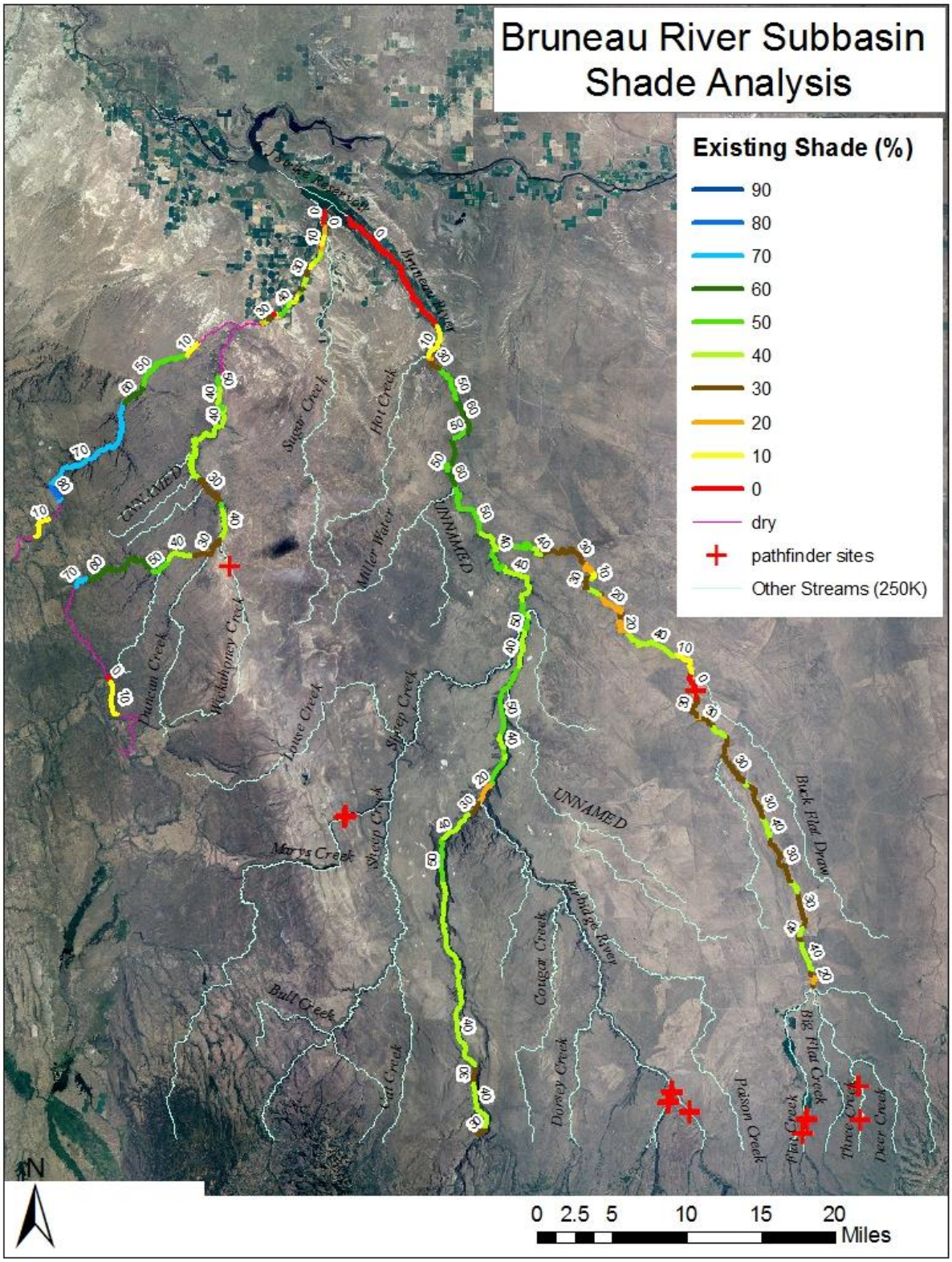


**Figure 8. Existing shade estimated for the Bruneau River subbasin by aerial photo interpretation.**

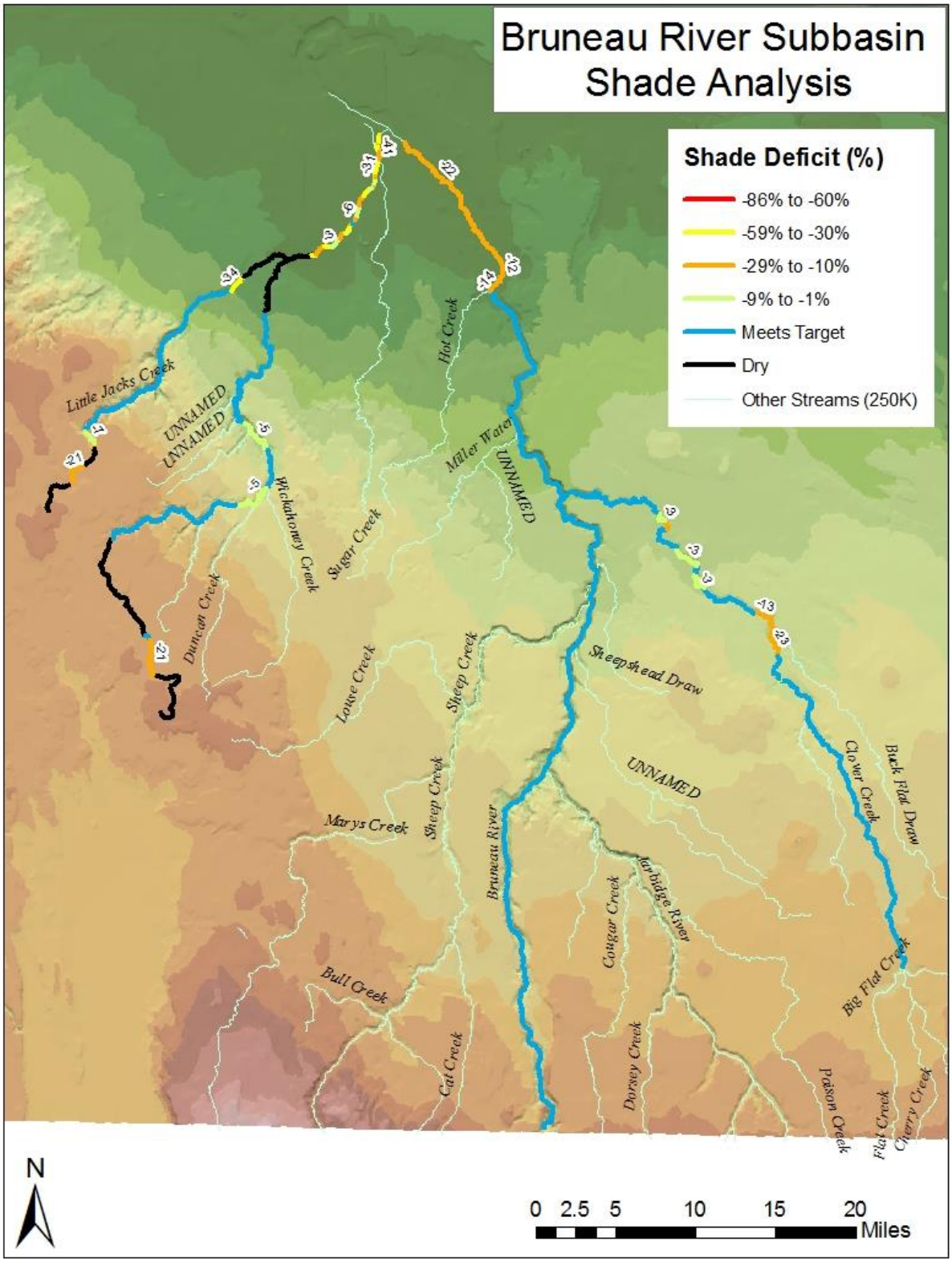


**Figure 9. Lack of shade (difference between existing and target) for the Bruneau River subbasin.**

## 5.4 Load and Wasteload Allocation

Because this TMDL is based on PNV, which is equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, in order to reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Therefore, load allocations are stream segment specific and dependent upon the target load for a given segment. Tables 7–11 show the target shade and corresponding target summer load. This target load (i.e., load capacity) is necessary to achieve background conditions. There is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL is dependent 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 12 and Table 13 show the total existing, target, and excess loads per linear meter for each water body examined. The size of a stream usually influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths. Table 12 and Table 13 list the tributaries in order of their excess loads, from highest to lowest. Normally, large tributaries tend to be listed first and small tributaries last. However, due to the shade produced by very deep canyon walls in this subbasin, many of the larger streams in canyons have no excess load or have positive loads resulting from existing canyon shade exceeding target shade levels based on vegetation alone.

Although this TMDL analysis focuses on total solar loads, it is important to note that differences between existing shade and target shade, as depicted in Figure 9, 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 for the entire segment is also listed in the table below and provides a general level of comparison among streams.

**Table 12. Total solar loads and average lack of shade for all tributaries.**

| Water Body | Total Existing Load (kWh/day) | Total Target Load (kWh/day) | Excess Load (kWh/day) (% Total Existing) | Average lack of Shade (%) |
|---|---|---|---|---|
| Jacks Creek | 1,100,000 | 770,000 | 320,000 (29%) | -23 |
| Little Jacks Creek | 420,000 | 370,000 | 43,000 (10%) | -10 |
| Big Jacks Creek | 2,000,000 | 2,100,000 | No excess | -3 |
| Clover Creek | 4,900,000 | 5,300,000 | No excess | -2 |
| Bruneau River | 13,000,000 | 14,000,000 | No excess | -1 |

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

**Table 13. Total solar loads and average lack of shade for listed assessment units.**

| Water Body | Total Existing Load (kWh/day) | Total Target Load (kWh/day) | Excess Load (kWh/day) (% Total Existing) | Average lack of Shade (%) |
|---|---|---|---|---|
| Jacks Creek ID17050102SW009_05 | 1,100,000 | 770,000 | 320,000 (29%) | -23 |
| Bruneau River ID17050102SW009_06 | 6,400,000 | 5,000,000 | 1,300,000 (20%) | -18 |
| Clover Creek ID17050102SW028_04 | 2,600,000 | 2,700,000 | No excess | -2 |
| Clover Creek ID17050102SW028_05 | 2,300,000 | 2,600,000 | No excess | -3 |

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

The Bruneau River had the highest existing and target solar loads commensurate with its size (Table 12). However, due to canyon wall shade, existing loads tended to be smaller than target loads, resulting in no excess heat loads to that river. Excess heat load is seen in the Bruneau River at the listed AU resulting from the agricultural area at its mouth, which has trees and shrubs and is outside of the canyon (Table 13). However, this area of the Bruneau River is also influenced by geothermal activity and would be expected to have higher river temperatures. Existing shade also exceeded target shade in Clover Creek with its large canyon sections. Thus, both listed AUs of Clover Creek do not have excess loads (Table 13). Figure 9 shows that most portions of these rivers meet target shade levels.

Big and Little Jacks Creeks are also dominated by canyon shade, but only Little Jacks Creek has excess heat loads (Table 12). Both streams may suffer from a lack of riparian shade in their headwaters due to their intermittent nature. Perennial flow does not exist at their headwaters or confluence. Flow in Jacks Creek further down the valley likely results from irrigation enhancements and geothermal springs. Jacks Creek appears to lack considerable riparian shade (Table 12). Excess solar load to Jacks Creek appears to be about 29% of its existing load (Tables 12 and 13).

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

### 5.4.1 Water Diversion

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

Although these water temperature effects may occur, nothing in this TMDL supersedes any water appropriation in the affected watershed. Section 101(g), the Wallop Amendment, was added to the Clean Water Act 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 this 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. This TMDL will lead to cooler water by achieving shade that would be expected under natural conditions and water temperatures resulting from that shade. DEQ encourages local landowners and holders of water rights to voluntarily do whatever they can to help instream flow for the purpose of keeping channel water cooler for aquatic life.

### 5.4.2 Margin of Safety

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

### 5.4.3 Seasonal Variation

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

### 5.4.4 Reasonable Assurance

Reasonable assurance will be achieved through implementation of measures that increase shading over time, through the monitoring of aquaculture temperatures to avoid exceedances of their wasteload allocations, and through improved vegetative cover along Jacks Creek. Various designated management agencies are listed under responsible parties (section 5.4.11) to help achieve the reduction of heat loading above natural conditions.

Already there has been at least one riparian work project implemented on Jacks Creek by one of the private landowners to allow for a portion of the adjacent land buffering Jacks Creek to have some grass filter strips, thus contributing to temperature reduction on Jacks Creek. The ISWCC (Southwest Idaho) will be the primary lead for nonpoint source implementation planning for private land ownership on Jacks Creek and the BLM for federal lands.

### 5.4.5 Wasteload Allocations

There are three NPDES point sources listed in EPA's PCS database in the affected watersheds: two fish farms along Jacks Creek (Ace Development, IDG130123, and Arraina Inc., IDG130122) and one feedlot with a discharge point listed as Jacks Creek via the South Side Canal (Bruneau Cattle Co., IDG010063). Water temperature and flow data were collected in the vicinity of the Arraina fish farm from summer 2013 to summer 2014. Continuously recording temperature monitors were placed at four locations in Jacks Creek and in two locations of Arraina's effluent stream. Flow was also recorded monthly at these locations. No temperature or flow data were obtained for the Ace Development fish farm. However, data generated for the Arraina wasteload allocation will be used as a guide for developing a wasteload allocation for Ace Development. No data are available for the Bruneau Cattle feedlot as there is no continuous discharge from this facility. Arraina fish farm discharges effluent water to an irrigation canal that conducts the effluent only (no other waters enter the canal) approximately 1.8 km down to a point on Jacks Creek 300 m below Cattle Drive Road. During the irrigation season, the effluent from Arraina is used to irrigate several pastures that surround the canal; thus effluent reaching Jacks Creek during irrigation season is reduced.

**Jacks Creek Flows**

Jacks Creek flows were monitored monthly at Shoofly Road, Cattle Drive Road, Davis Road, and the location immediately upstream of the discharge point. Irrigation seasons vary from year to year. In 2013, the canals were on up to and including the November 1, 2013, sampling event. The 2014 irrigation season ended before the October 22, 2014, sample event. Flows at the six locations in Table 14 vary depending on how they are affected by irrigation demands. Flows at Shoofly Road do not occur often, and when they do it is usually during the irrigation season probably in response to localized return flow from fields. Shoofly Road is a location on Jacks Creek that is above the influence of springs and seeps that occur in the reach downstream where the fish farms are located. Water in Jacks Creek at Shoofly Road is more representative of standing water from localized drainage. Above Shoofly Road is the reach below the confluence of Little Jacks Creek and Big Jacks Creek. Flow does not occur in this area every year, but is usually restricted to wet years when flow coming out of Big and Little Jacks Creeks is high. Flows in Jacks Creek at Cattle Drive Road are in response to the fish farm outlets and are less affected by season than other locations. Flows at Cattle Drive Road remain very constant (5–

6 cfs) throughout the year as a result of the springs in the area. Irrigation season flows in Jacks Creek immediately above the outfall (2.46 cfs) are half as much as flows during the nonirrigation season (5.34 cfs). This results from an agricultural diversion just below Cattle Drive Road.

**Table 14. Flow (cfs) for Jacks Creek and Arraina effluent—2013–2014.**

| Sample Date | Jacks Cr @ Shoofly Rd | Jacks Cr @ Cattle Drive | Jacks Cr above Outfall | Jacks Cr @ Davis Rd | Effluent @ Arraina | Effluent @ Outfall |
|---|---|---|---|---|---|---|
| 6/5/13 | | | 0.78 | | | 1.09 |
| 7/19/13 | | | 1.11 | | 3.49 | 2.01 |
| 8/8/13 | | | 0.4 | | 2.77 | 0.21 |
| 9/11/13 | | 4.71 | 2.06 | | 3.23 | 1.01 |
| 10/4/13 | 0.25 | 6.76 | 6.17 | | 4.29 | 3.5 |
| 11/1/13 | 0 | 5.63 | 6.84 | 9.57 | 3.72 | 3.63 |
| 12/13/13 | 0 | 5.69 | 5.39 | 13.97 | 4.5 | 4.29 |
| 1/13/14 | 0 | 6.28 | 5.53 | 11.84 | 4.88 | 4.2 |
| 2/10/14 | 0 | 6.44 | 5.08 | 12.11 | 4.76 | 4.28 |
| 3/10/14 | 0 | 6.02 | 5.36 | 11.7 | 4.79 | 4.79 |
| 4/15/14 | 0 | 6.32 | 4.76 | 10.08 | 3.73 | 1.35 |
| 6/9/14 | 0 | 5.09 | 1.05 | 2.69 | 3.57 | 0.89 |
| 6/30/14 | 1.0 | 5.49 | 0.64 | 2.11 | 2.96 | 0.71 |
| 8/11/14 | 0.62 | 5.08 | 0.8 | 2.03 | 3.15 | 1.12 |
| 9/15/14 | 0.6 | 5.99 | | 2.94 | | |
| 10/22/14 | 0 | 5.75 | | 9.43 | | |
| 11/13/14 | 0 | 5.62 | | 11.26 | | |
| Total avg | 0.19 | 5.78 | 3.28 | 8.31 | 3.83 | 2.36 |
| IR on avg | 0.55 | 5.27 | 2.46 | 2.44 | 3.43 | 1.55 |
| IR off avg | 0.03 | 6.06 | 5.34 | 11.25 | 4.73 | 4.39 |

*Note*: Irrigation on = orange, irrigation off = blue, IR = irrigation, avg = average or mean, Cr = creek, Rd = road.

### Jacks Creek Water Temperature

Water temperatures were recorded in Jacks Creek at Shoofly Road approximately 2.8 km above the fish farm outfalls from August 12, 2014, to November 12, 2014 (see Figure B-30 in Appendix B for temperature profile). This is a partial data set compared to other locations and is of limited use here. Temperatures at Shoofly Road appear to be similar to Jacks Creek at Cattle Drive Road (Figure 4), the next recording location downstream, for the same time period.

Water temperatures were recorded from summer 2013 (July or August) to late summer or fall 2014 (August–November) in Jacks Creek at: (1) Cattle Drive Road approximately 300 m upstream of the canal discharge point that carries flows from Arraina fish farm (Figure B-31), (2) a location immediately upstream of the canal discharge point that carries Arraina flows (Figure B-32), and (3) at Davis Road (Figure B-33) approximately 1.9 km downstream from the discharge point (Figure 4). There is a major point of agricultural diversion in that 300 m distance

from Cattle Drive Road to the temperature logger immediately above the discharge point which affects flows in the irrigation season.

Maximum temperature statistics for the various monitoring locations is provided in Table 15. With respect to daily and weekly maximum temperatures, Jacks Creek above the outfall and the effluent have very similar statistics. Daily and weekly average maximums are slightly cooler in Jacks Creek, reflecting more diurnal fluctuation than the effluent. Jacks Creek at Cattle Drive Road is even warmer than at the outfall. The statistics suggest that Jacks Creek at Davis Road, 1.9 km below the outfall, is 1 or 2 degrees cooler than Jacks Creek above the outfall.

**Table 15. Maximum temperature statistics for Jacks Creek and Arraina effluent—2013–2014.**

| Location | MDMT (Date) | MWMT (Date) | MDAT (Date) | MWAT (Date) |
|---|---|---|---|---|
| Jacks Cr @ Cattle Drive Rd | 41.1 °C (8/11/14) | 28.6 °C (7/16/14) | 26.1 °C (7/14/14) | 25.4 °C (7/17/14) |
| Jacks Cr above outfall | 33.6 °C (7/4/14) | 31.3 °C (7/6/14) | 25.9 °C (7/14/14) | 25.1 °C (7/16/14) |
| Jacks Cr @ Davis Rd | 28.8 °C (7/13/14) | 28.1 °C (7/16/14) | 24.6 °C (7/12/14) | 24.2 °C (7/17/14) |
| | | | | |
| Effluent @ facility | 35.9 °C (7/13/14) | 34.9 °C (7/14/14) | 33.4 °C (7/14/14) | 32.6 °C (7/14/14) |
| Effluent @ outfall | 33.0 °C (7/20/14) | 31.7 °C (7/26/14) | 28.6 °C (7/21/14) | 27.9 °C (7/26/14) |

*Note*: MDMT = maximum daily maximum temperature.
MWMT = maximum weekly maximum temperature. Dates for weekly statistics are the last day of the 7-day average.
MDAT = maximum daily average temperature.
MWAT = maximum weekly average temperature.

It is noted that Davis Road is approximately 1.2 miles downstream (or north) of Cattle Drive Road. The outfall of the irrigation canal at Cattle Drive Road into Jacks Creek is approximately 0.13 miles downstream (or north) of Cattle Drive Road. Based on DEQ's temperature data, the facility effluent MDAT is 33.4 °C and drops to 28.6 °C at the effluent outfall via the irrigation canal. Jacks Creek at Cattle Drive Road is 26.1 °C, dropping to 25.9 °C just above the outfall, and dropping to 24.6 °C by the time it gets to Davis Road.

### Arraina Fish Farm

The technical support document (Buhidar 2006) that was prepared for support of the Bruneau subbasin assessment and TMDL (DEQ, 2000), summarized the flows and temperatures found in the Arraina and Ace Development fish farms on Jacks Creek. Both farms are supplied with warm water from geothermal wells constructed in the 1940s. Influent temperatures averaged 36.7 ˚C and effluent temperatures averaged 26.8 ˚C, suggesting a 10˚ cooling as water passes through the facility and presumably down the canal. Influent and effluent flows also varied through each facility. Resulting effluent flows at that time were 4.4 cfs for Arraina and 2.7 cfs for Ace Development. The owner of these facilities indicated that 85% of the effluent flow is directed to agricultural lands during the irrigation season, thus only 15% of these flows reached Jacks Creek directly during that time period.

