APPENDIX G
REPRESENTATIVE REFERENCE SHADE CONDITIONS AND DAILY TEMPERATURE LOADING

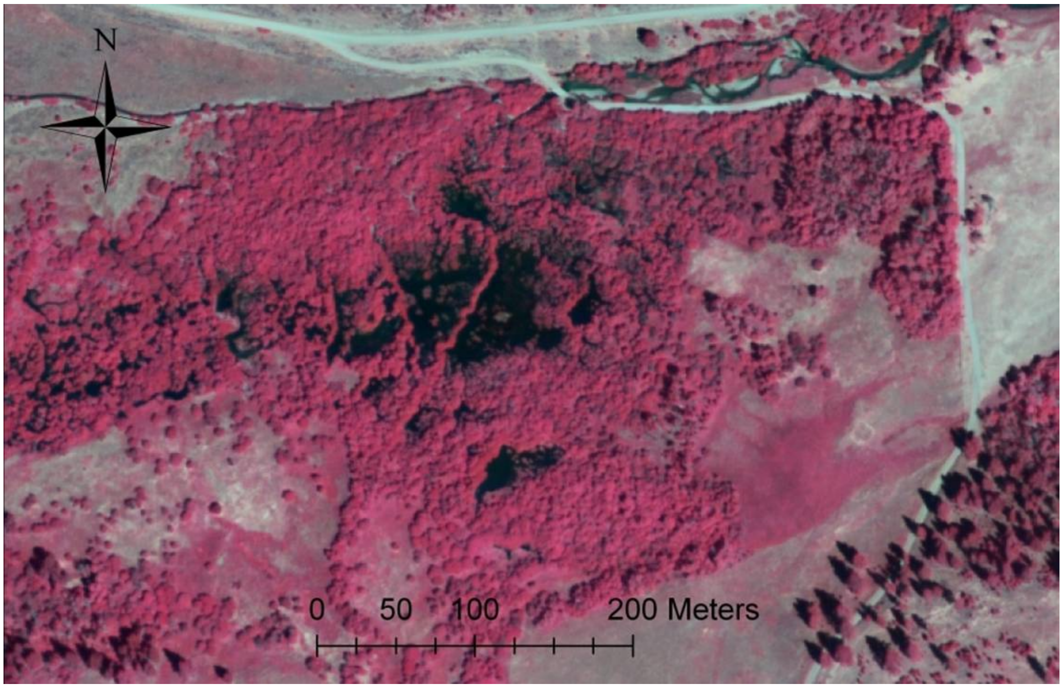

Figure G-1. Reference Shade Condition S ½ Sections 29 and 30, Township 12 North, Range 8 West, Upper Nevada Creek