Water temperatures and flows were recorded during the 2013–2014 monitoring event in the Arraina effluent at two locations in the irrigation canal (Figure 10):

1. Immediately downstream of its release from the facility (Figure B-34)
2. Immediately above the point of discharge from the canal to Jacks Creek (Figure B-35).

Effluent water flows were monitored monthly during the 2013–2014 temperature monitoring time period at the two irrigation canal locations (Table 14).

Effluent flows at the outfall are substantially reduced compared to facility flows during the irrigation season, primarily due to its use as irrigation water for nearby fields. Although historically 85% of the flow is diverted for agriculture, return flows cause the volume reduction to be closer to 30%. Effluent flow coming out of the Arraina facility averaged 3.43 cfs during the irrigation season but only 1.55 cfs at the outfall, a reduction by 54.8%. During the non-irrigation season, effluent flows at either end of the canal were more similar (4.73 cfs and 4.39 cfs), a reduction by 7.2% (see Table 14).

Effluent temperatures at the facility varied from 30–35 °C in the summer months (i.e., June, July, and August) to 20–25 °C in the winter months (December, January, and February; Figure B-34). Effluent temperatures at the outfall (Figure B-35) were more variable presumably as a result of exposure to the environment in the canal. Maximum temperature statistics (Table 15) show that maximum daily averages for the effluent at the outfall were consistently about 4.8 °C lower than at the facility (or the facility effluent of 33.4 °C minus the effluent at the outfall of 28.6 °C, or a net of 4.8 °C). Daily and weekly maximum effluent temperatures at the outfall were very similar to the same statistics for Jacks Creek above the outfall (Table 15). However, daily and weekly maximum temperatures of the effluent outfall were several degrees warmer than Jacks Creek; whereas, the maximum weekly average was less (see Table 15).

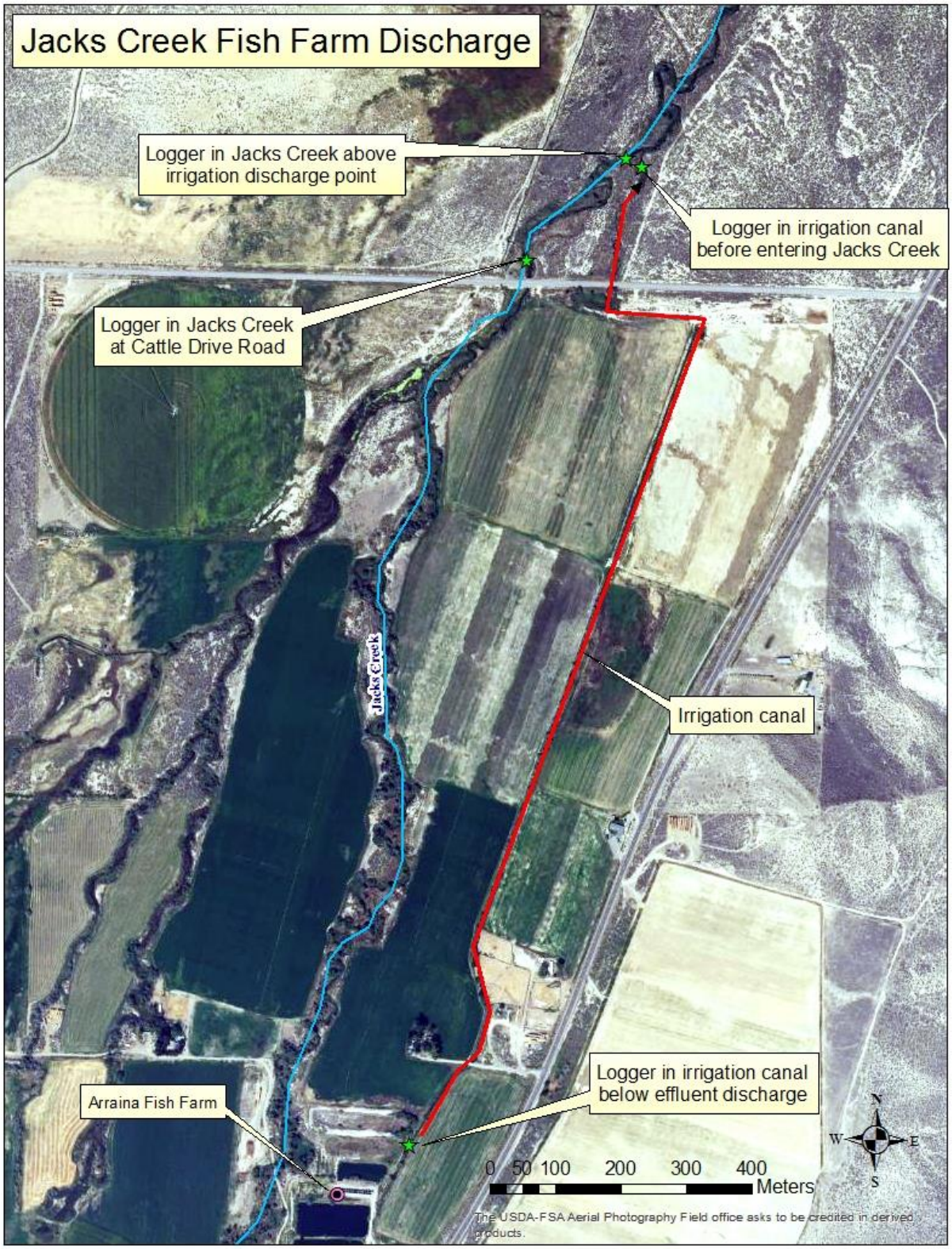


**Figure 10. Temperature logger placement in the vicinity of Arraina outfall.**

### Wasteload Allocation

In order to determine an appropriate wasteload allocation for the Arraina outfall, given that most waters in the area are geothermally influenced, DEQ first tested the mixing characteristics of the effluent as it enters Jacks Creek with the Cormix Mixing Zone Expert System model. DEQ used the heated discharge routine with channel dimensions measured in the field for both Jacks Creek and the outfall channel. DEQ chose to model average conditions that occur within the seasonal CWAL beneficial use season of June 21–September 22. Flow in Jacks Creek above the outfall was modeled as 1.1 cfs; average effluent flow was 1 cfs. The average of the daily averages from that time period for Jacks Creek was 22.6 °C, whereas the effluent average was 2.5 °C warmer at 25.1 °C. Other model parameters included a heat loss coefficient of 20 $W/m^2$ °C and water densities dependent on temperature differential. The Cormix model showed at the point of complete mixing in the water column and before passive decay, the effluent temperature excess would decrease from 2.5 °C to 0.78 °C in 400 m downstream. The allowable increase as indicated in Idaho Water Quality Standards is 0.15 °C or one-half of 0.3 °C allowable increase. The other half of this allowable increase is dedicated to the Ace Development fish farm discharge upstream of Arraina's outfall.

The Cormix model was used to predict what effluent excess temperature would be permissible to allow for only 0.15 °C increase in Jacks Creek at complete mixing. An effluent excess temperature of 0.3 °C is required. To establish a wasteload allocation for each fish farm, we added 0.3 °C to the 25.1 °C maximum weekly average temperature (MWAT in Table 15) of Jacks Creek above the outfall to obtain a wasteload allocation of 25.4 °C (or 0.3 °C + 25.1 °C = 25.4 °C) for each fish farm during the seasonal CWAL season. Therefore, the temperature value of 25.4 °C represents the temperature wasteload allocation for each facility. Figure 11 displays the daily average temperatures for Jacks Creek above the outfall, the wasteload allocation of 25.4 °C above that average (shown as a red line), and Arraina effluent daily average at the point of discharge. See also Table 15. During the 2013–2014 monitoring period, effluent daily averages exceeded the wasteload allocation in 58 of 116 days or 50% of the time.

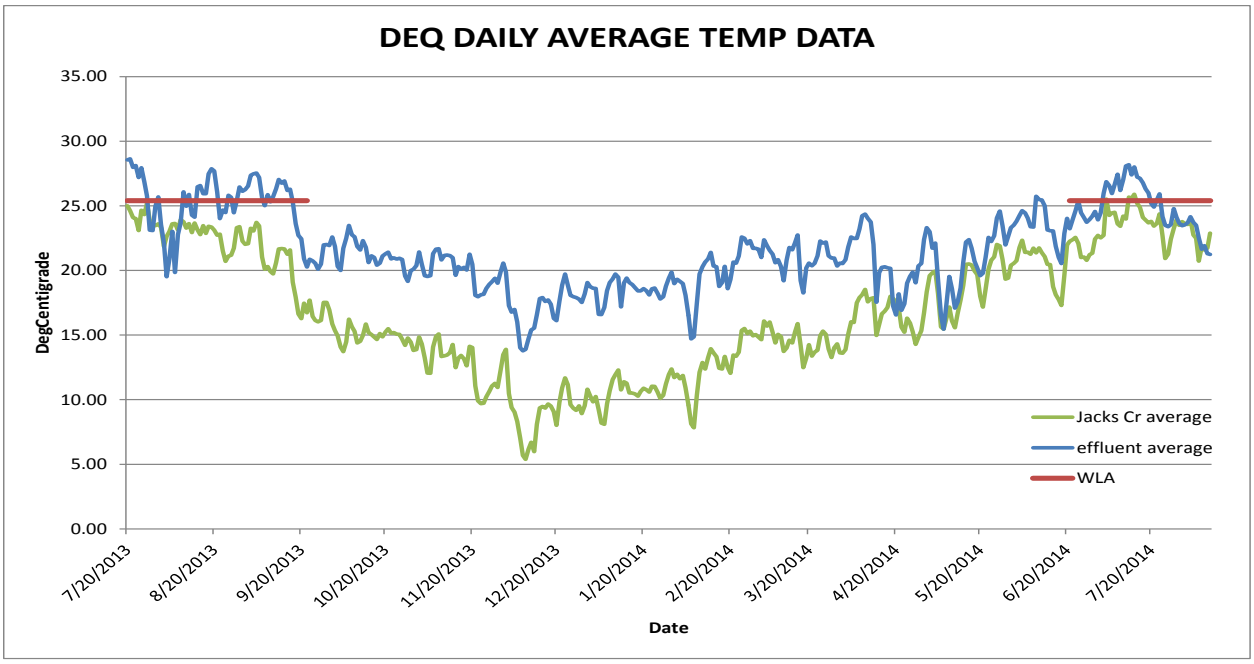


**Figure 11. Daily average temperatures for Jacks Creek and Arraina effluent (2013–2014).**

Should other point sources be proposed that would have thermal consequence on these waters, then background provisions addressing such discharges in Idaho water quality standards (IDAPA 58.01.02.200.09 and IDAPA 58.01.02.401.01) should be involved (see Appendix A).

### 5.4.6 Construction Stormwater

Stormwater runoff is water from rain or snowmelt that does not immediately infiltrate into the ground and flows over or through natural or man-made storage or conveyance systems. When undeveloped areas are converted to land uses with impervious surfaces—such as buildings, parking lots, and roads—the natural hydrology of the land is altered and can result in increased surface runoff rates, volumes, and pollutant loads. Certain types of stormwater runoff are considered point source discharges for Clean Water Act purposes, including stormwater that is associated with municipal separate storm sewer systems (MS4s), industrial stormwater covered under the Multi-Sector General Permit (MSGP), and construction stormwater covered under the Construction General Permit (CGP).

#### *5.4.6.1 Municipal Separate Storm Sewer Systems*

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

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

As of September 22, 2015 there were no MS4s in the Bruneau River subbasin.

#### *5.4.6.2 Industrial Stormwater Requirements*

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

**Multi-Sector General Permit and Stormwater Pollution Prevention Plans**

In Idaho, if an industrial facility discharges industrial stormwater into waters of the U.S., the facility must be permitted under EPA's most recent MSGP. To obtain an MSGP, the facility must prepare a stormwater pollution prevention plan (SWPPP) before submitting a notice of intent for permit coverage. The SWPPP must document the site description, design, and installation of control measures; describe monitoring procedures; and summarize potential pollutant sources. A copy of the SWPPP must be kept on site in a format that is accessible to workers and inspectors and be updated to reflect changes in site conditions, personnel, and stormwater infrastructure. There are no known MSGPs discharging to the temperature listed streams in this TMDL.

**Industrial Facilities Discharging to Impaired Water Bodies**

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

Also, because different industrial activities have sector-specific types of material that may be exposed to stormwater, EPA grouped the different regulated industries into 29 sectors, based on their typical activities. Part 8 of EPA's MSGP details the stormwater management practices and monitoring that are required for the different industrial sectors. EPA anticipates issuing a new MSGP in December 2013. DEQ anticipates including specific requirements for impaired waters as a condition of the 401 certification. The new MSGP will detail the specific monitoring requirements.

**TMDL Industrial Stormwater Requirements**

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

#### *5.4.6.3 Construction Stormwater*

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

**Construction General Permit and Stormwater Pollution Prevention Plans**

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

DEQ determined that as of September 22, 2015, the EPA 2012 CGP for Bruneau County had only two projects. They are described as Twin Wetland Restoration Projects and include the following:

- IDR12C578 – Ducks Unlimited – Bruneau River Ranch Restoration: Submitted 01/11/2013 and terminated 01/25/2013. Impaired water = Bruneau River. This project involved construction of a series of low-profile dikes and installation of water-control structures to enhance natural floodwater distribution, supplement the floodplain with irrigation water, and restore seasonally flooded shallow grasslands. (See www.ducks.org/idaho/twin-wetland-restoration-projects-completed-in-southern-idaho for more information.) The total size is a 100-acre project in the Bruneau River floodplain.
- IDR12C861 – Ducks Unlimited – Obendorf Restoration: Submitted 02/01/2013 and terminated 02/15/2013. Impaired water = Jacks Creek. The total size is a 101-acre project on the Little Jacks Creek floodplain.

**TMDL Construction Stormwater Requirements**

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

**Post-construction Stormwater Management**

Many communities throughout Idaho are currently developing rules for post-construction stormwater management. Sediment is usually the main pollutant of concern in construction site stormwater. DEQ's *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties* (DEQ 2005) should be used to select the proper suite of BMPs for the specific site, soils, climate, and project phasing in order to sufficiently meet the standards and requirements of the CGP to protect water quality. Where local ordinances have more stringent and site-specific standards, those are applicable.

### 5.4.7 Reserve for Growth

There is no reserve for growth provided. There is no mention of future growth reserved from the load capacity in the Bruneau River TMDL (EPA approved 2000). But in the Jacks Creek TMDL reference is made to "existing or future point sources of pollution" (Buhidar 2007, p. 7) for point sources and nonpoint sources Buhidar 2007, p. 10) of pollution. And it can be concluded that it would only be derived from the existing loading capacity for each pollutant and if growth is possible given other industries already having an allocation. The Jacks Creek TMDL states the following:

- "In terms of future growth for nonpoint sources, no specific allocation was set aside for this; therefore the allocation is zero" (Buhidar 2007, p. 12).
- "The conversion of nonpoint source lands to point sources would require the NPDES permitting process and is a separate issue from what has been discussed as future growth for nonpoint sources; but likewise must meet the limitations imposed by their NPDES permit to protect and maintain the beneficial uses of Jacks Creek" (Buhidar 2007, p. 12).

Consequently, there is no reserve for growth provided in this TMDL.

### 5.4.8 Implementation Strategies

Implementation strategies for TMDLs produced using PNV-based shade and solar loads should incorporate the load analysis tables presented in this TMDL (Tables 7–11). 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 the TMDL goals are not being met or significant progress is not being made toward achieving the goals.

### 5.4.9 Time Frame

Increases in shade provided to the stream from riparian vegetation may only take a few years to establish, but many years will be required for vegetation to achieve its full potential to reduce solar inputs. Once implementation actions and strategies have been established, DEQ believes 10–20 years (depending on vegetation type) will be required for a diverse and mature vegetation community to become well-established and provide maximum shade to meet water quality standards. Shade targets will not be achieved all at once. Given their smaller bank-full widths, smaller streams may reach shade targets sooner than larger streams.

DEQ and the designated watershed advisory group (WAG) or basin advisory group (BAG) 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.

### 5.4.10 Approach

TMDLs will be implemented through the continuation of ongoing pollution control activities in the subbasin. The designated WAG or BAG, designated management agencies (DMAs), local organizations, and other appropriate public process participants are expected to do the following:

- Develop BMPs to achieve load allocations.
- Give reasonable assurance that management actions will meet load allocations through both quantitative and qualitative analysis of management measures.
- Adhere to measurable milestones for progress.
- Develop a timeline for implementation, including cost and funding.
- Develop a monitoring plan to determine if BMPs are being implemented, if individual BMPs are effective, and if load allocations are being met.
- Determine whether stormwater BMPs increase or reduce runoff temperatures. These may include conventional BMPs (vegetated swale, detention pond, retention pond), low impact development (bioretention, gravel wetland) and manufactured treatment devices (storm tech isolator row, ADS [Advanced Drainage System] infiltration system, hydrodynamic separator).
- Identify BMP design parameters that influence temperature reduction. BMPs that may be explored include: development of a bioretention area (to allow stormwater to infiltrate into the soil), development of a stormwater wetland (with an inlet and outlet design) and development of a wet pond system (water depths greater than 4 feet).

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

### 5.4.11 Responsible Parties

In addition to the DMAs, the public—through the WAG or BAG and other equivalent organizations or processes—will have opportunities to be involved in developing the implementation plan to the maximum extent practical. The following Idaho DMAs are responsible for management activities:

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

The US Forest Service and Bureau of Land Management, through governmental memoranda of understanding, also serve as designated agencies on the federal lands they manage.

Ultimately, however, it is the on-the-ground land managers, landowners, and citizens who are responsible for implementation and who reap the rewards of achieving the plan's goals.

### 5.4.12 Monitoring Strategy

Effective shade monitoring can take place on any reach throughout the Bruneau River subbasin and be compared to existing shade estimates seen in Figure 8 and described in Tables 7–11. 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 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.

Monitoring conducted within the Bruneau River subbasin to evaluate the effectiveness of BMPs and ambient water quality will be conducted using DEQ-approved monitoring procedures at the time of sampling. These procedures will help to ensure the data are compatible and useable during the DEQ assessment process. Monitoring progress toward achieving shade targets will follow the guidelines established in *The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar and De Varona 2009).

# 6 Conclusions

This study suggests that the Bruneau River subbasin is largely meeting shade targets due to its extreme inaccessibility and topographic shade. Only a few areas require riparian improvements. The Bruneau River subbasin is characterized by deep basalt canyons and has many areas with significant topographic shade exceeding expectations based on riparian vegetation alone.

The region does have stream segments that are impacted by a lack of shade and should be investigated. Several locations experience disturbance in agricultural/grazing areas outside of canyons (e.g., Jacks Creek and lower Bruneau River). Jacks Creek had significant lack of shade, possibly due to a lack of water in this area preventing riparian development. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts. A summary of the outcomes of this temperature TMDL assessment is provided in Table 16.

**Table 16. Summary of assessment outcomes.**

| Water Body / Assessment Unit | Pollutant | TMDL(s) Completed | Recommended Changes to §303(d) List | Justification |
|---|---|---|---|---|
| Bruneau River ID17050102SW009_06 | Temperature | Yes | Move to Category 4a | Excess solar load from lack of shade |
| Clover Creek ID17050102SW028_05 ID17050102SW028_04 | Temperature | Yes | Move to Category 4a | Excess solar load from lack of shade |
| Jacks Creek ID17050102SW002_05 | Temperature | Yes | Move to Category 4a | Excess solar load from lack of shade |
| Buck Flat Draw ID17050102SW035_04 | Temperature | No | Move to Category 3 | This reach has never been assessed by DEQ. No temperature data exists suggesting impairment. It was erroneously listed in 2002. |

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

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## GIS Coverages

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# Glossary

**§303(d)**

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

**Ambient**

General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).

**Anthropogenic**

Relating to, or resulting from, the influence of human beings on nature.

**Assessment Unit (AU)**

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

**Beneficial Use**

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

**Beneficial Use Reconnaissance Program (BURP)**

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

**Exceedance**

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

**Fully Supporting**

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

**Load Allocation (LA)**

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

| | |
|---|---|
| **Load(ing)** | The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration. |
| **Load Capacity (LC)** | How much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, a margin of safety, and natural background contributions, it becomes a total maximum daily load. |
| **Margin of Safety (MOS)** | An implicit or explicit portion of a water body's loading capacity set aside to allow for uncertainty about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution. |
| **Natural Condition** | The condition that exists with little or no anthropogenic influence. |
| **Nonpoint Source** | A dispersed source of pollutants generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point of origin. They include, but are not limited to, irrigated and nonirrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites. |
| **Not Assessed (NA)** | A concept and an assessment category describing water bodies that have been studied but are missing critical information needed to complete a use support assessment. |
| **Not Fully Supporting** | Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002). |
| **Point Source** | A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable "point" of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater. |

**Pollutant**

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

**Pollution**

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

**Potential Natural Vegetation (PNV)**

A.U. Küchler (1964) defined potential natural vegetation as vegetation that would exist without human interference and if the resulting plant succession were projected to its climax condition while allowing for natural disturbance processes such as fire. Our use of the term reflects Küchler's definition in that riparian vegetation at PNV would produce a system potential level of shade on streams and includes recognition of some level of natural disturbance.

**Riparian**

Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.

**Stream Order**

Hierarchical ordering of streams based on the degree of branching. A 1st-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher-order streams result from the joining of two streams of the same order.