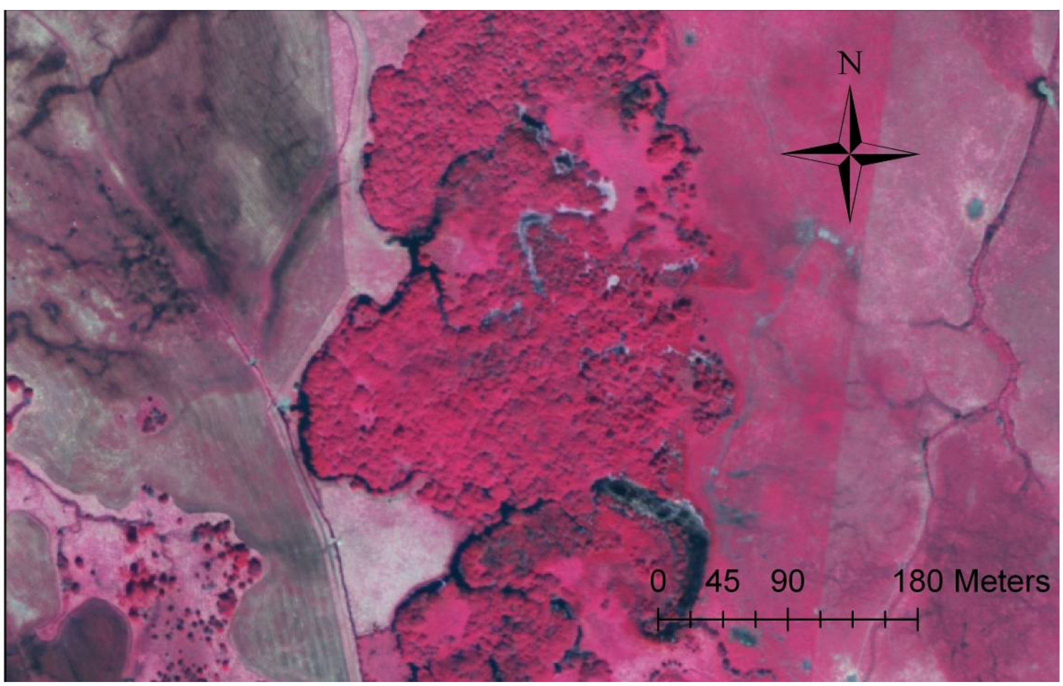

Figure G-2. Reference Shade Condition SW ¼ Section 24, Township 13 North, Range 11 West, Lower Nevada Creek

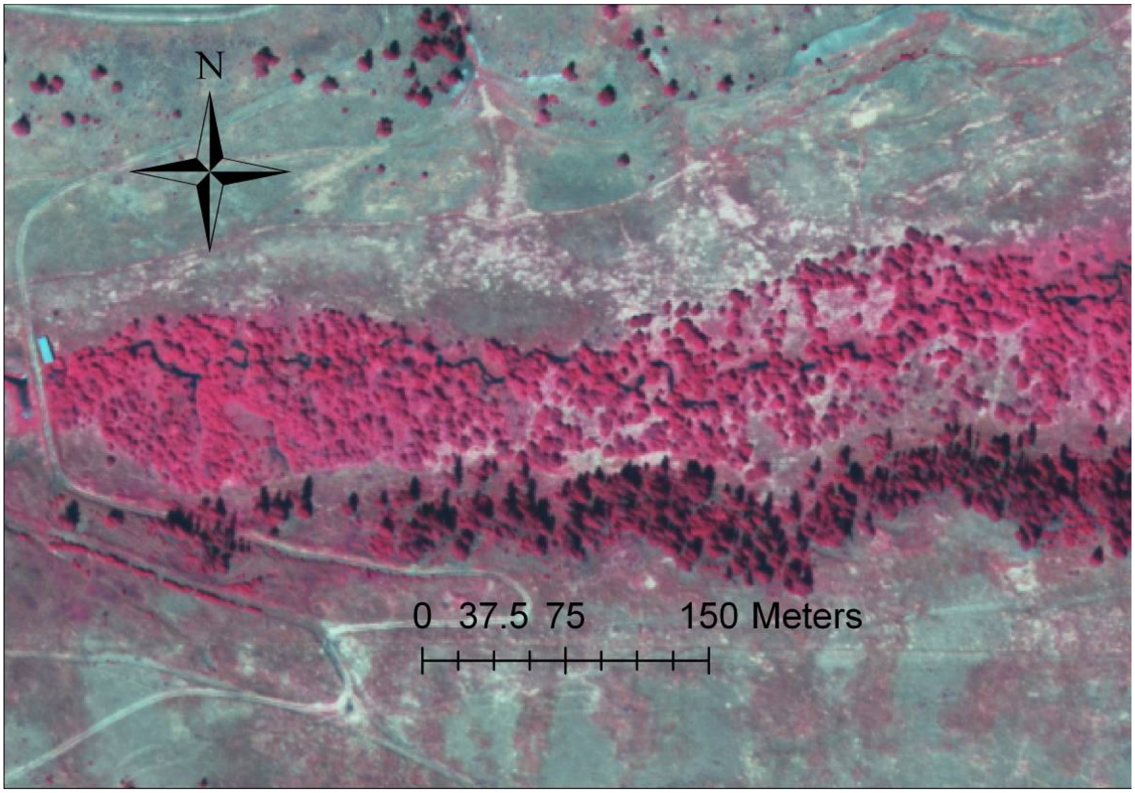

Figure G-3. Reference Shade Condition W ½ Section 20, Township 12 North, Range 12 West, Upper Douglas Creek