**Total Maximum Daily Load (TMDL)**

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

**Wasteload Allocation (WLA)**

The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution.

| | |
|---|---|
| | Wasteload allocations specify how much pollutant each point source may release to a water body. |
| **Water Body** | A stream, river, lake, estuary, coastline, or other water feature, or portion thereof. |
| **Water Quality Criteria** | Levels of water quality expected to render a water body suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes. |
| **Water Quality Standards** | State-adopted and US Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses. |

# Appendix A. 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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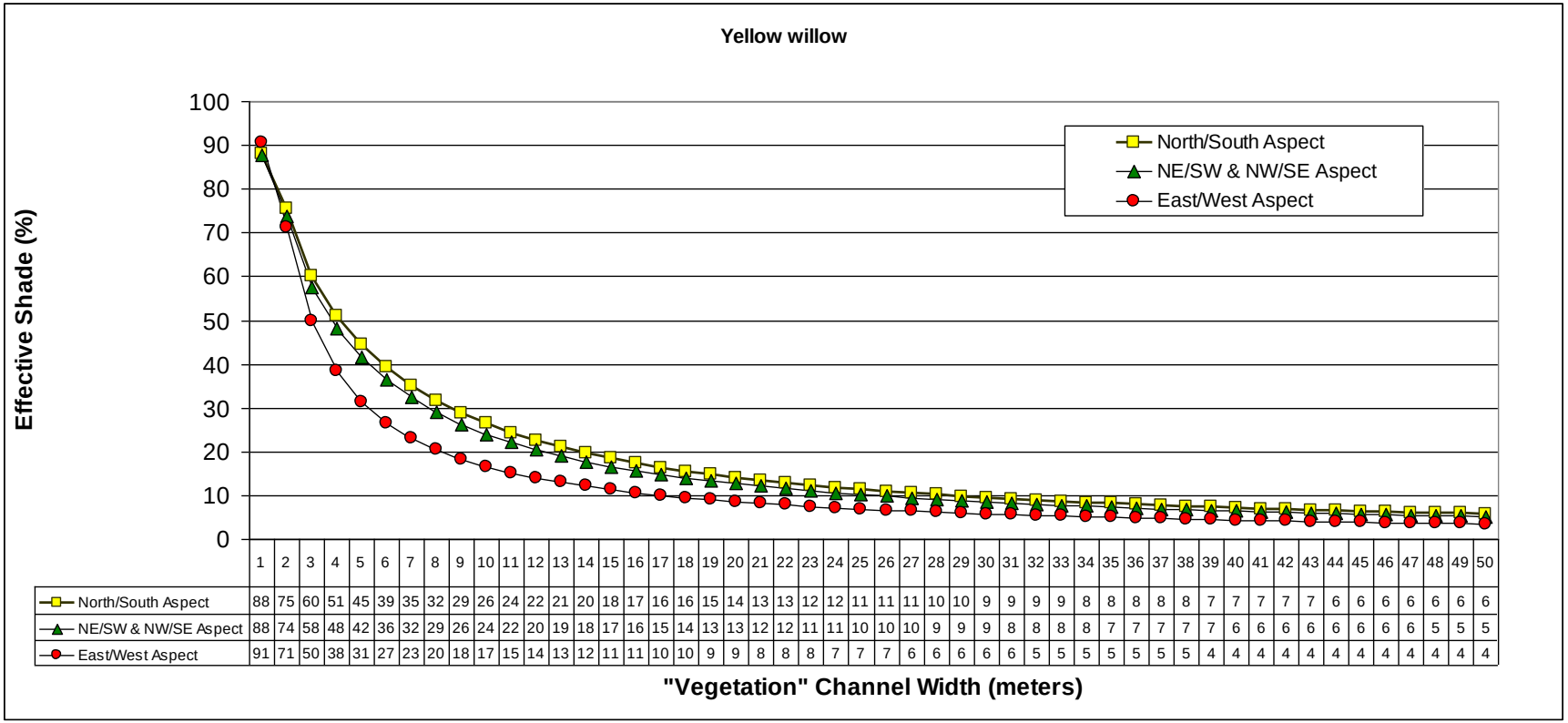
# Appendix B. Data Sources and Target Shade Curves

## Data Sources

**Table B-1. Data sources for Bruneau River subbasin TMDLs.**

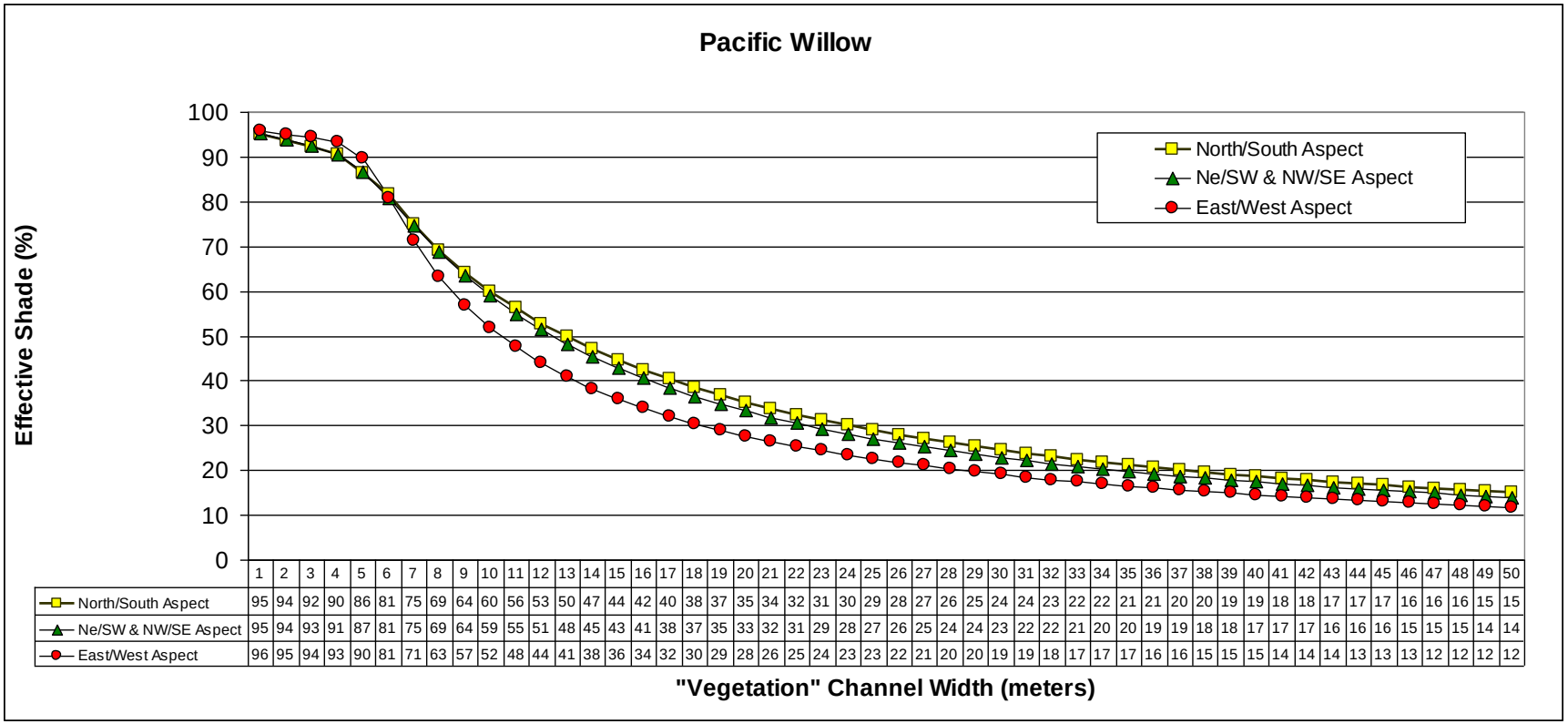
| Water Body | Data Source | Type of Data | Collection Date |
|---|---|---|---|
| Bruneau River and 12 tributaries | DEQ State Technical Services Office | Solar Pathfinder effective shade and stream width | September–October 2006 |
| Bruneau River and 12 tributaries | DEQ State Technical Services Office | Aerial photo interpretation of existing shade and stream width estimation | August–September 2006 |
| Bruneau River, Clover Creek, Jacks Creek | DEQ IDASA database | Temperature | |

## Shade Curves



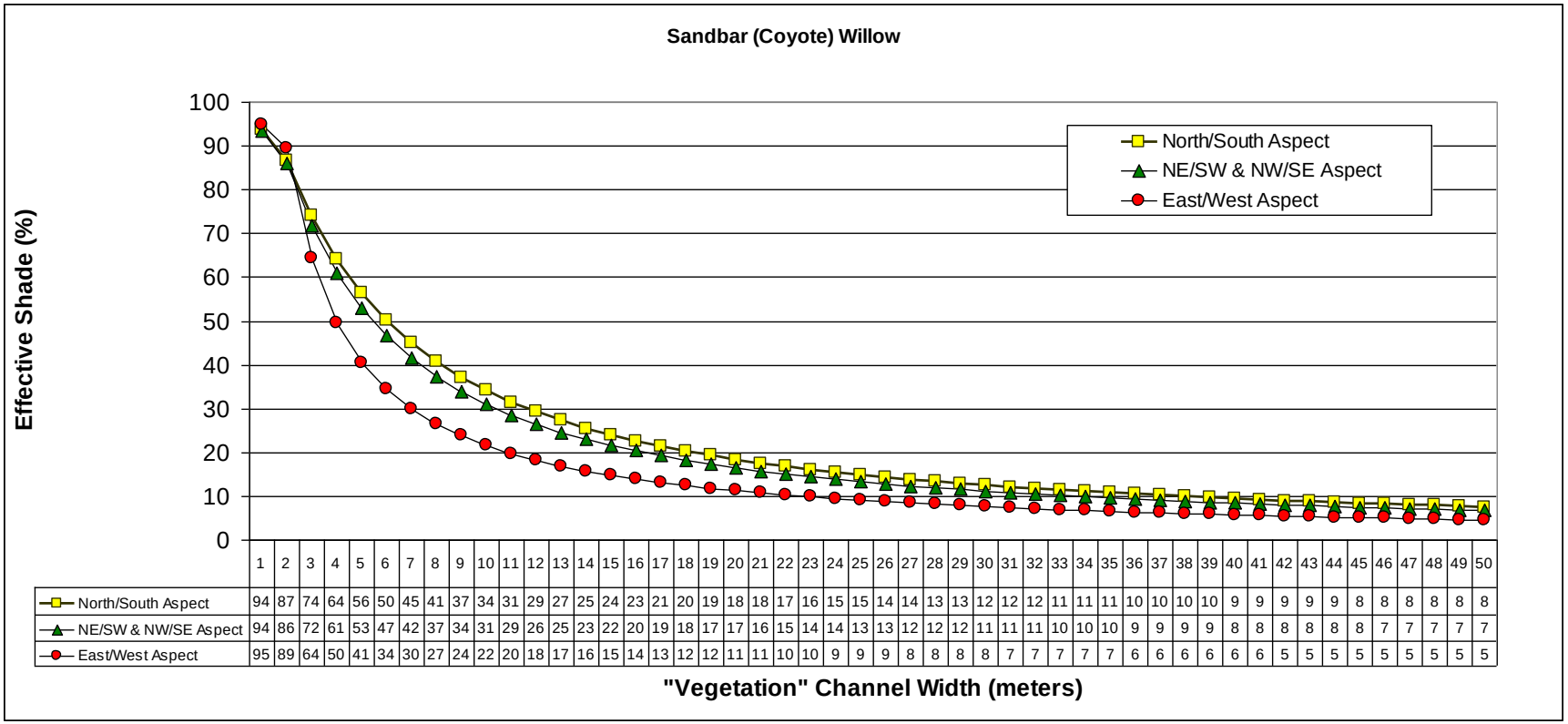

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North/South Aspect | 88 | 75 | 60 | 51 | 45 | 39 | 35 | 32 | 29 | 26 | 24 | 22 | 21 | 20 | 18 | 17 | 16 | 16 | 15 | 14 | 13 | 13 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| NE/SW & NW/SE Aspect | 88 | 74 | 58 | 48 | 42 | 36 | 32 | 29 | 26 | 24 | 22 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 13 | 12 | 12 | 11 | 11 | 10 | 10 | 10 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 |
| East/West Aspect | 91 | 71 | 50 | 38 | 31 | 27 | 23 | 20 | 18 | 17 | 15 | 14 | 13 | 12 | 11 | 11 | 10 | 10 | 9 | 9 | 8 | 8 | 8 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

**Figure B-1. Yellow willow (*Salix lutea*) vegetation type. Corrected for 25% overlap.**



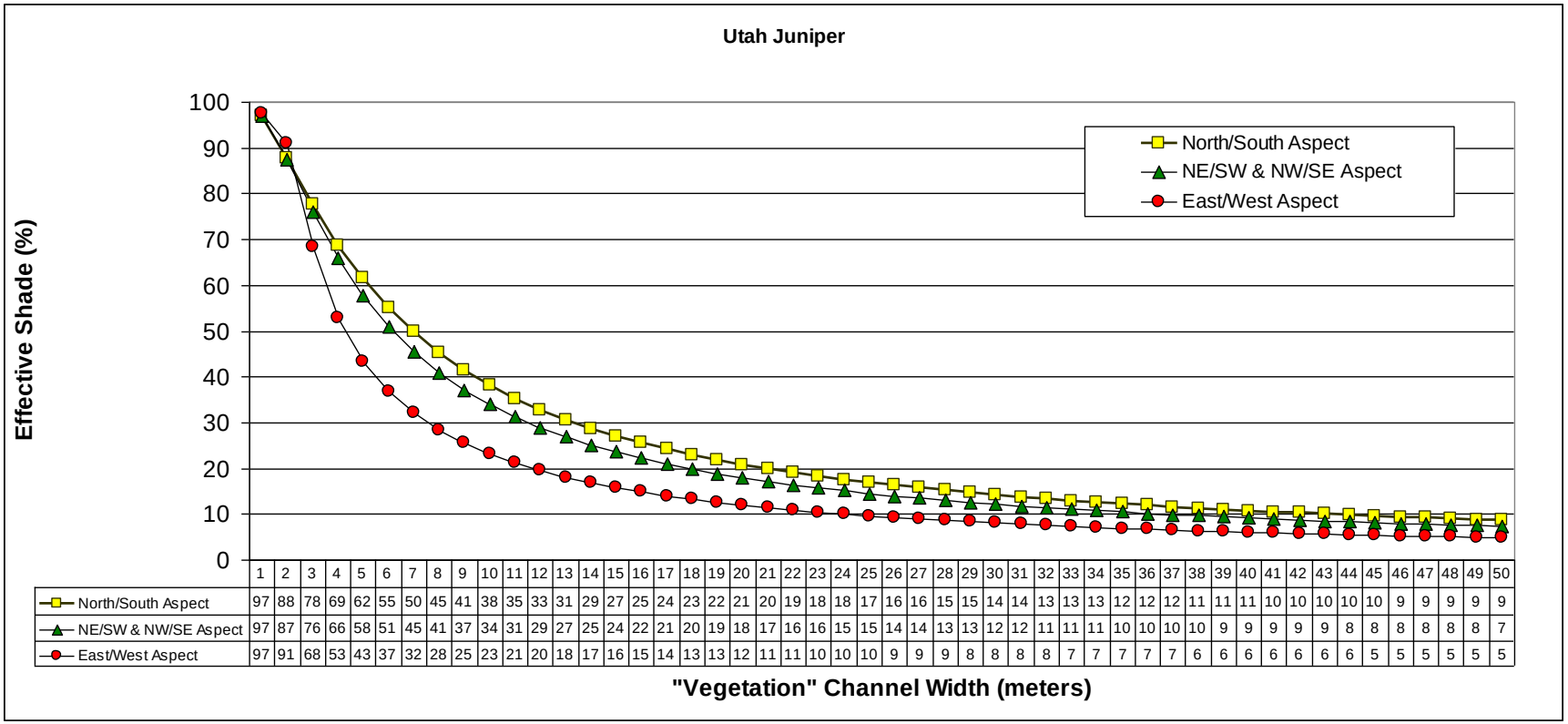

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North/South Aspect | 95 | 94 | 92 | 90 | 86 | 81 | 75 | 69 | 64 | 60 | 56 | 53 | 50 | 47 | 44 | 42 | 40 | 38 | 37 | 35 | 34 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 24 | 23 | 22 | 22 | 21 | 21 | 20 | 20 | 19 | 19 | 18 | 18 | 17 | 17 | 17 | 16 | 16 | 16 | 15 | 15 |
| Ne/SW & NW/SE Aspect | 95 | 94 | 93 | 91 | 87 | 81 | 75 | 69 | 64 | 59 | 55 | 51 | 48 | 45 | 43 | 41 | 38 | 37 | 35 | 33 | 32 | 31 | 29 | 28 | 27 | 26 | 25 | 24 | 24 | 23 | 22 | 22 | 21 | 20 | 20 | 19 | 19 | 18 | 18 | 17 | 17 | 17 | 16 | 16 | 16 | 15 | 15 | 15 | 14 | 14 |
| East/West Aspect | 96 | 95 | 94 | 93 | 90 | 81 | 71 | 63 | 57 | 52 | 48 | 44 | 41 | 38 | 36 | 34 | 32 | 30 | 29 | 28 | 26 | 25 | 24 | 23 | 23 | 22 | 21 | 20 | 20 | 19 | 19 | 18 | 17 | 17 | 17 | 16 | 16 | 15 | 15 | 15 | 14 | 14 | 14 | 13 | 13 | 13 | 12 | 12 | 12 | 12 |

**Figure B-2. Pacific willow (*Salix lucida* ssp*. lasiandra*) vegetation type. Corrected for 25% overlap.**



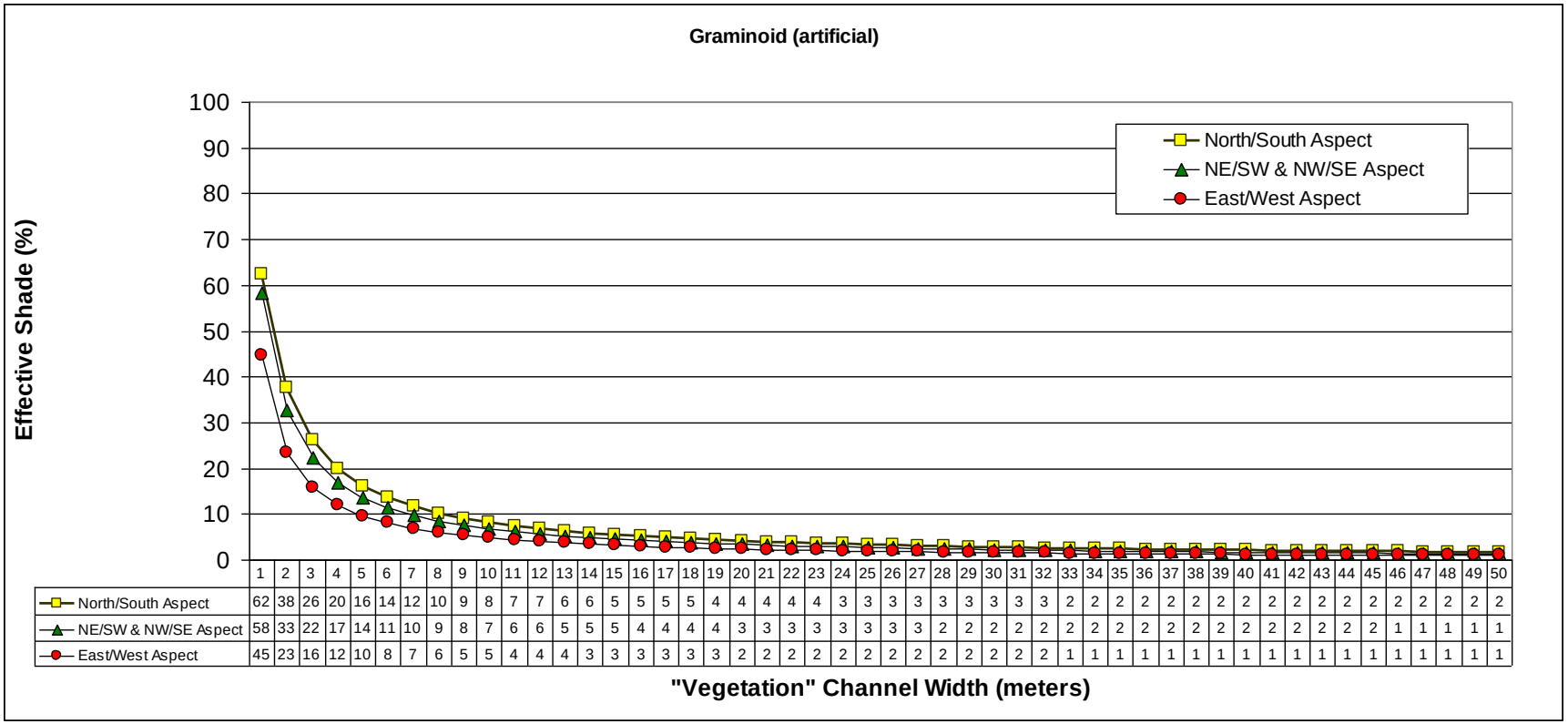

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North/South Aspect | 94 | 87 | 74 | 64 | 56 | 50 | 45 | 41 | 37 | 34 | 31 | 29 | 27 | 25 | 24 | 23 | 21 | 20 | 19 | 18 | 18 | 17 | 16 | 15 | 15 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 |
| NE/SW & NW/SE Aspect | 94 | 86 | 72 | 61 | 53 | 47 | 42 | 37 | 34 | 31 | 29 | 26 | 25 | 23 | 22 | 20 | 19 | 18 | 17 | 17 | 16 | 15 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 7 |
| East/West Aspect | 95 | 89 | 64 | 50 | 41 | 34 | 30 | 27 | 24 | 22 | 20 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 12 | 11 | 11 | 10 | 10 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

**Figure B-3. Coyote willow (*Salix exigua*) vegetation type.**




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North/South Aspect | 97 | 88 | 78 | 69 | 62 | 55 | 50 | 45 | 41 | 38 | 35 | 33 | 31 | 29 | 27 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 18 | 17 | 16 | 16 | 15 | 15 | 14 | 14 | 13 | 13 | 13 | 12 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 |
| NE/SW & NW/SE Aspect | 97 | 87 | 76 | 66 | 58 | 51 | 45 | 41 | 37 | 34 | 31 | 29 | 27 | 25 | 24 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 16 | 15 | 15 | 14 | 14 | 13 | 13 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 7 |
| East/West Aspect | 97 | 91 | 68 | 53 | 43 | 37 | 32 | 28 | 25 | 23 | 21 | 20 | 18 | 17 | 16 | 15 | 14 | 13 | 13 | 12 | 11 | 11 | 10 | 10 | 10 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 |