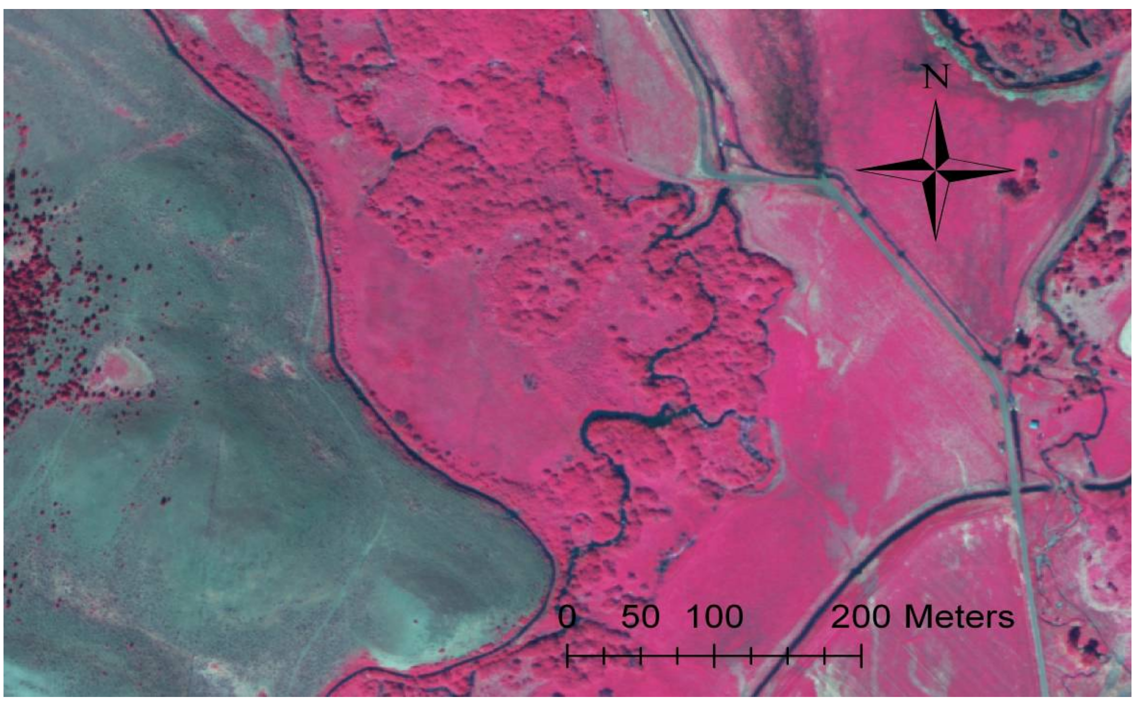

Figure G-4. Reference Shade Condition NW ¼ Section 33, Township 13 North, Range 11 West, Lower Douglas Creek

Daily Temperature Loading Example

A TMDL is the sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources (**Equation G-1**). In addition, the TMDL includes a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream.

Equation G-1. $TMDL = \Sigma WLA + \Sigma LA + MOS.$

Where:

ΣWLA = Waste Load Allocation = Pollutants from NPDES Point Sources
ΣLA = Load Allocation = Pollutants from Nonpoint Sources + Natural Sources
MOS = Margin of Safety

Total maximum daily loads are based on the loading of a pollutant to a water body. Federal Codes indicate that for each thermally listed water body the total maximum daily thermal load cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. Such estimates shall take into account the water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters. The following approach for setting numeric temperature TMDLs considers all of the factors listed above.