**Figure B-4. Utah juniper (*Juniperus osteosperma*) vegetation type. Corrected for 25% overlap.**




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North/South Aspect | 62 | 38 | 26 | 20 | 16 | 14 | 12 | 10 | 9 | 8 | 7 | 7 | 6 | 6 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| NE/SW & NW/SE Aspect | 58 | 33 | 22 | 17 | 14 | 11 | 10 | 9 | 8 | 7 | 6 | 6 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| East/West Aspect | 45 | 23 | 16 | 12 | 10 | 8 | 7 | 6 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Figure B-5. Graminoid (grass meadow) vegetation type.**

## Temperature Data

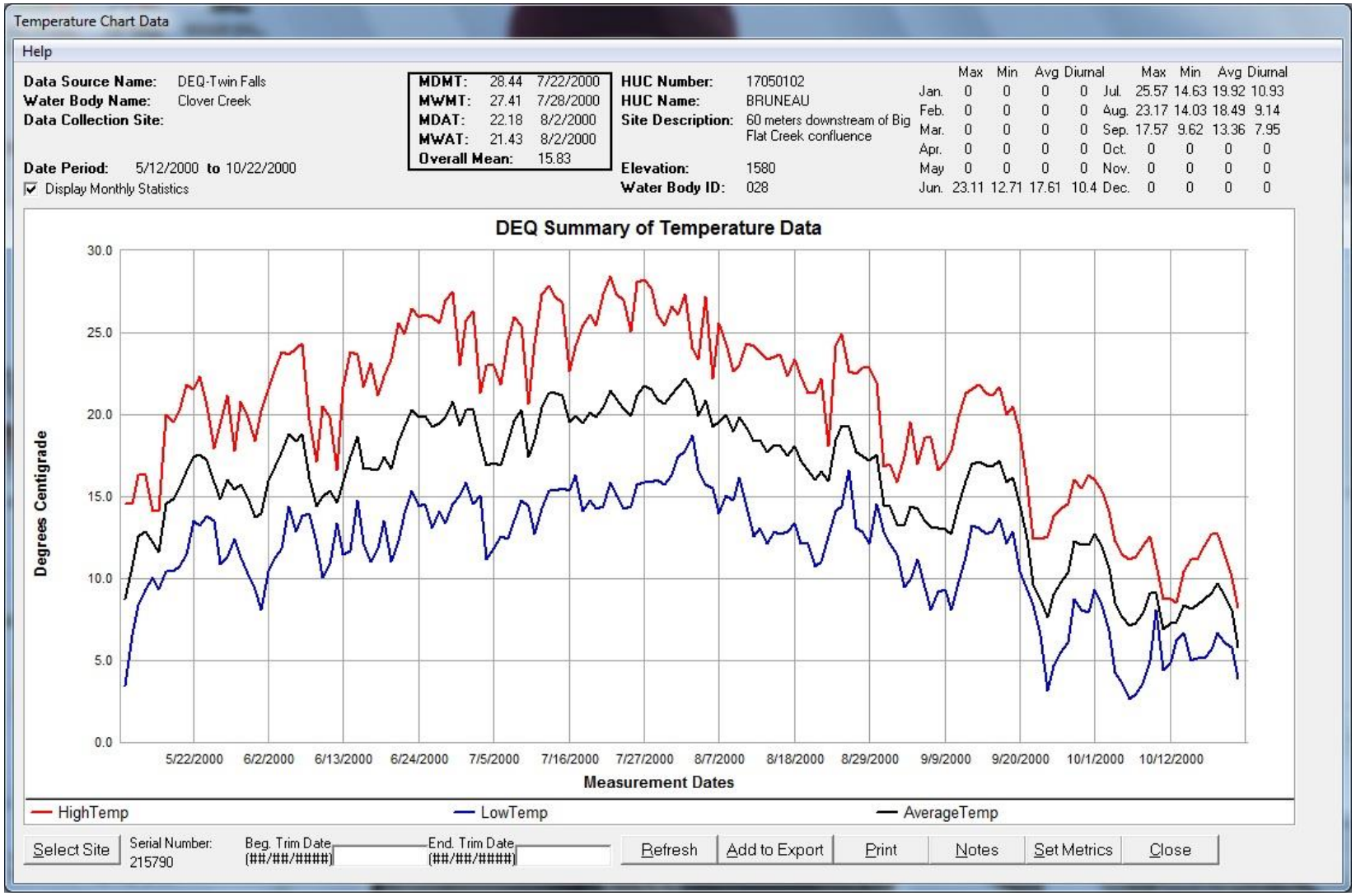



**Figure B-6. Listing temperature data for Clover Creek (2000STWFTL0010).**

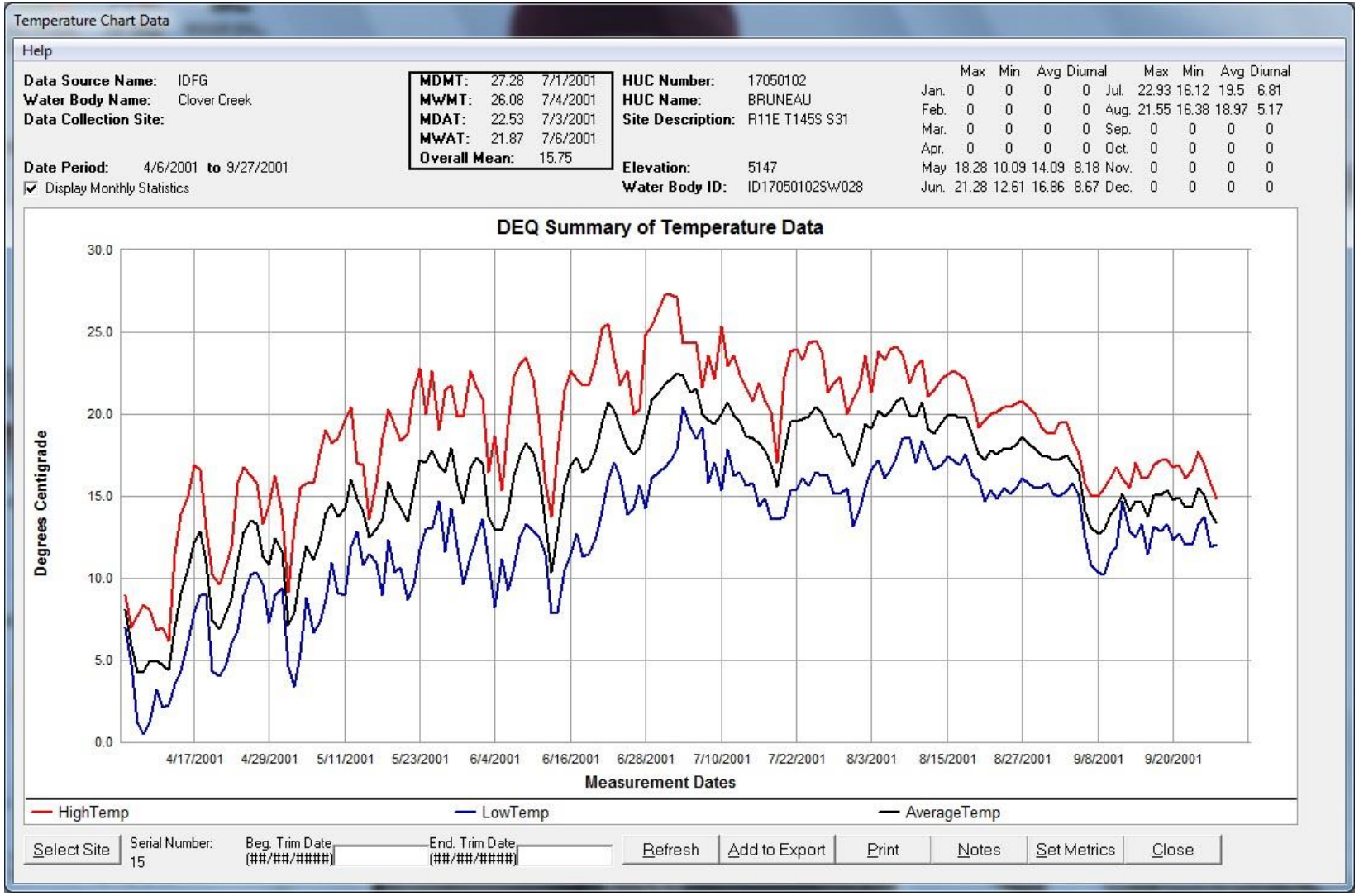



**Figure B-7. Listing temperature data for Clover Creek (2001IDFGTL012).**

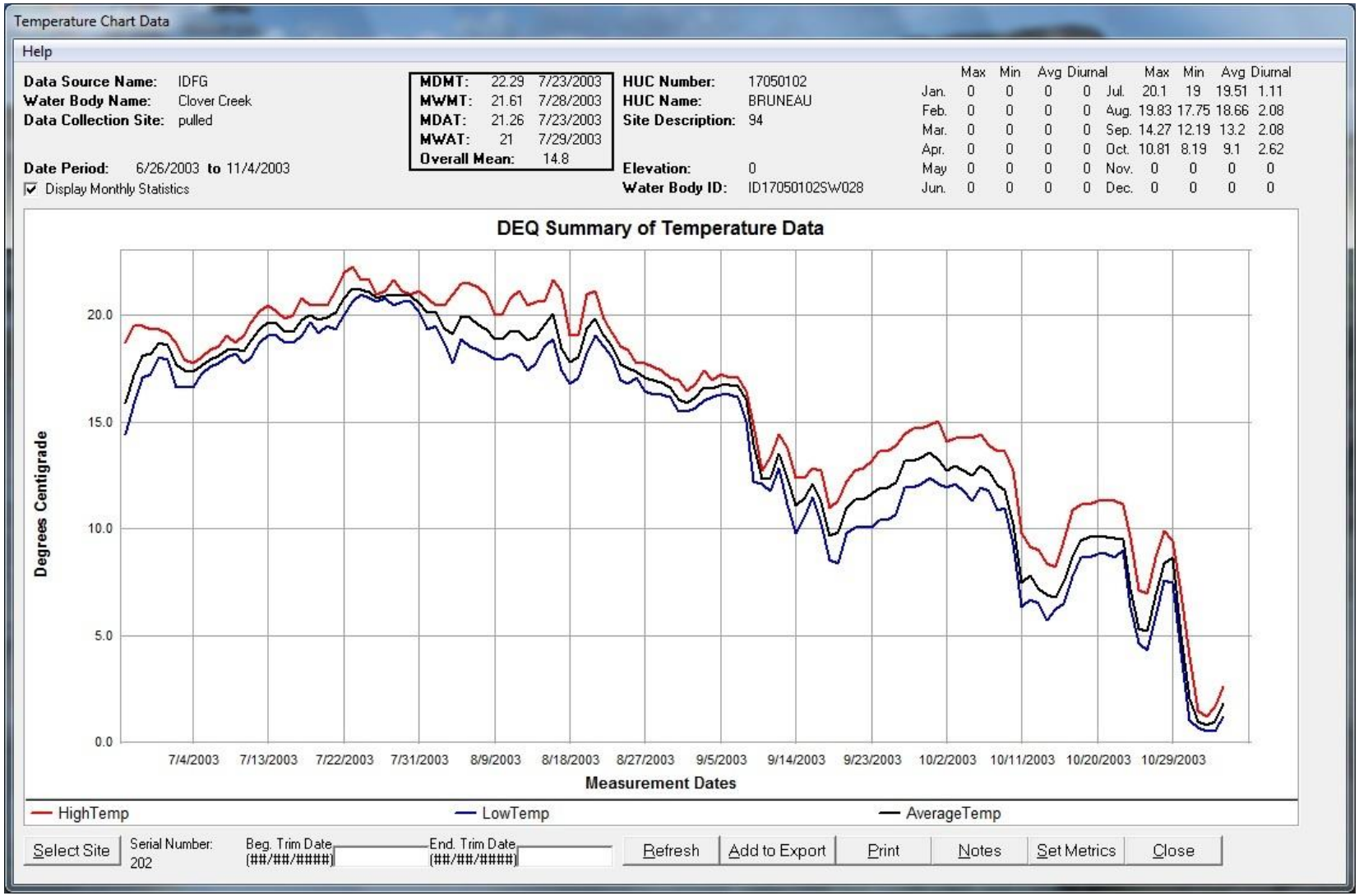



**Figure B-8. Listing temperature data for Clover Creek (2003IDFGTL194).**

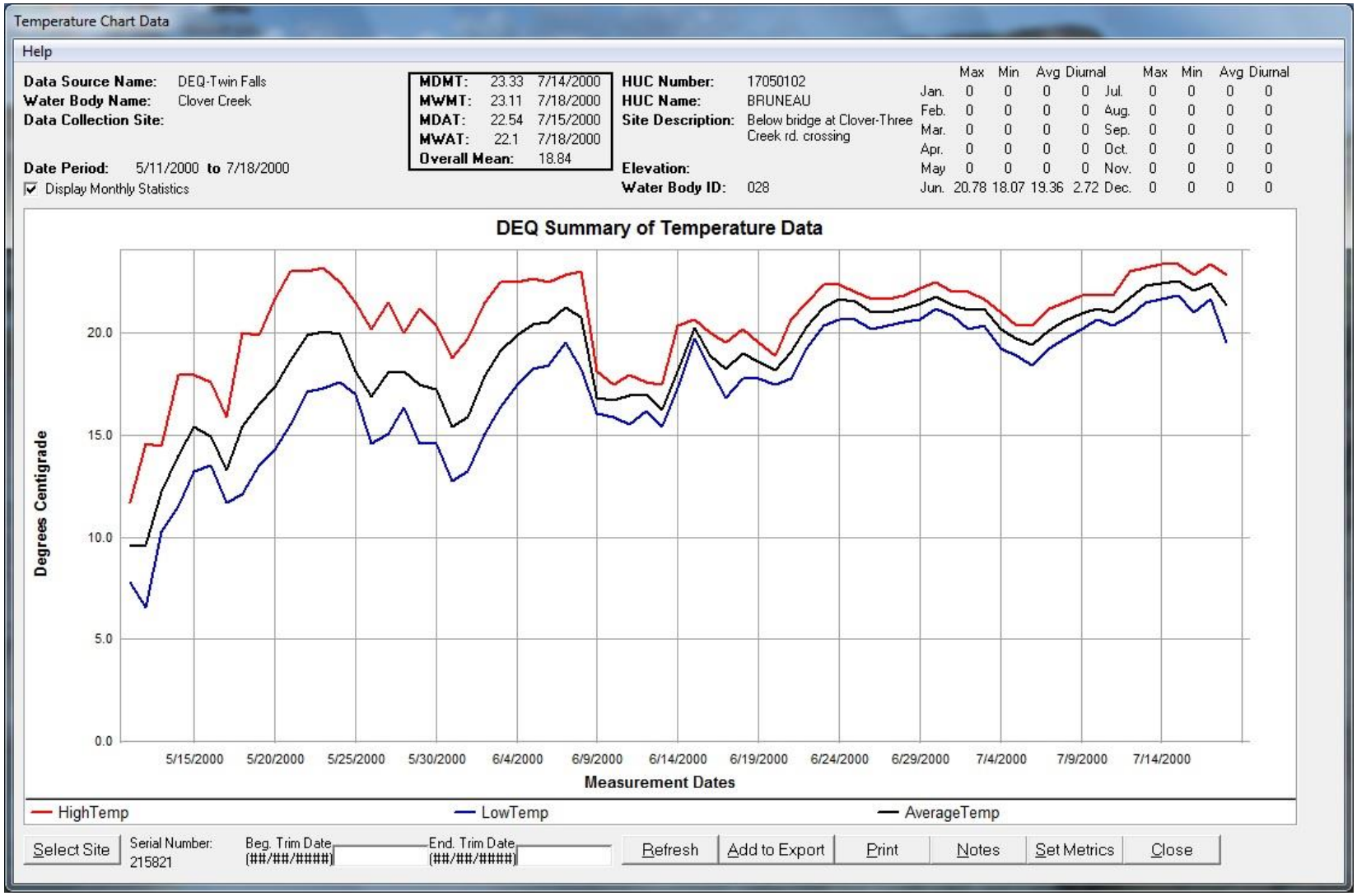



**Figure B-9. Listing temperature data for Clover Creek (2000STWFTL0012).**

**Figure B-10. Listing temperature data for Clover Creek (2003IDFGTL172).**

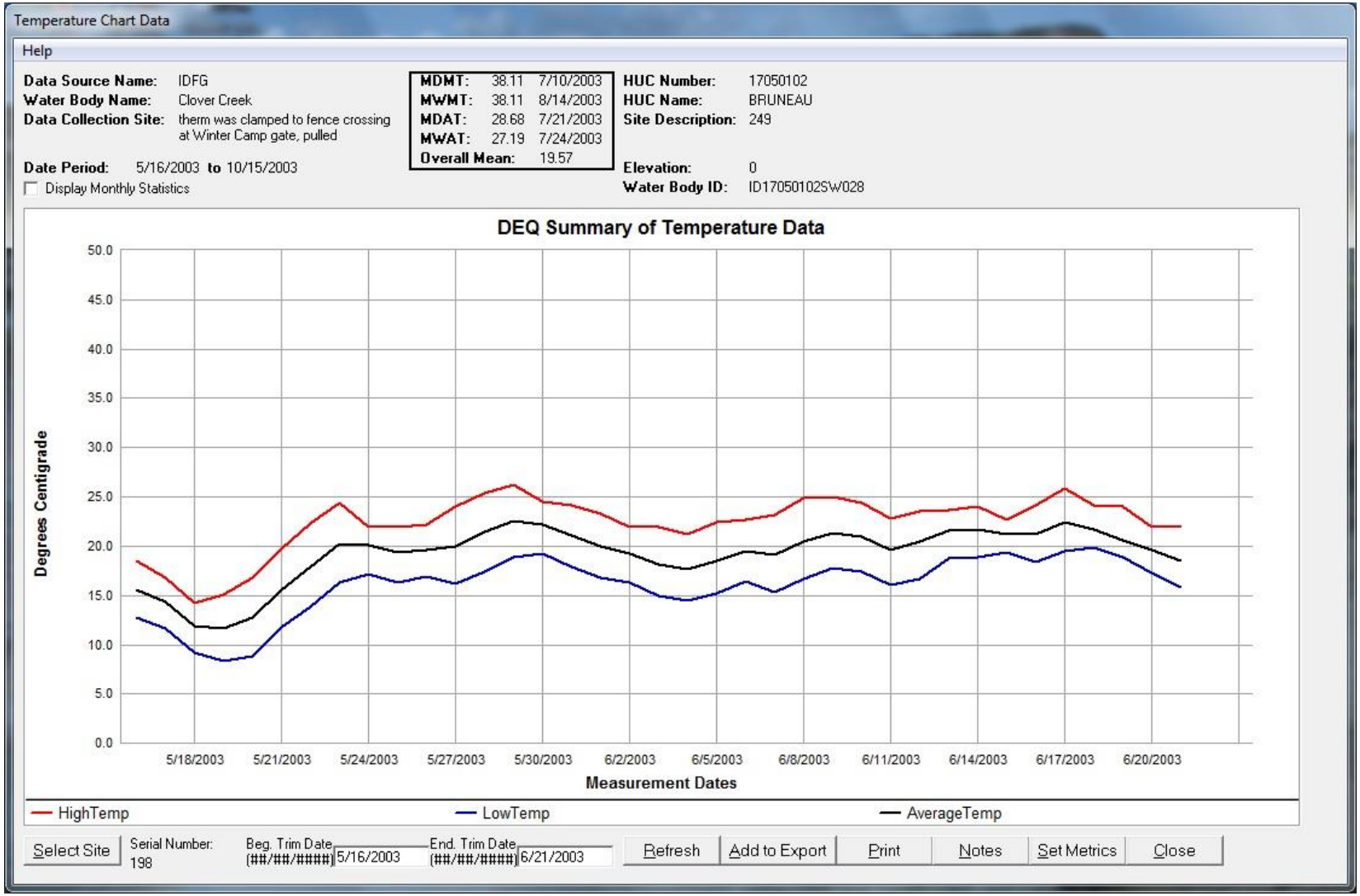



**Figure B-11. Listing temperature data for Clover Creek (2003IDFGTL190).**

**Figure B-12. Listing temperature data for the Bruneau River (2003IDFGTL196).**

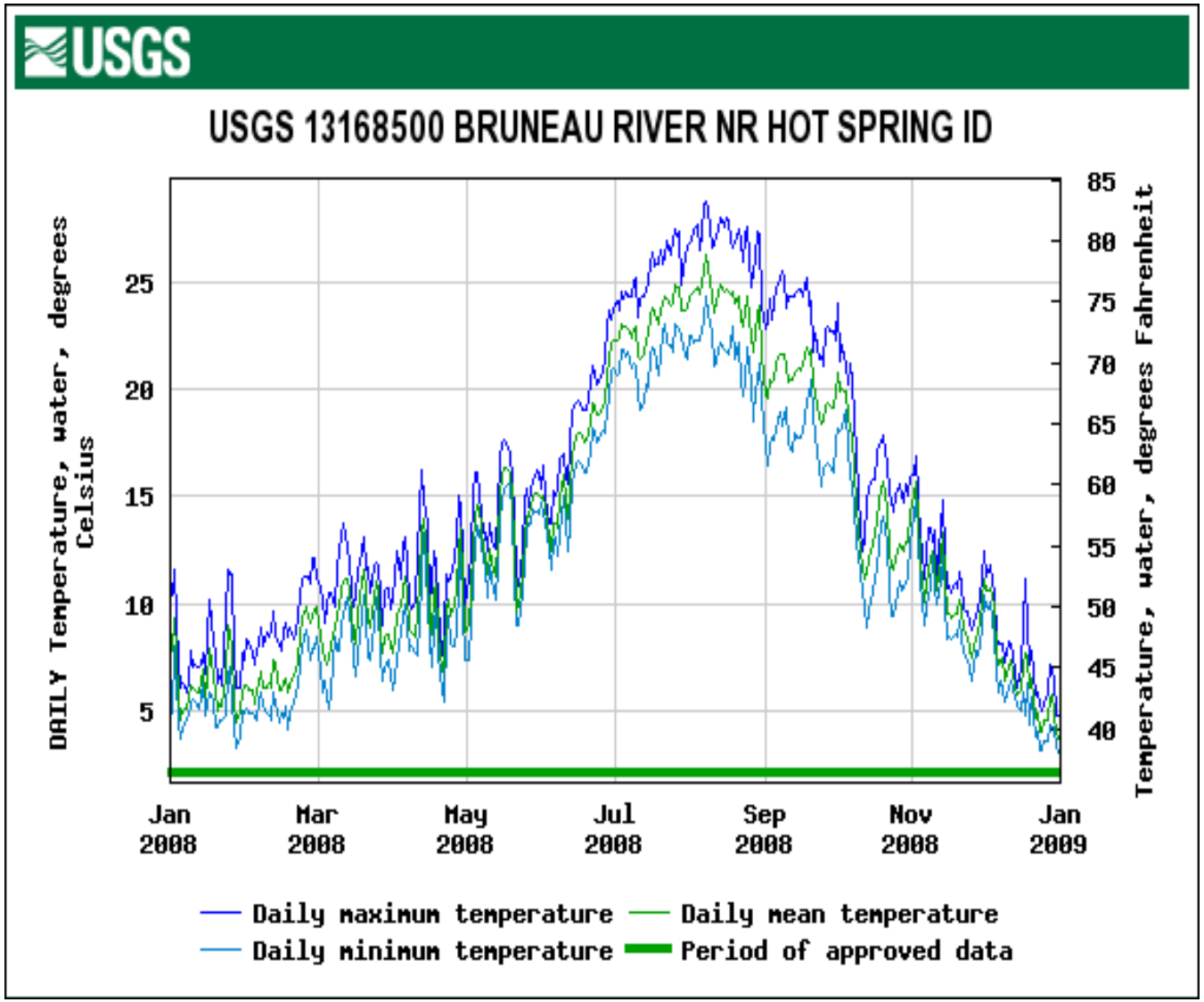



**Figure B-13. Listing temperature data for the Bruneau River (2008USGS13168500).**

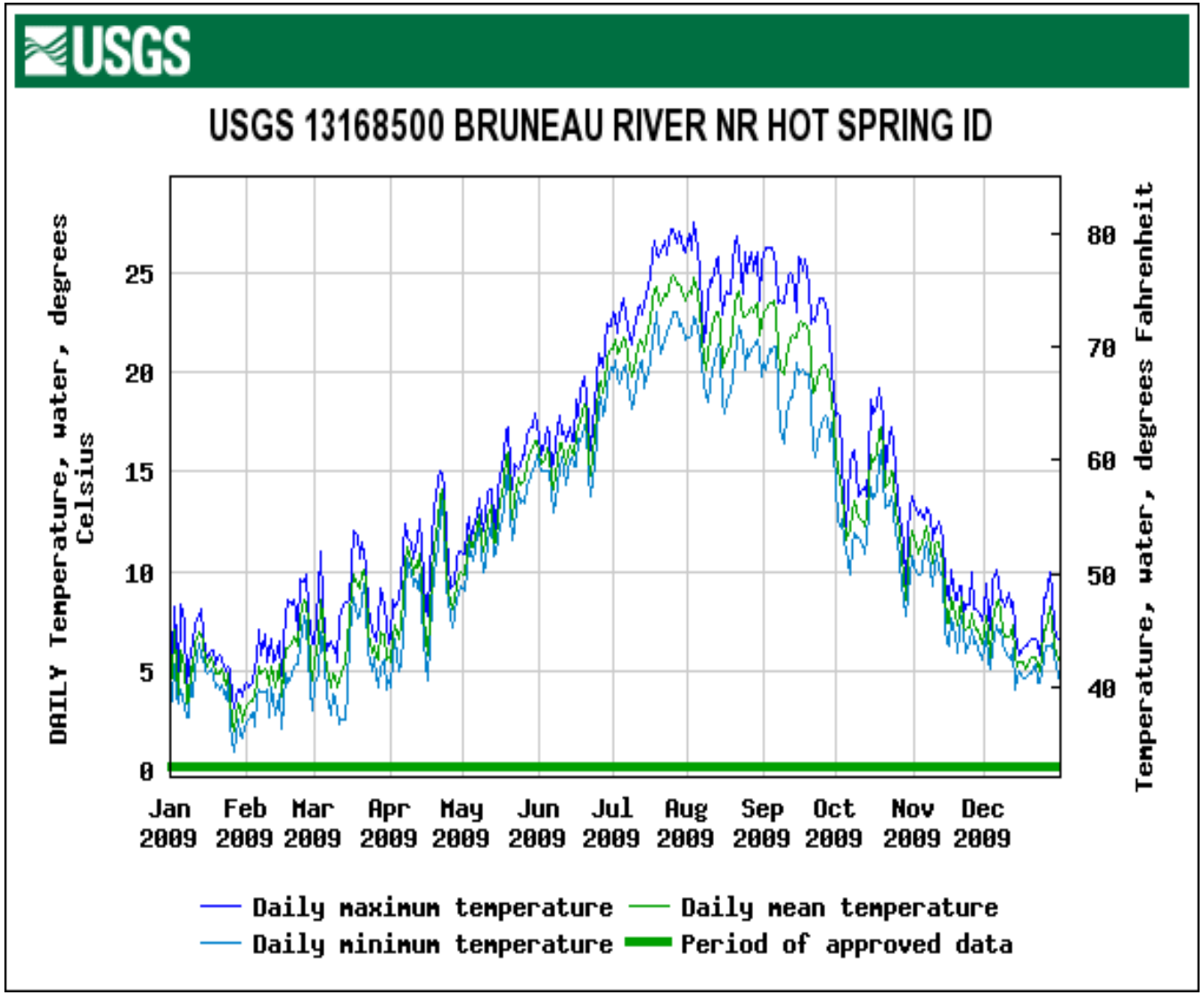



**Figure B-14. Listing temperature data for the Bruneau River (2009USGS13168500).**

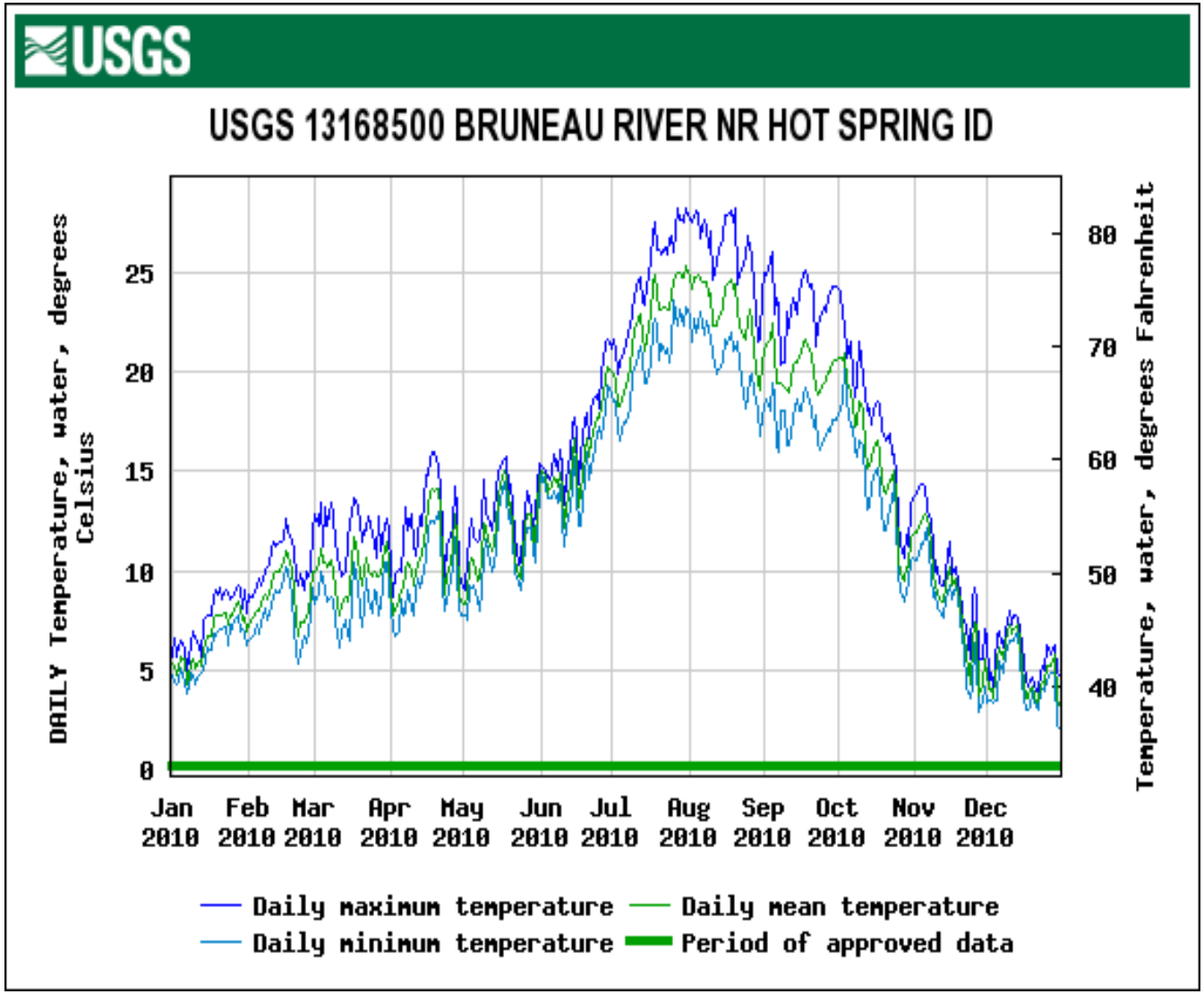



**Figure B-15. Listing temperature data for the Bruneau River (2010USGS13168500).**

**Figure B-16. Listing temperature data for the Bruneau River (2011STWFTL0000).**

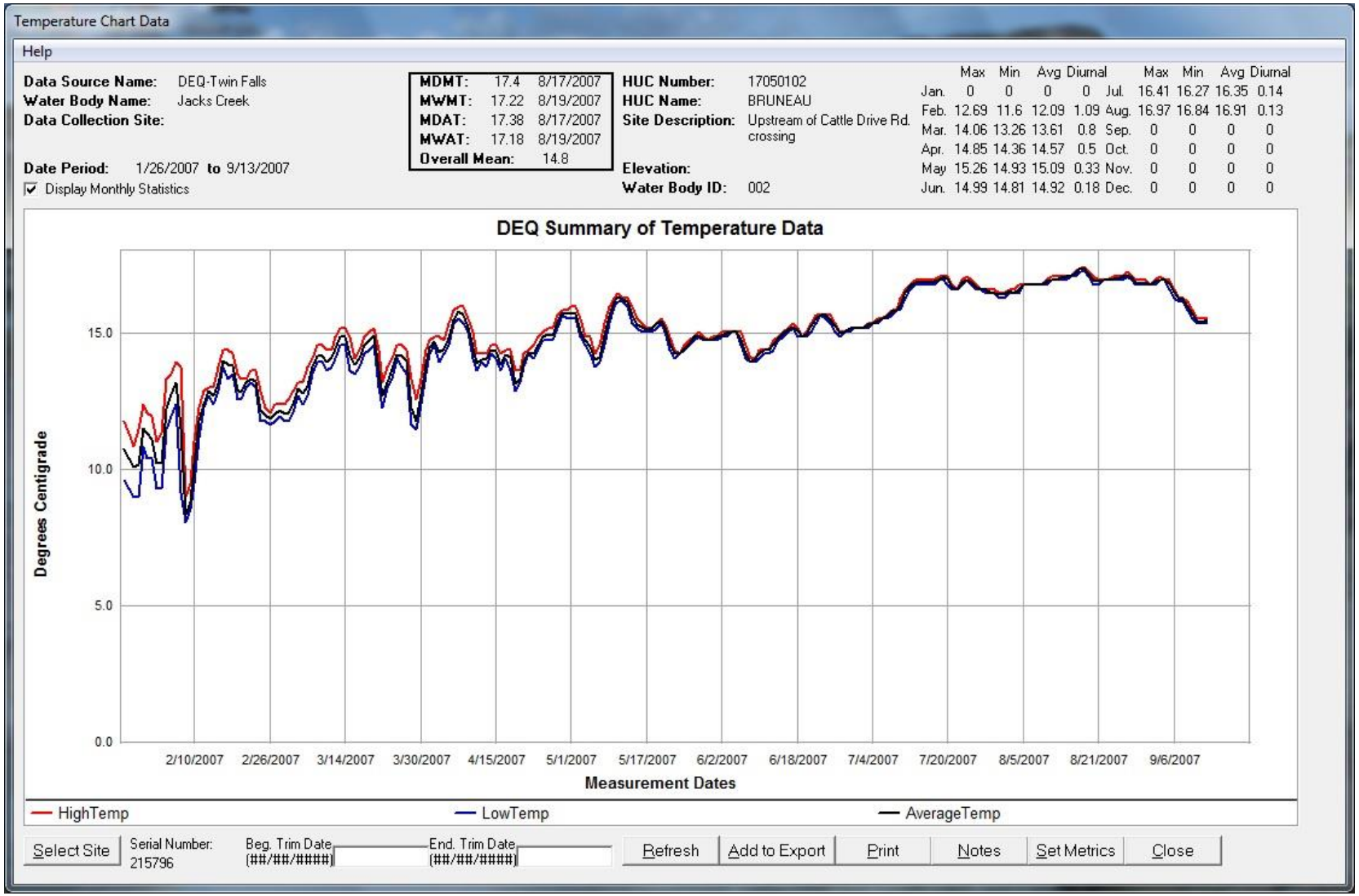



**Figure B-17. Listing temperature data for Jacks Creek (2007STWFTL0001).**

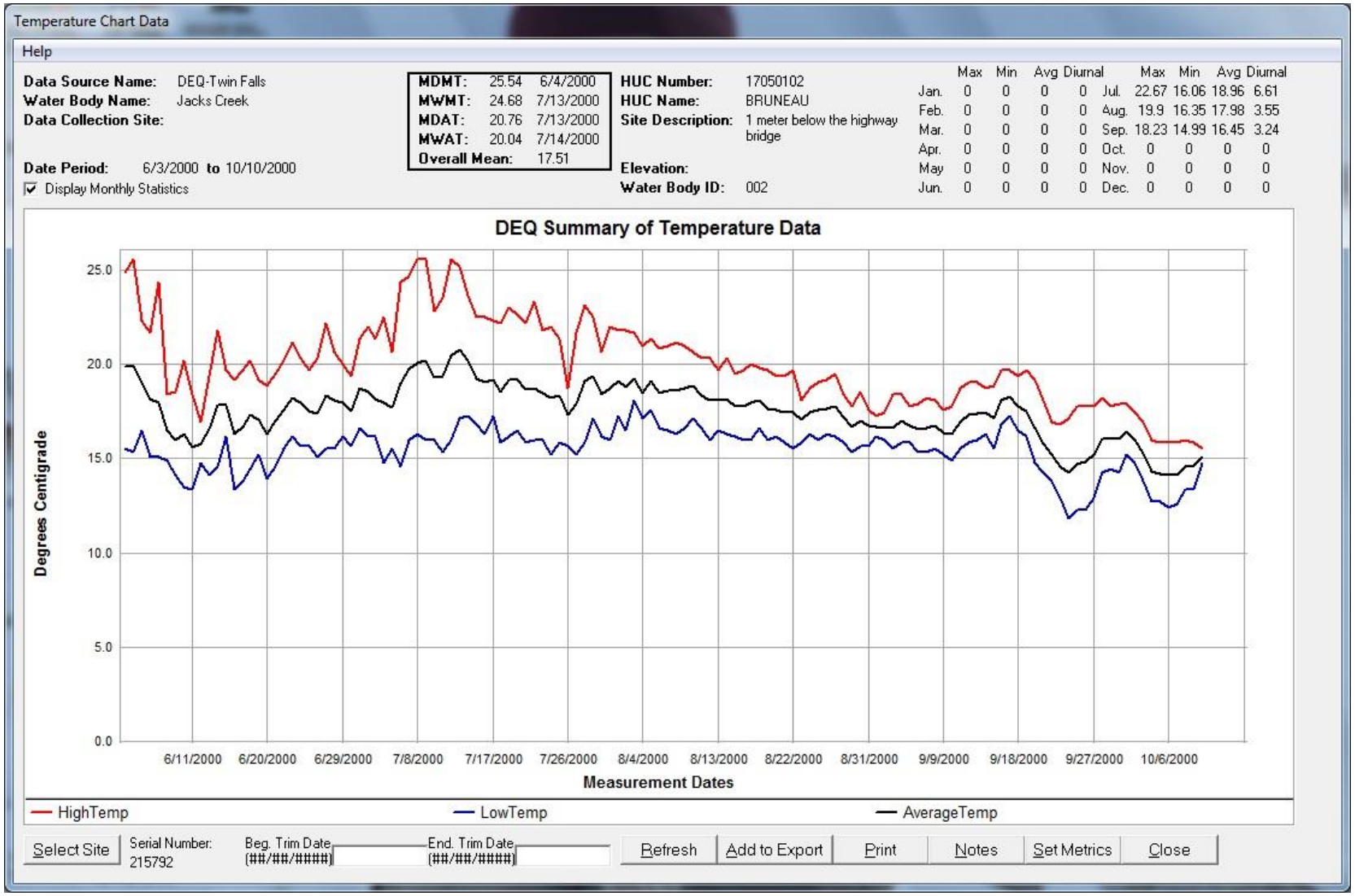



**Figure B-18. Listing temperature data for Jacks Creek (2000STWFTL0011).**

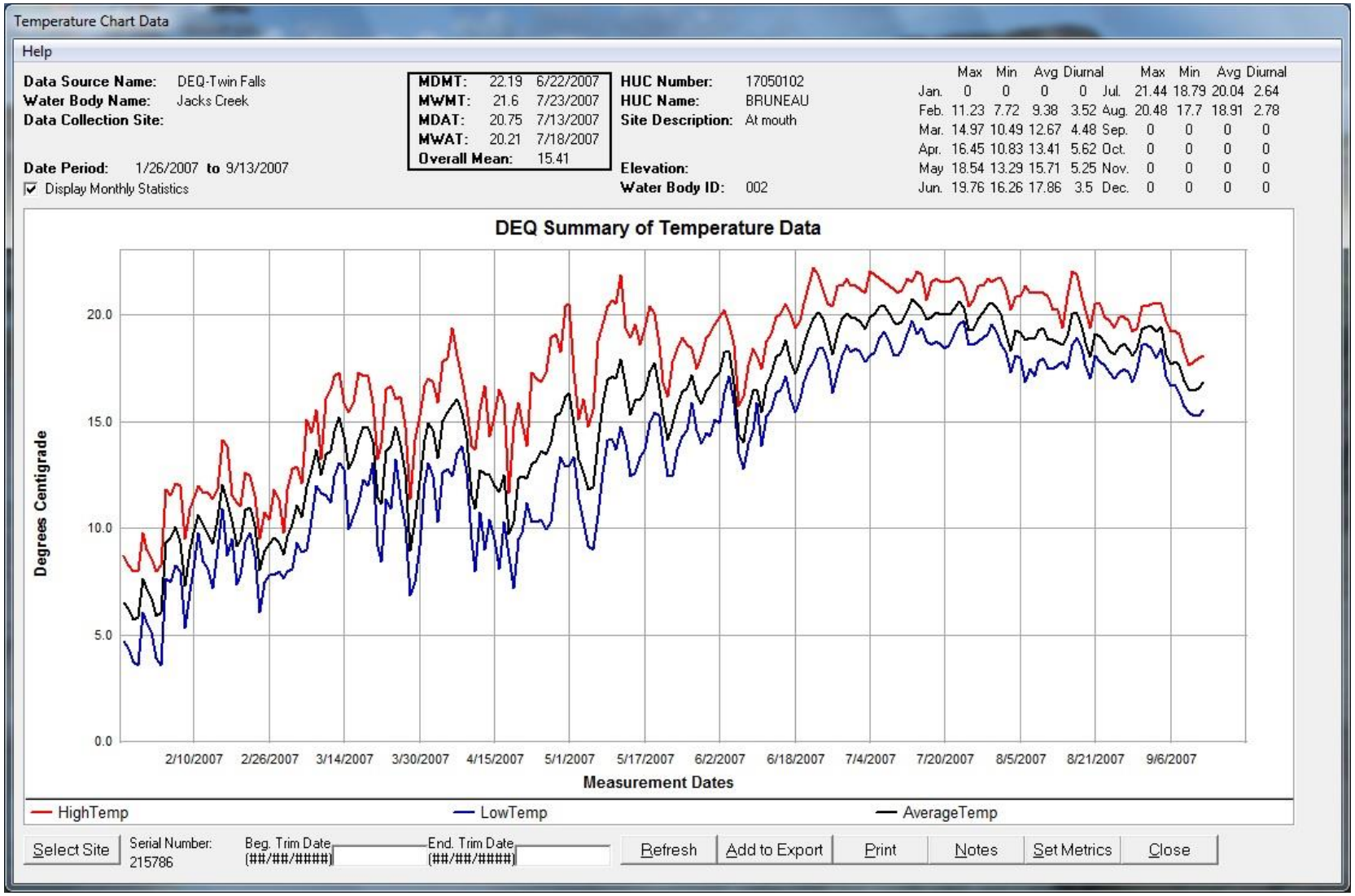



**Figure B-19. Listing temperature data for Jacks Creek (2007STWFTL0000).**

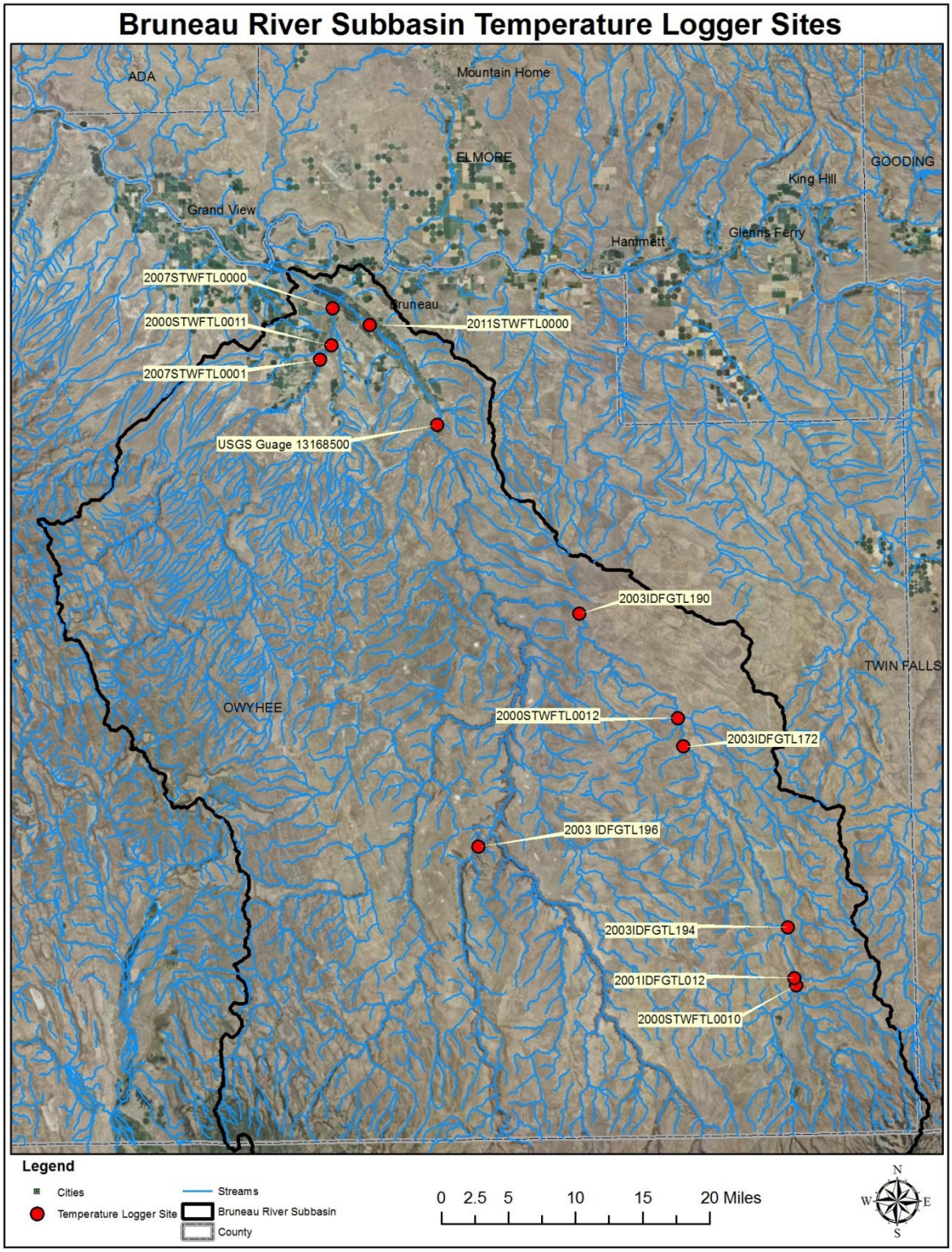



**Figure B-20. Location of listing temperature logger sites.**

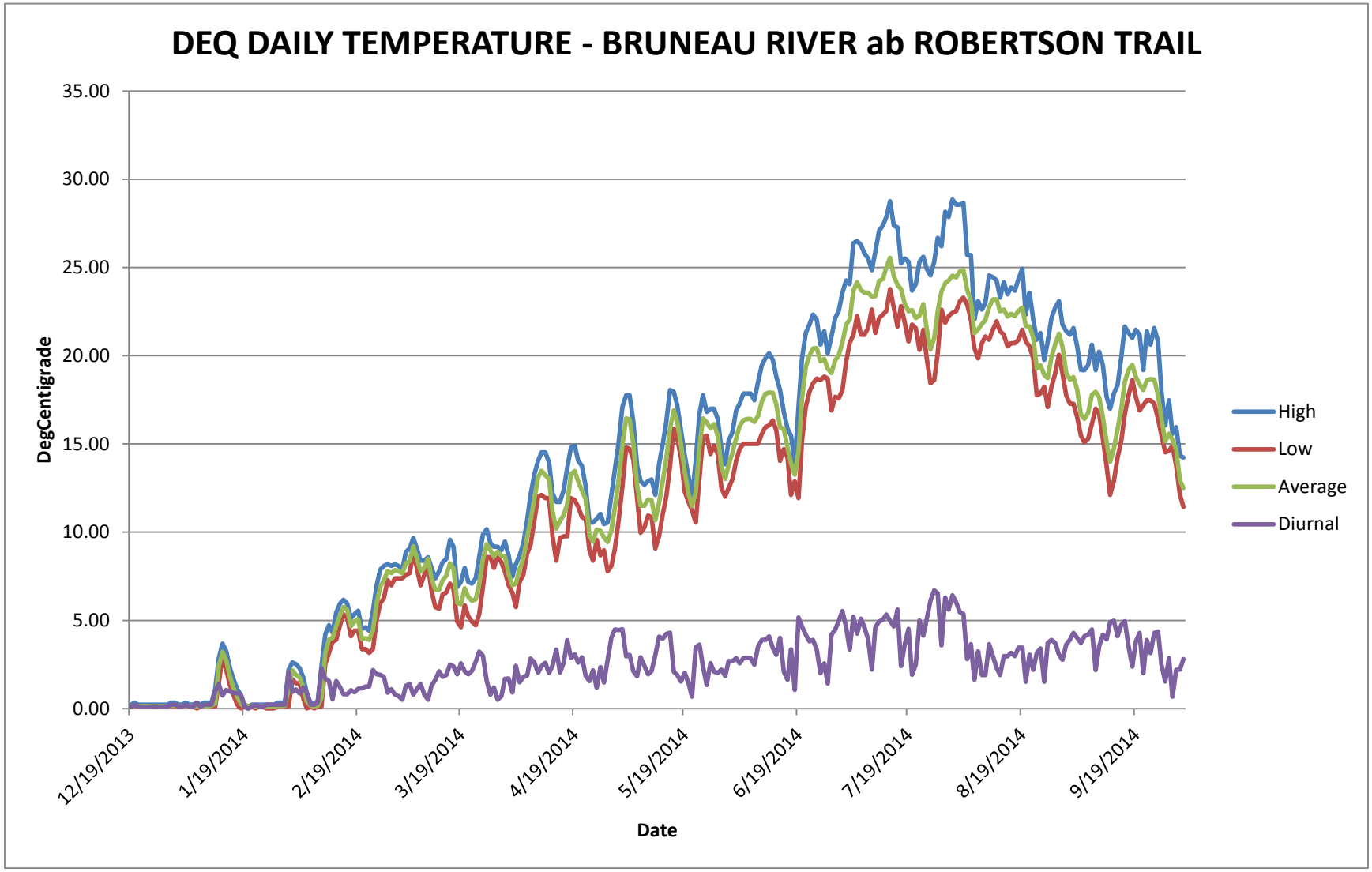



**Figure B-21. Logger temperature data for Bruneau River ab Robertson Trail (2013STWFTL0003).**

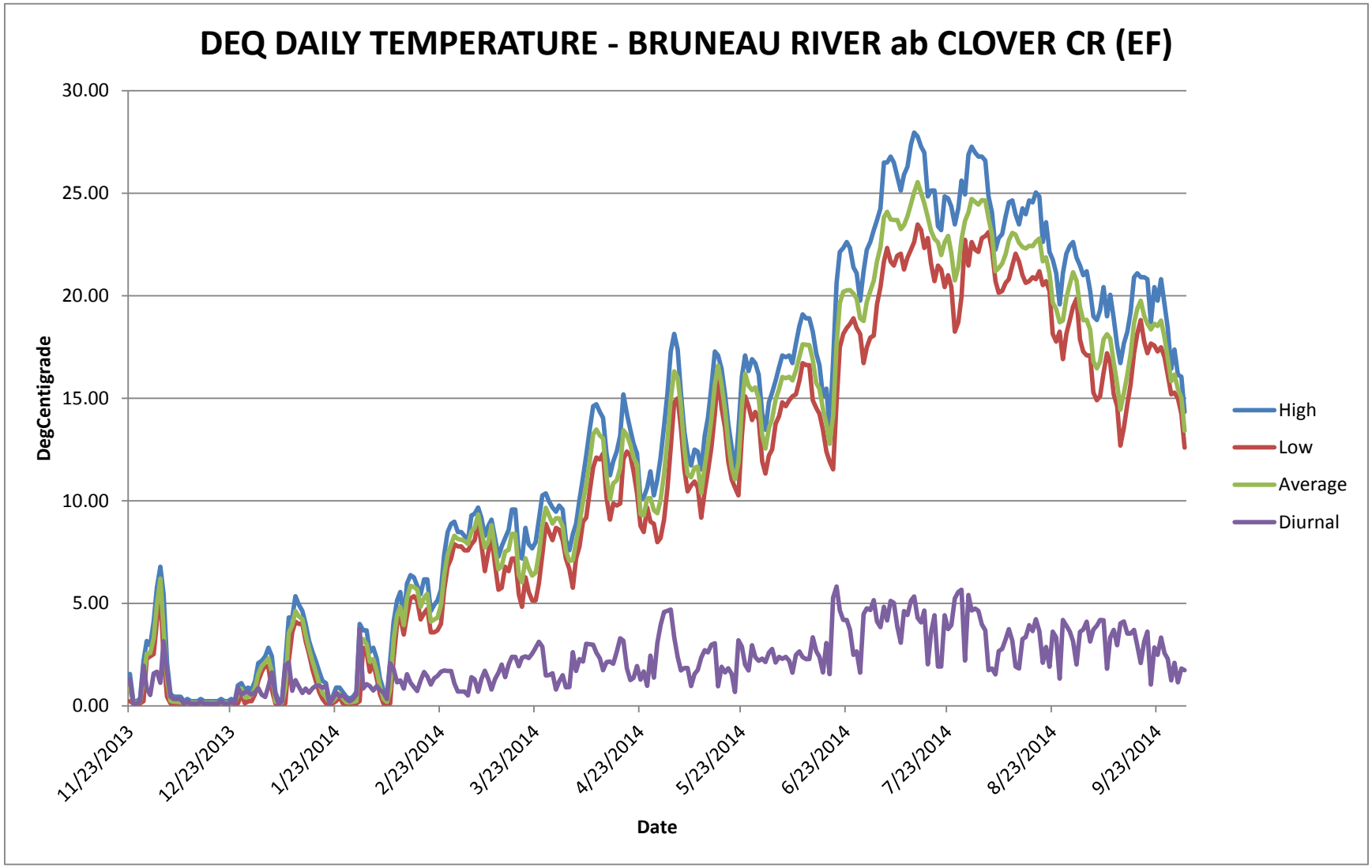



**Figure B-22. Logger temperature data for Bruneau River ab Clover Creek (2013STWFTL0004).**

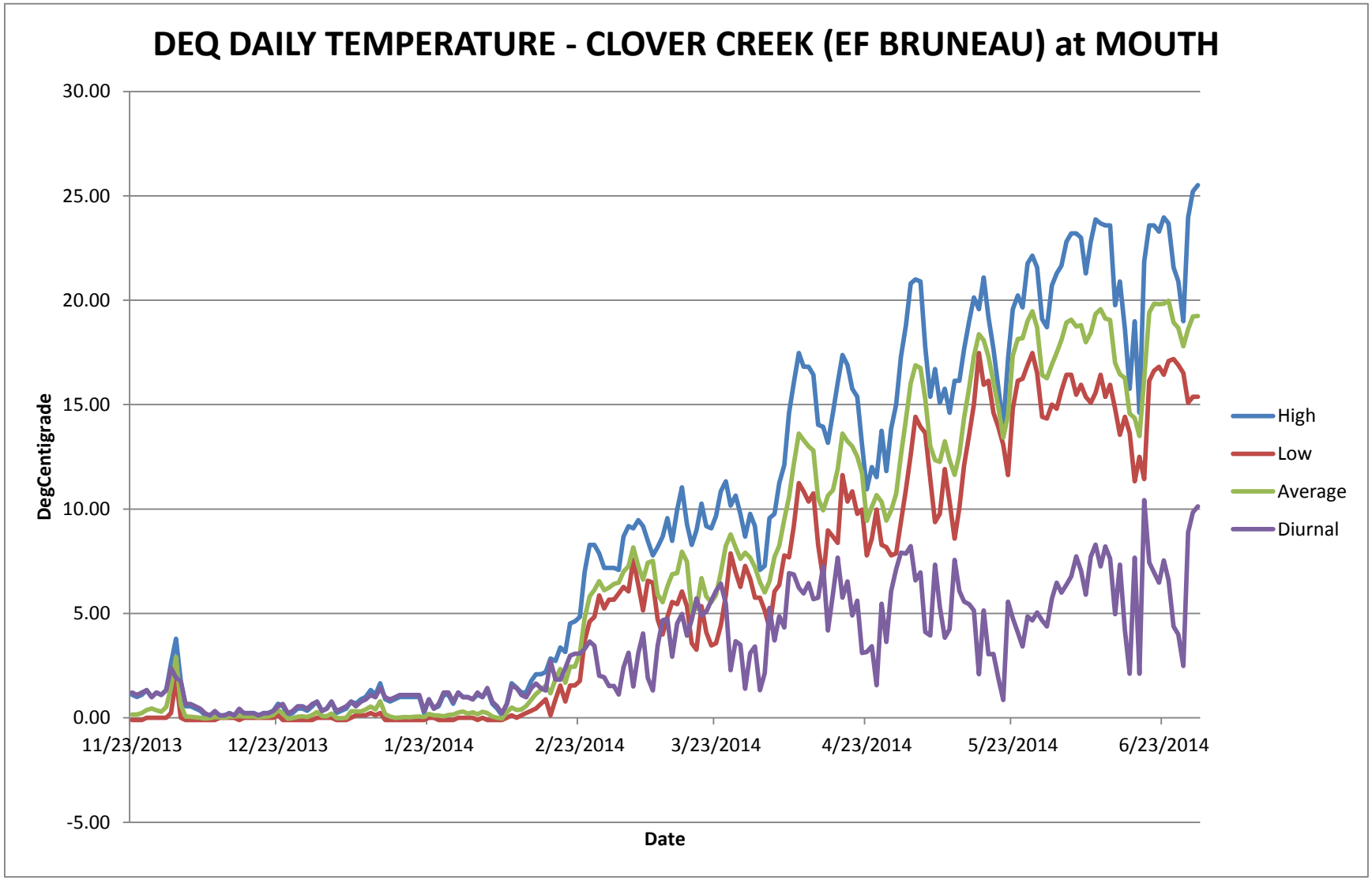



**Figure B-23. Logger temperature data for Clover Creek (EF Bruneau) at mouth (2013STWFTL0005).**

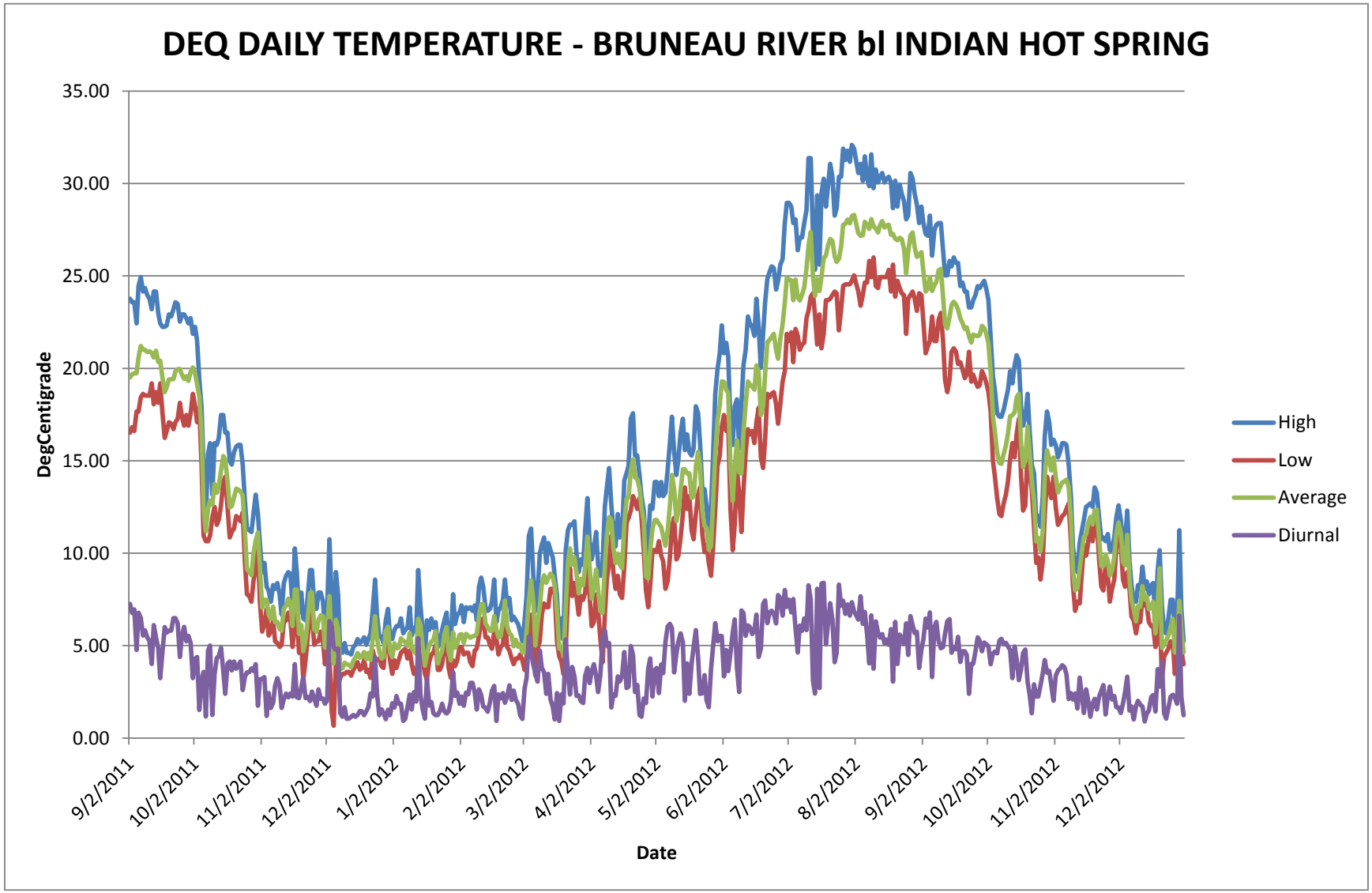



**Figure B-24. Logger temperature data for Bruneau River bl Indian Hot Springs (2011STWFTL0021).**

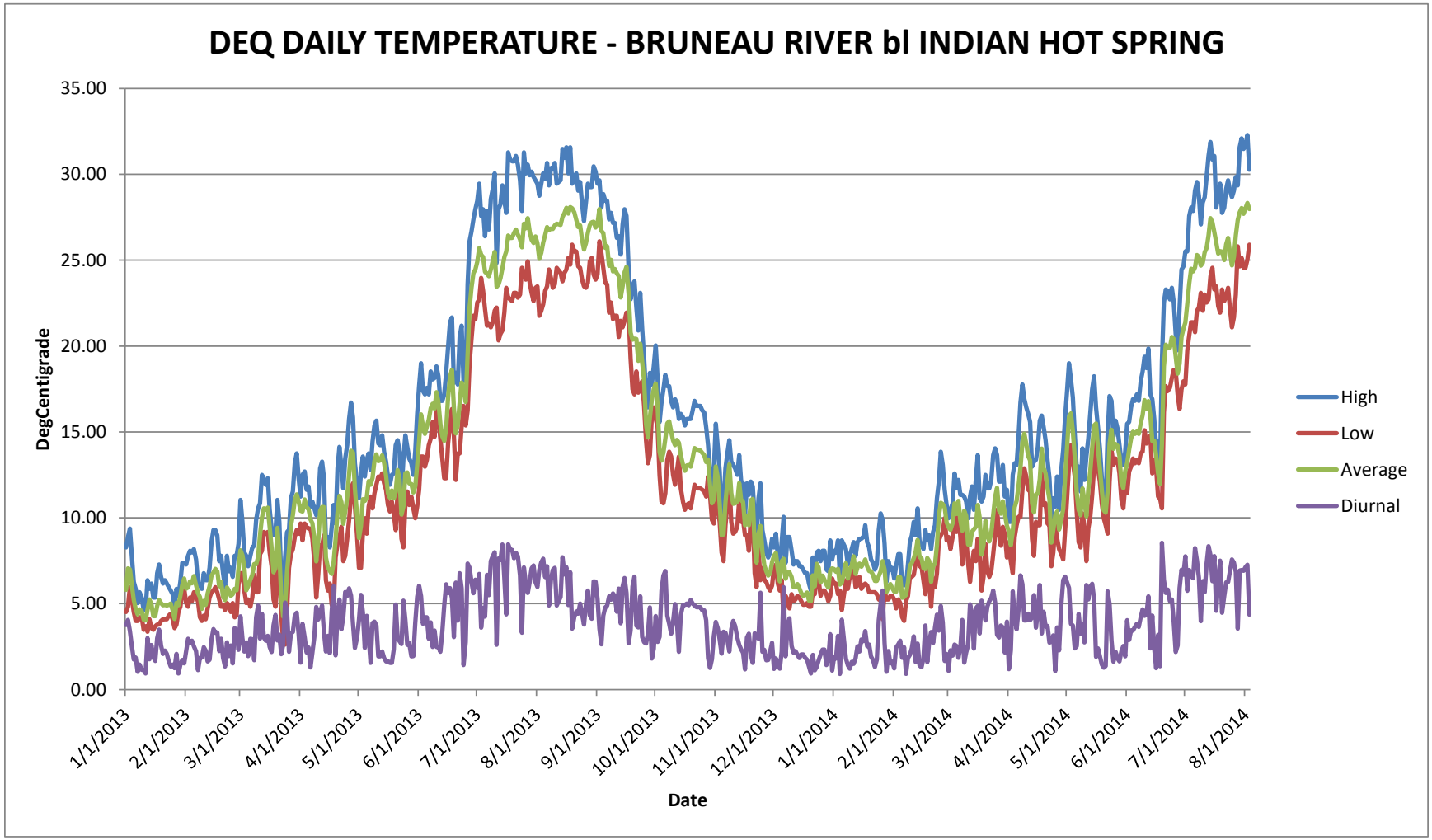