The numeric daily temperature TMDLs presented in this appendix apply to all the temperature impaired waters in the Middle Blackfoot-Nevada Creek planning area including:

- Upper Nevada Creek
- Lower Nevada Creek
- Murray Creek
- Cottonwood Creek
- Upper DouglasCreek
- Lower Douglas Creek
- Kleinschmidt Creek

All waters in the Middle Blackfoot-Nevada Creek planning area are classified as B1. Montana's temperature standard for B1 classified waters is depicted in **Figure G-5**. An example of the temperature TMDL and instantaneous temperature load (ITL) application to a water body is provided at the end of this appendix.

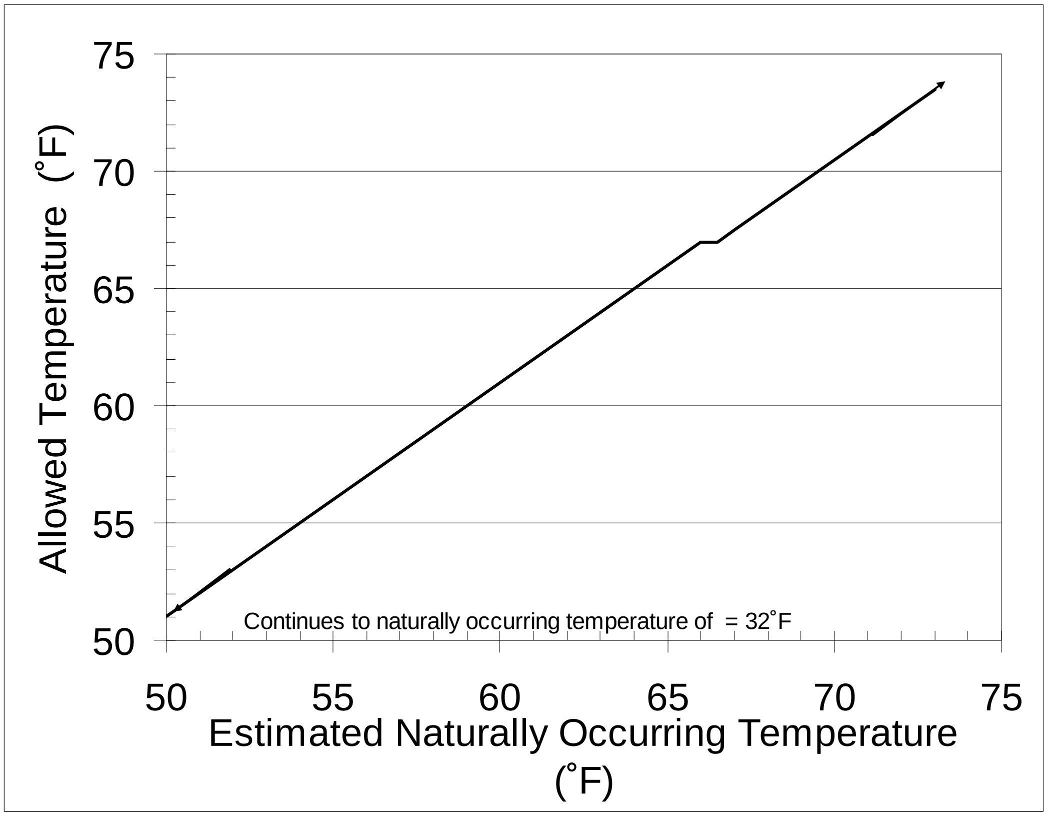

Figure G-5. In-Stream Temperatures Allowed by Montana's B-1 Classification Temperature Standard

Daily Thermal Load

The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure G-5**) and using a modeled or estimated naturally occurring daily average daily temperature. The daily average total maximum load at any location in the water body is provided by **Equation G-2**. The daily allowable loading is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kilocalorie increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure G-5**.