**Figure B-25. Logger temperature data for Bruneau River bl Indian Hot Springs (2013STWFTL0006 & 0007).**

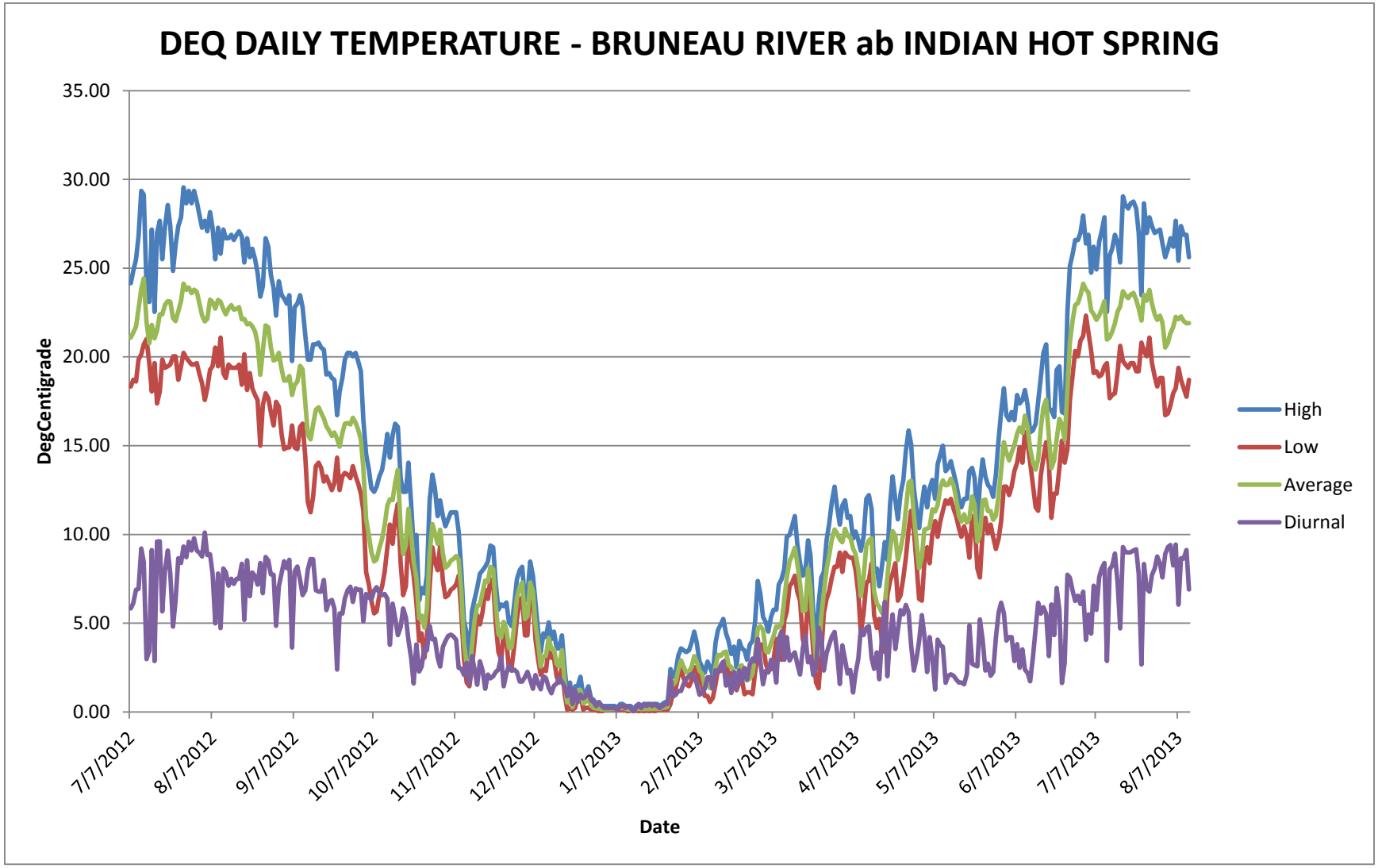



**Figure B-26. Logger temperature data for Bruneau River ab Indian Hot Springs (2012STWFTL0000).**

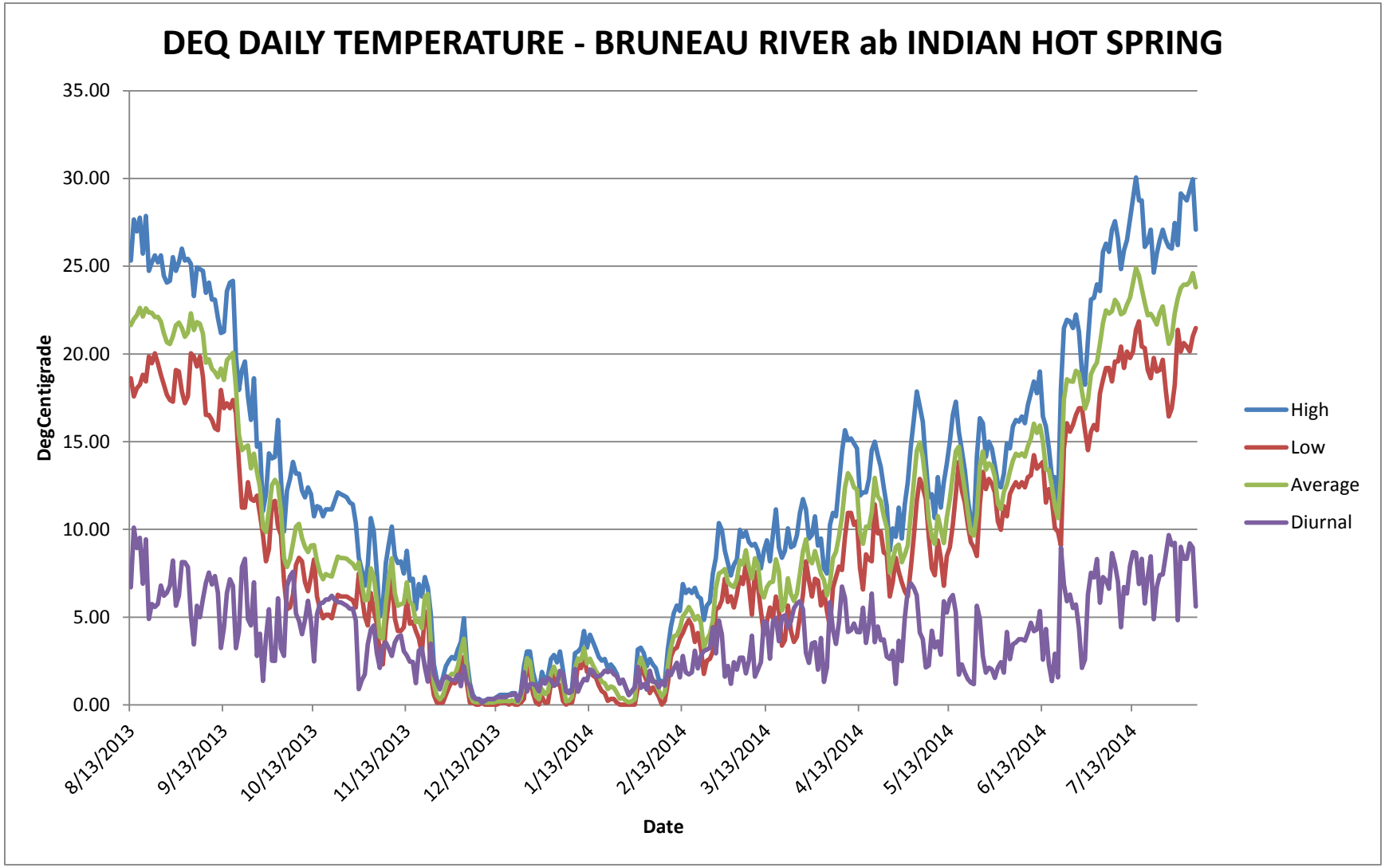



**Figure B-27. Logger temperature data for Bruneau River ab Indian Hot Springs (2013STWFTL0008).**

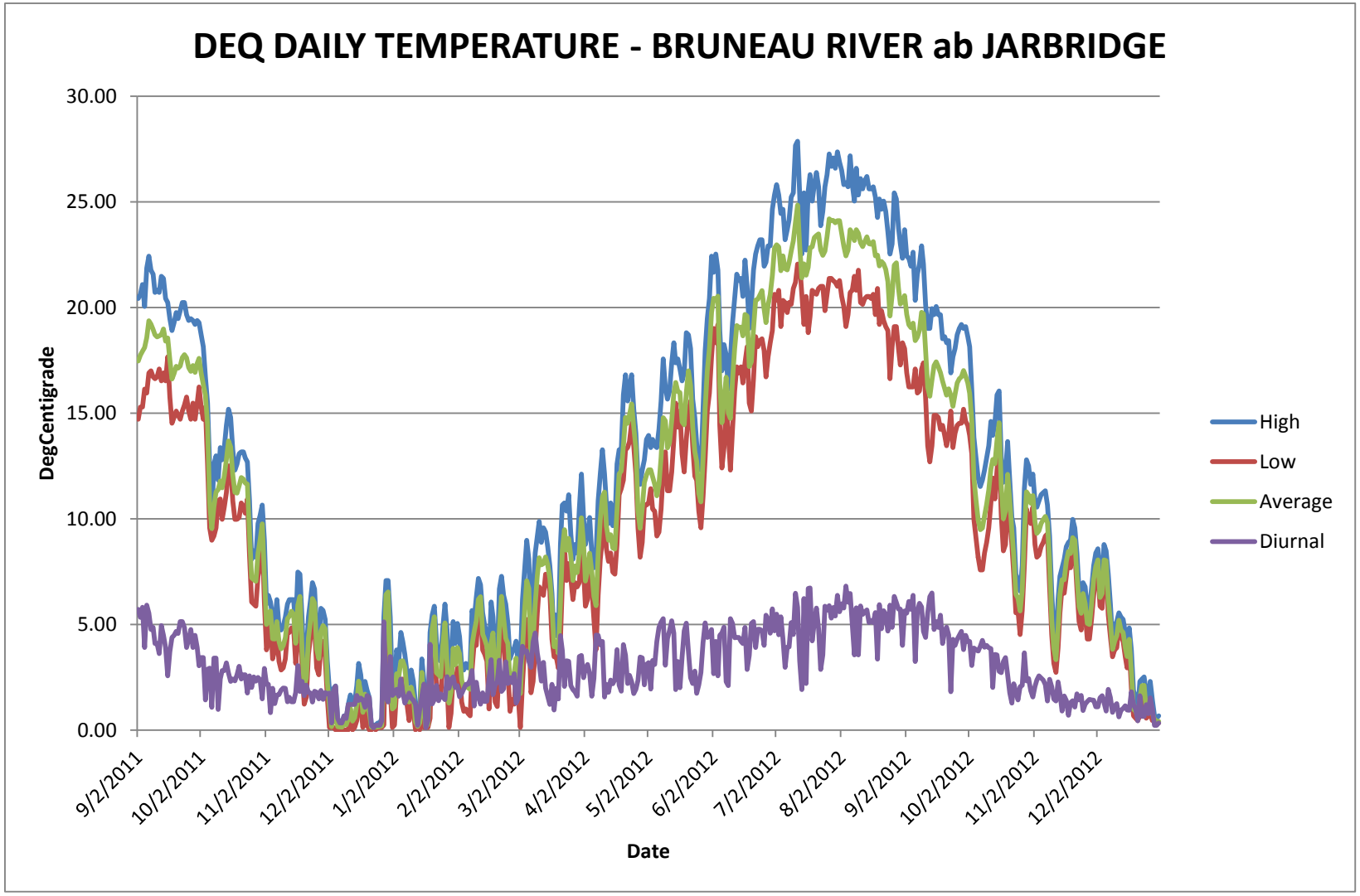



**Figure B-28. Logger temperature data for Bruneau River ab Jarbridge River (2011STWFTL0022).**

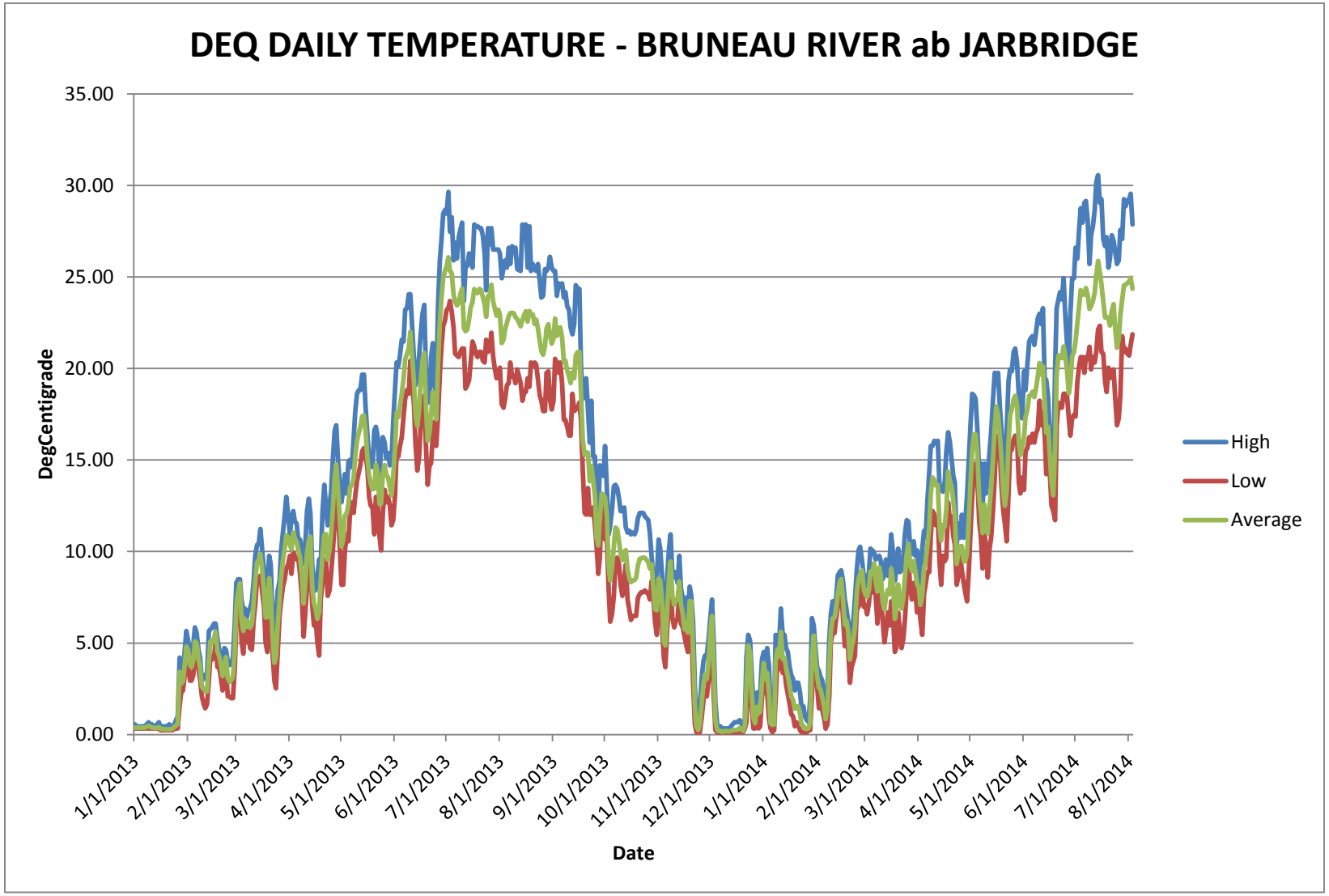



**Figure B-29. Logger temperature data for Bruneau River ab Jarbridge River (2013STWFTL0009 & 0010).**

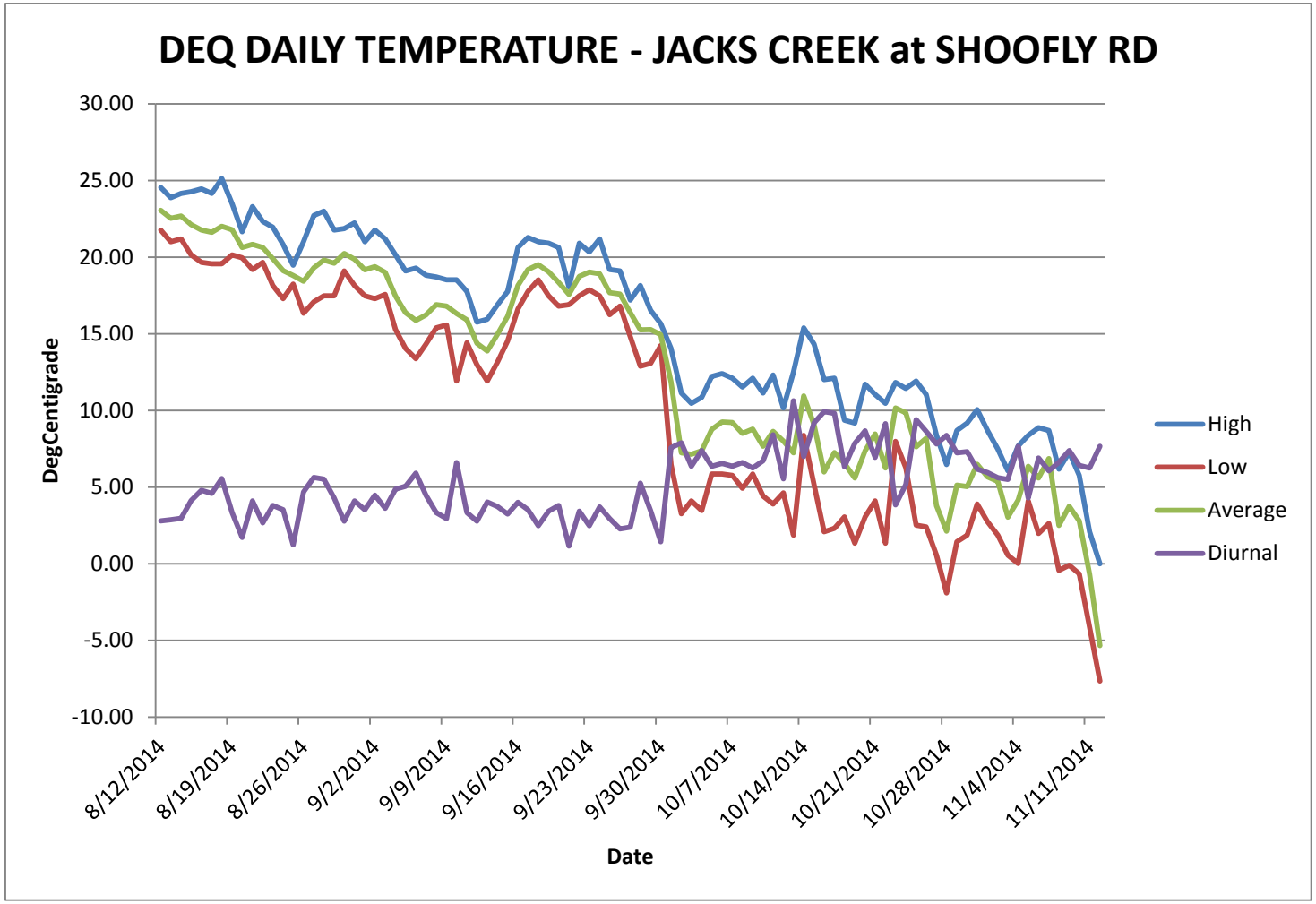



**Figure B-30. Logger temperature data for Jacks Creek at Shoofly Road (2014STWFTL0000).**

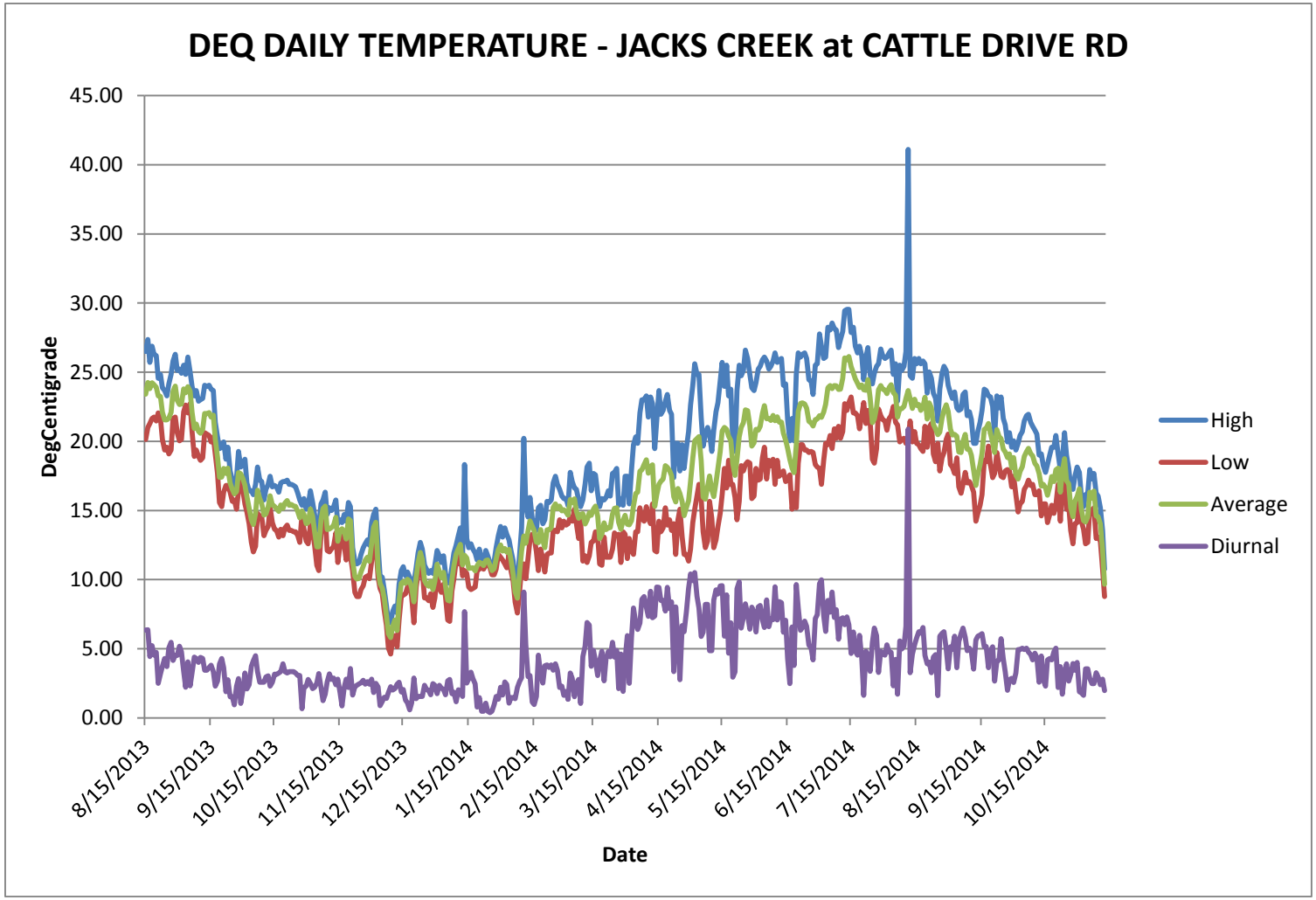



**Figure B-31. Logger temperature data for Jacks Creek at Cattle Drive Road (2013STWFTL0000).**

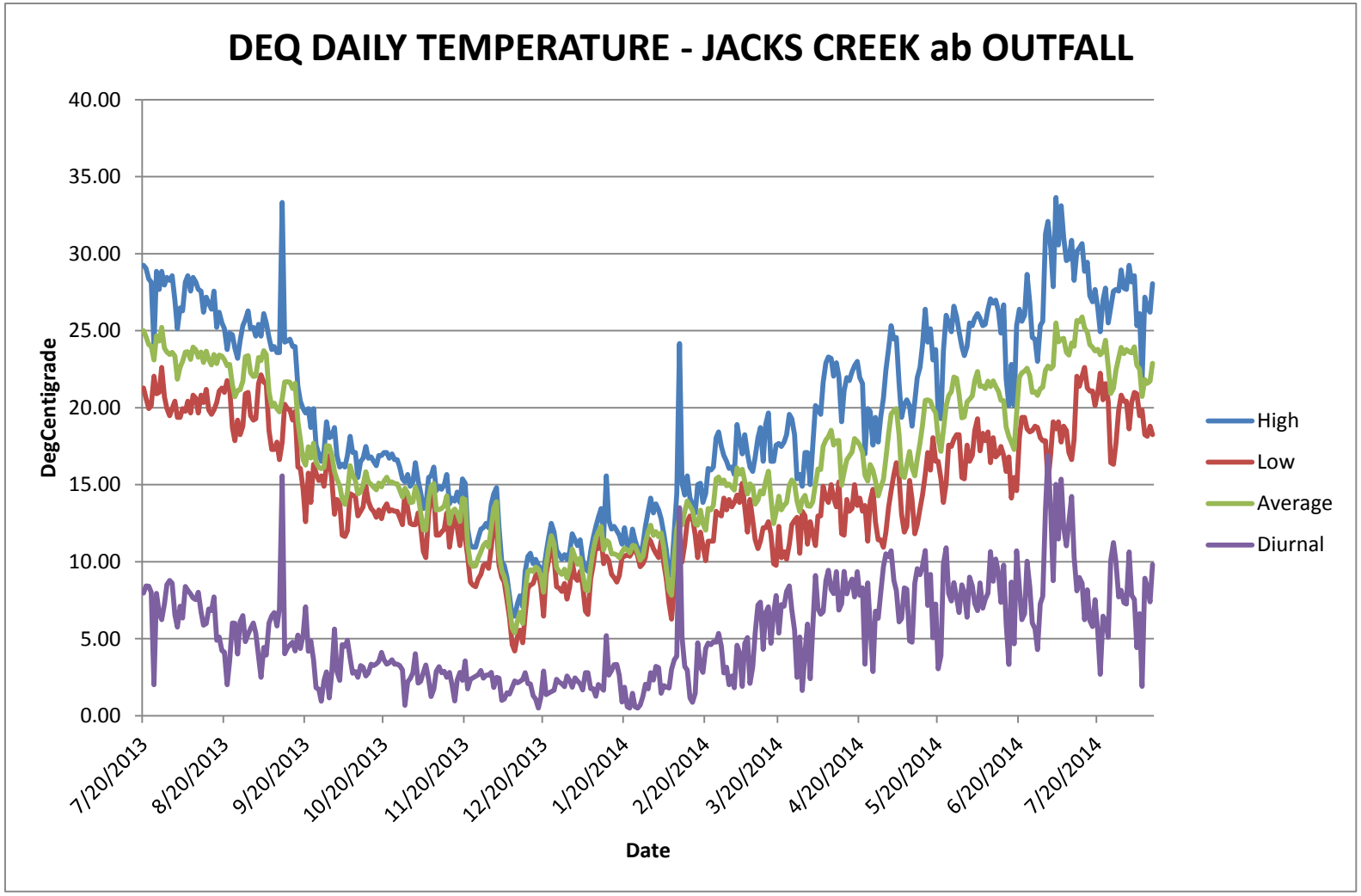



**Figure B-32. Logger temperature data for Jacks Creek ab Arraina outfall (2013STWFTL0001).**

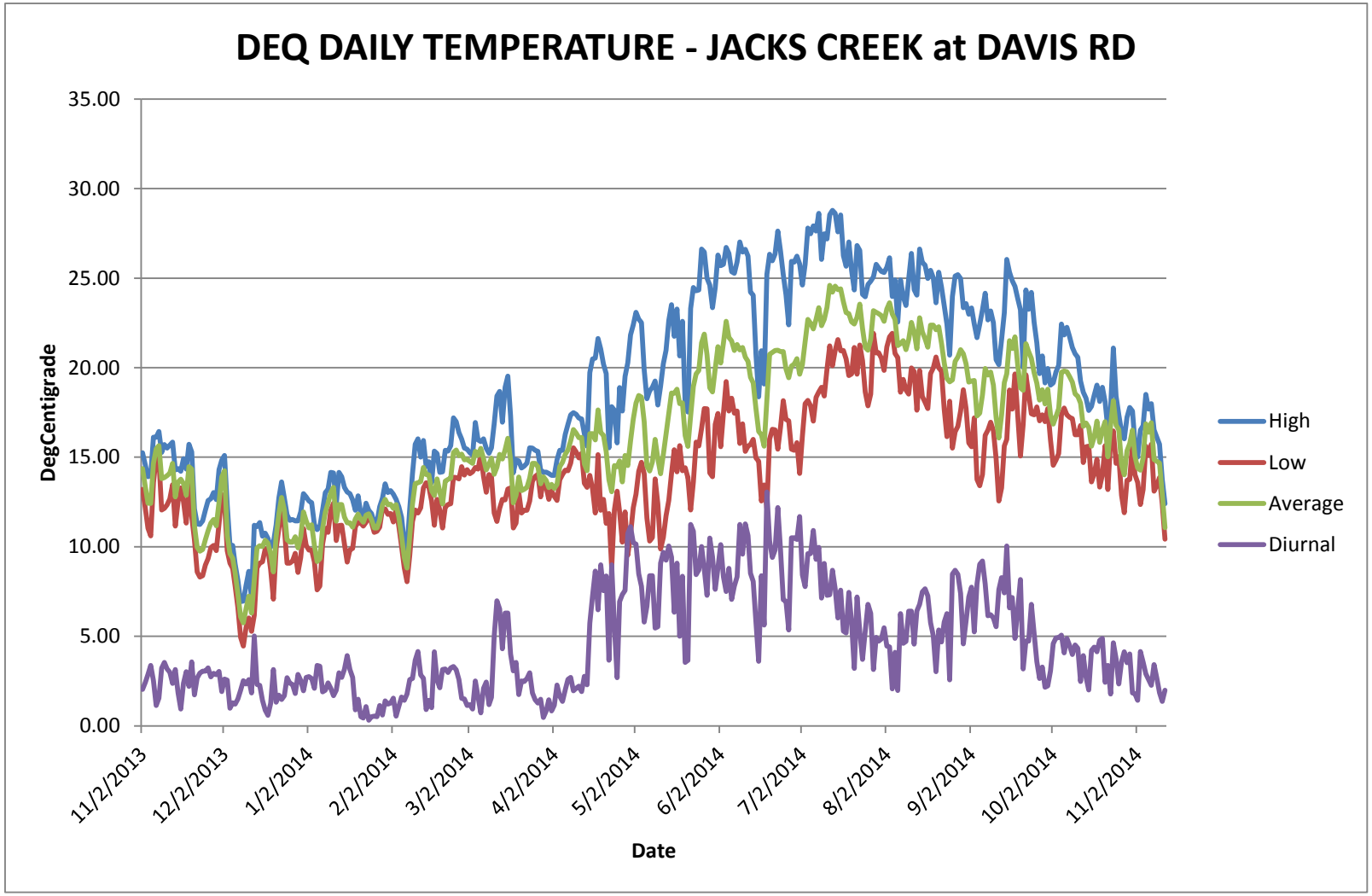



**Figure B-33. Logger temperature data for Jacks Creek at Davis Road (2013STWFTL0002).**

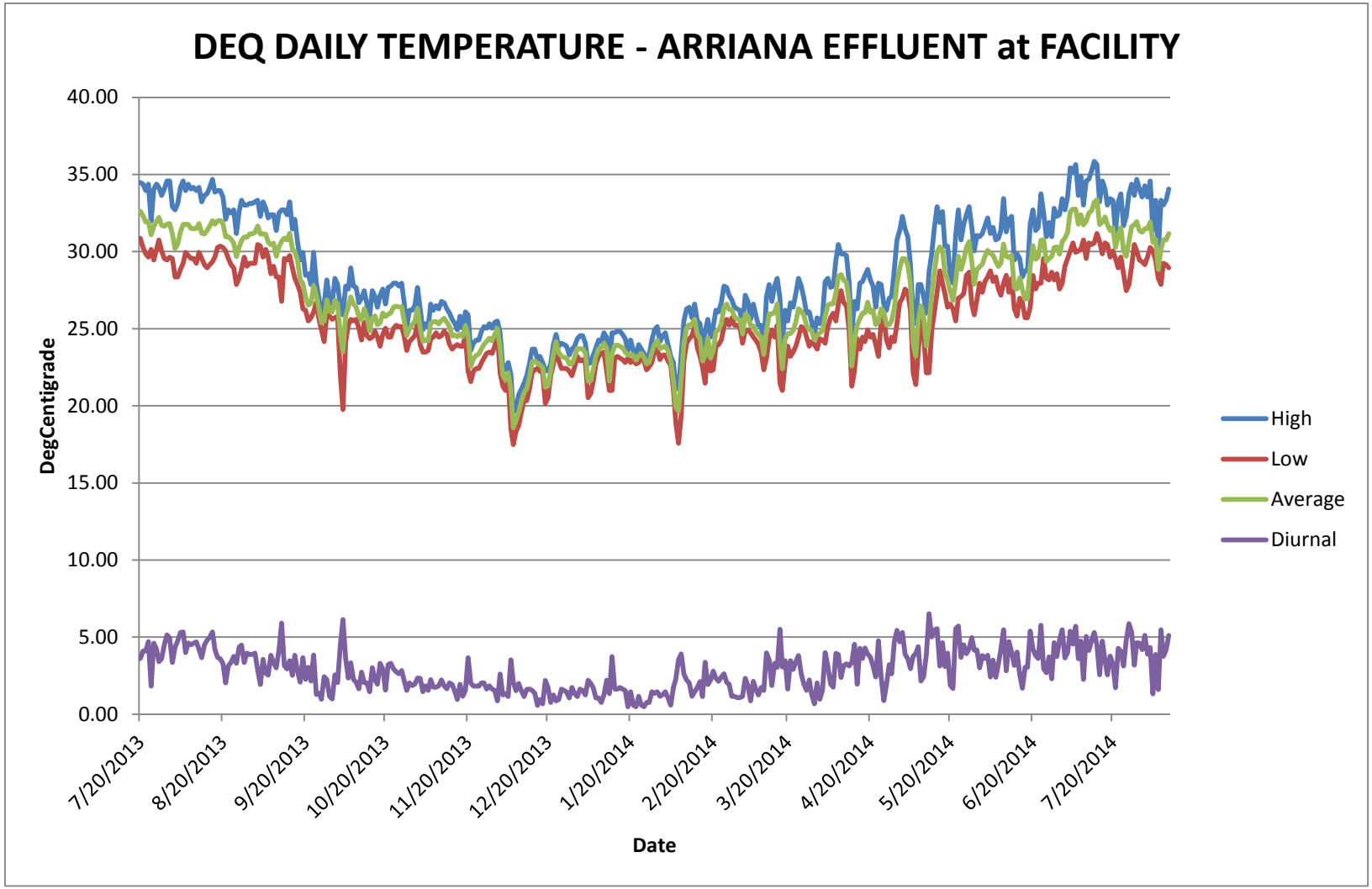



**Figure B-34. Logger temperature data for Arraina effluent at facility (2013OTWFTL0000).**

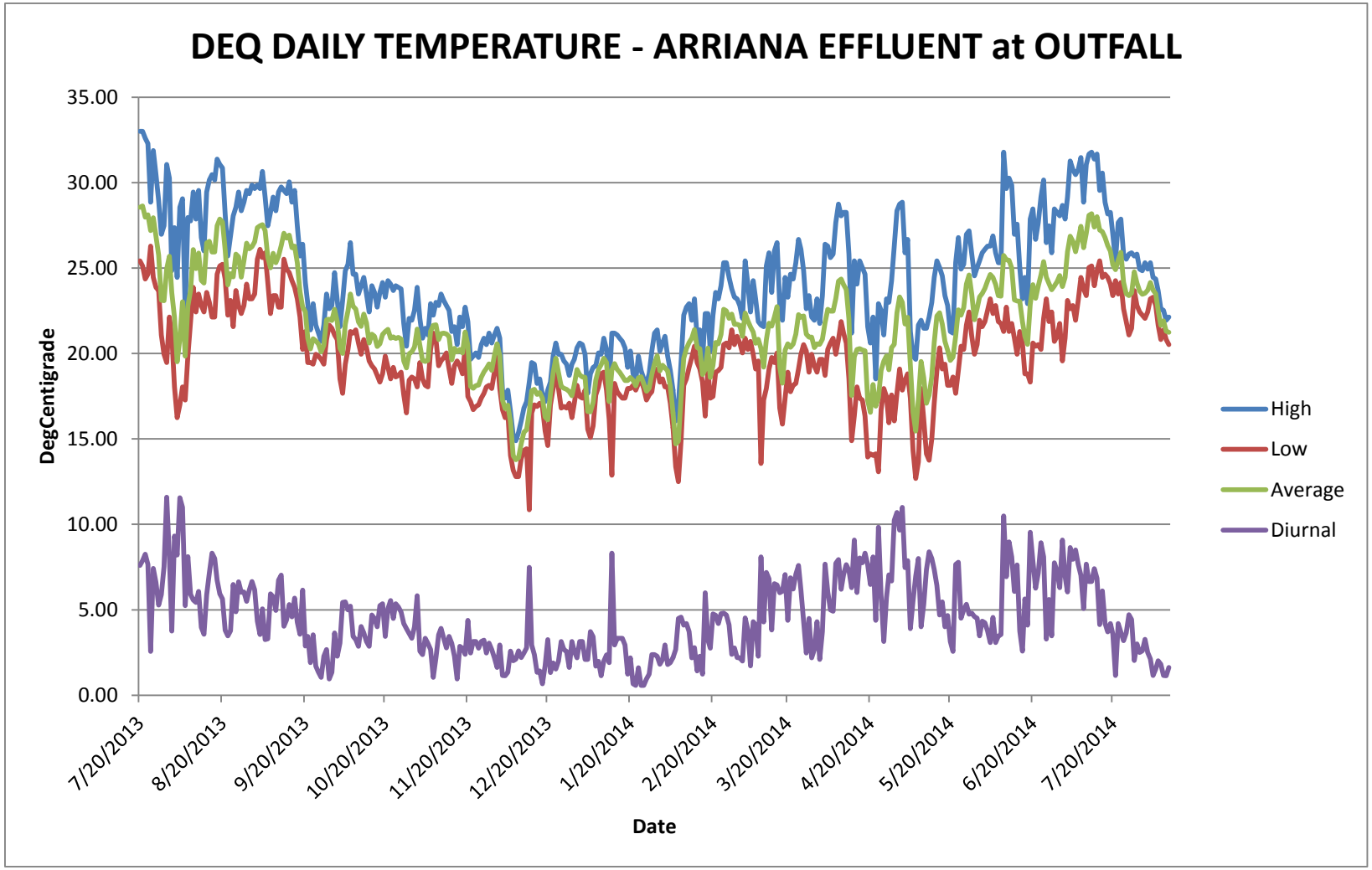