Equation G-2

$(\Delta-32)*(Q)*(1.36 \times 10^6) = TMDL$

Where:

Δ = allowed temperatures from **Figure G-5** using any daily temperature condition

Q = average daily discharge in cubic feet per second (CFS)

TMDL = daily TMDL in Calories (kilocalories) per day above waters melting point

Conversion Factor = 1.36×10^6

There are no point sources, and therefore, no wasteload allocations in the Middle Blackfoot-Nevada Creek planning area. The TMDL load allocation for each stream is a combination of the 1°F allowable loading shared between the human caused sources identified in the stream in addition to the naturally occurring loading as defined in state law. See the main document for more information about the allocations. The daily TMDL allocation is equal to the load allocation shared by all human-caused sources plus the load allocated to naturally occurring temperatures as shown in **Equation G-3**.

Equation G-3

Load Allocation= Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios -32)*(Discharge (CFS))*(1.36 X 10^6)

Allowable Human Sources = (1°F)*(1.36 X 10^6)*(Discharge (CFS))

Instantaneous Thermal Load

Because of the dynamic temperature conditions during the course of a day, an instantaneous load is also provided for temperature. For temperature, the daily average thermal conditions are not always an effective indicator of impairment to fisheries. The heat of the day is the usually the most stressful timeframe for salmonids and char. Also, in high altitudes, thermal impacts that heat during the day may produce advanced cooling conditions during the night so that the daily temperature fluctuations increase greatly with potentially significant negative impacts to fish without much impact on daily average temperature conditions. Therefore, Montana provides an instantaneous thermal load to protect during the hottest timeframes in mid to late afternoon when temperatures are most stressful to the fishery, which is the most sensitive use in reference to thermal conditions.

The instantaneous load is computed by the second. The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure G-5**) and using a modeled or estimated naturally occurring instantaneous temperature. The instantaneous total maximum load (per second) at any location in the water body is provided **Equation G-4**. The allowable loading over a second is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kCal increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure G-5**.

Equation G-4

(Δ-32)*(Q)*(15.7) = Instantaneous Thermal Load (ITL)

Where:

Δ = allowed temperatures from **Figure G-5** using daily temperature condition
Q = instantaneous discharge in CFS
ITL = Allowed thermal load per second in kilocalories per day above waters melting point
Conversion factor = 15.7

There are no point sources that increase water temperatures, and therefore, no wasteload allocations in the Middle Blackfoot-Nevada Creek planning area. The ITL load allocation for each stream is a combination of the 1°F allowable loading shared between the human caused sources identified in the stream in addition to the naturally occurring loading as defined in state law. See the main document for more information about the allocations. The ITL allocation is equal to the load allocation shared by all human caused sources plus the load allocated to naturally occurring temperatures as shown in **Equation G-5**.

Equation G-5

Load Allocation= Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios -32)*(Discharge (CFS))*(15.7)

Allowable Human Sources = (1°F)*(15.7)*(Discharge (CFS))

Margins of Safety, Seasonal Variations and Future Sources

See **Section 9.5** of the main document for this discussion.

Example Numeric TMDL Application for Kleinschmidt Creek

Kleinschmidt Creek Daily Thermal Load Example Application

A calibrated SNTEMP thermal loading modeling was constructed for Kleinschmidt Creek. A model scenario used reference riparian shade conditions along the entire length of the stream to estimate naturally occurring temperatures. The monitoring and modeling effort is described **Section 8.2.2.1**. Naturally occurring average daily temperature at the first Highway 200 crossing of Kleinscmidt Creek was estimated at 62.5°F. This temperature is used to determine the allowable temperature according to **Figure G-5**, Montana's temperature standard. The allowable mean daily temperature is estimated at 63.5°F. **Equation G-2** from above is used to calculate Kleinschmidt Creek TMDL.

$(\Delta\text{-}32)*(Q)*(1.36\text{x}10^6) = \text{TMDL}$

Where:

Δ = allowed temperatures from **Figure G-1** using daily temperature condition = 63.5°F
Q = average daily discharge in cubic feet per second (CFS) = 2.5cfs
TMDL = daily TMDL in Calories (kilocalories) per day above water's
melting point = $1.07\text{x}10^7$ kilocal/day.