**Figure B-35. Logger temperature data for Arraina effluent at outfall (2013OTWFTL0001).**

# Appendix C. Public Comments

There are no active WAGs in the Bruneau River Subbasin. However, the subbasin is represented by a group of individuals that represent various industries (i.e., farming, ranching, fish farms, land management agencies, etc.) in the Jacks Creek drainage. Any TMDL-related issues will be discussed with the ISWCC, the associated Soil Conservation Districts in Southwest Idaho; and the Southwest BAG. The DEQ State Office presented a draft copy of the TMDL in April 2015 to the Southwest BAG and they gave concurrence to DEQ to move forward with an updated temperature analysis for the two fish farm facilities. There were no issues from the BAG with the PNV. And, they are interested in ultimately getting the designation for Jacks Creek changed to seasonal cold or simply invoke natural conditions.

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# Appendix D. Distribution List

This document was distributed to the following:

- ISWCC – Southwest Idaho (c/o Delwyne Trefz and Jason Miller), 250 North Bruneau Highway, Marsing, Idaho 83639
- NRCS-Marsing Service Center (c/o Stacy Thornbrugh, District Conservationist), 250 North Bruneau Highway, Marsing, Idaho 83639
- NRCS-Mountain Home Service Center, 795 South Haskett Street, Mountain Home, Idaho 83647-3378
- Owyhee Soil Conservation District (c/o Delywne Treftz), 250 North Bruneau Highway, Marsing, Idaho 83639