This load represents that from natural background sources, plus human caused sources where all reasonable land, soil, and water conservation practices area applied, plus the additional loading allowed by the 1°F increase. The portion of the Kleinschmidt Creek TMDL represented by the 1°F allowable increase alone is:

(1°F) (2.5 cfs) $(1.36\text{x}10^6) = 1.7 \text{ x } 10^6$ kilocalories per day

This portion of the TMDL is appropriated to the human caused sources combined that are identified in **Section 9.4.6** of the main document. The remainder of the TMDL is appropriated to naturally occurring thermal load that includes human sources with reasonable land, soil, and water conservation practices applied. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. The remainder of the TMDL is apportioned to naturally occurring thermal loading. Currently the daily total maximum daily load is not being met because the current temperature exceeds the naturally occurring temperature by more than 1°F.

The mean daily temperature of the site was 65.1°F, which equates to a thermal load of $1.12\text{x}10^7$ kilocal/day and exceeds standard and the TMDL when a daily averaged timeframe is considered. Because this site on Kleinschmidt Creek is not meeting Montana's temperature standard during an average daily condition, it exceeds the average daily TMDL. Montana's temperature standard is applied to any timeframe because no duration is provided in the standard. Therefore, we can also investigate the instantaneous thermal load. The instantaneous load will consider heating during the warm summer afternoons when the fishery is the most stressed.

Kleinschmidt Creek Instantaneous Thermal Load

The instantaneous thermal load (ITL) is described as the heat passing a monitoring location per second. The most sensitive timeframe for the fishery occurs during the heat of the day for the hottest period of the year. The same modeling described in this appendix was used to model daily maximum temperatures. The naturally occurring daily maximum temperature at the first highway 200 crossing on Kleinschmidt Creek was estimated at 65.8°F using a SNTEMP model.

This temperature is used to determine the allowable temperature according to **Figure G-5**, Montana's temperature standard. Therefore, the allowable maximum temperature during this timeframe is estimated at 66.8°F (73°F plus an additional 0.5°F for this temperature range).

Equation G-4 from above is used to calculate the Kleinschmidt Creek ITL.

(Δ-32)*(Q)*(15.7`) = Instantaneous Thermal Load (ITL)

Where:
Δ = allowed temperatures from **Figure G-1** using daily temperature condition = 66.8°F
Q = average daily discharge in cubic feet per second (CFS) = 2.5cfs
ITL = Allowed thermal load per second in kilocalories per day above water's melting point = 1366 kilocal/second

This load represents that from natural background sources, plus human caused sources where all reasonable land, soil, and water conservation practices area applied, plus the additional loading allowed by the 1°F increase. The portion of the Kleinschmidt Creek TMDL represented by the 1°F allowable increase alone is:

(1°F) (2.5 cfs) (15.7) = 39 kilocal/second

The Kleinschmidt Creek load allocation for the ITL is 1366 kilocalories per second and is appropriated to all human caused sources combined that are identified in **Section 9.4.6** of the main document. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. The remainder of the load allocation for the ITL is apportioned to naturally occurring thermal loading.

The hottest temperature estimated for current conditions at this site was 73.0°F, which equates to a thermal load of 1609 kilocal/sec. The temperature is above the State's temperature standard and the thermal load is above the allowable instantaneous load when considered during a one second timeframe. Because this site on Kleinschmidt Creek is not meeting Montana's temperature standard during a one second timeframe, the thermal load during a one second timeframe is also above the ITL. This scenario would also hold true for an hourly time step. This indicates that Montana's temperature standard at this site is not being met during an important timeframe for the most sensitive use.

A similar analysis could be completed for the remaining seven temperature impaired, stream segments, but for the sake of brevity is not provided since it is easy to figure if the TMDL and ITL are met by looking at measured temperatures and comparing them to Montana's temperatures standard instead of caloric loads.