- BLM-Bruneau Field Office (Tanya Thrift, Field Manager), 3948 Development Avenue, Boise, Idaho 83705
- BLM-Jarbidge Field Office (Elliot Traher, Field Manager), 2536 Kimberly Road, Twin Falls, Idaho 83301
- Idaho Fish and Game, C. J. Strike Wildlife Management Area, 3101 South Powerline Road, Nampa, Idaho 83686
- Idaho Power Company (c/o Brian Hoelscher, Senior Biologist), 1221 West Idaho Street, Boise, Idaho 8l3702)
- SeaPac of Idaho (Filer, Idaho; former operator of Arraina & Ace Development) – in c/o Gary Marquardt, 4074 N 2000 East Road, Filer Idaho 83328
- Best Sea Foods (Arraina Fish Farm), 13923 SE Gladstone Street, Portland, Oregon 97235-3571
- J.R. Simplot Company (Ace Development Fish Farm), c/o David Spurling, 999 Main Street, Suite 1300, Boise, Idaho 83707
- Bruneau Cattle Company, c/o Eric Davis, 28719 Jacks Creek Road, Bruneau, Idaho 83604-5036
- Harley Ranches (Arraina Fish Farm), 272906 Joe Black Road, Hammett, Idaho 83627-5021
- Craig L. and Sherry L. Christiansen (Arraina Fish Farm), 30953 State Highway 51, Bruneau, Idaho 83604-5078
- South Side Bruneau Canal Company, Ltd., c/o Eugene C. Davis, 31878 Clover Three Creek Road, Bruneau, Idaho 83604-5023
- DEQ-Boise Regional Office (c/o Lance Holloway), 1445 North Orchard, Boise, Idaho 83706
- Southwest Idaho Basin Advisory Group (c/o DEQ-BRO), 1445 North Orchard, Boise, Idaho 83706

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