Addendum to the Mid-Snake/Succor Subbasin Assessment and TMDL: South Fork Castle Creek Bacteria Analysis And Succor Creek and Castle Creek Temperature Total Maximum Daily Loads

Department of Environmental Quality

Revised November 2007

Succor Creek and Castle Creek Temperature TMDLs

And
South Fork Castle Creek Analysis

Revised August 2007

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Acknowledgments

Cover photo (Castle Creek, October 2005) by Hawk Stone.

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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
BMP	best management practice
C	Celsius
CWA	Clean Water Act
CWE	cumulative watershed effects
DEQ	Department of Environmental Quality
EPA	United States Environmental Protection Agency
GIS	Geographical Information Systems
HUC	Hydrologic Unit Code
I.C.	Idaho Code
IDAPA	Refers to citations of Idaho administrative rules
IDFG	Idaho Department of Fish and Game
IDL	Idaho Department of Lands
LA	load allocation
LC	load capacity
m	meter
mi	mile
mi^2	square miles
MOS	margin of safety
MWMT	maximum weekly maximum temperature
n.a.	not applicable
NB	natural background
nd	no data (data not available)
PNV	potential natural vegetation
SBA	subbasin assessment
TMDL	total maximum daily load
U.S.	United States
U.S.C.	United States Code
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USGS	United States Geological Survey
WLA	wasteload allocation
WQMP	water quality management plan
WQS	water quality standard

Executive Summary

This TMDL has been revised to include Succor Creek Reservoir and Succor Creek from the Reservoir to the Idaho/Oregon border. These portions of Succor Creek were overlooked in the original loading analysis.

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. 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 Mid-Snake/Succor Subbasin that have been placed on Idaho's current §303(d) list. This document only addresses the temperature TMDLs for these three streams and their associated tributaries. For more information about these watersheds and the subbasin as a whole see the *Mid Snake River/Succor Creek Subbasin Assessment and Total Maximum Daily Loads* (IDEQ, 2003).

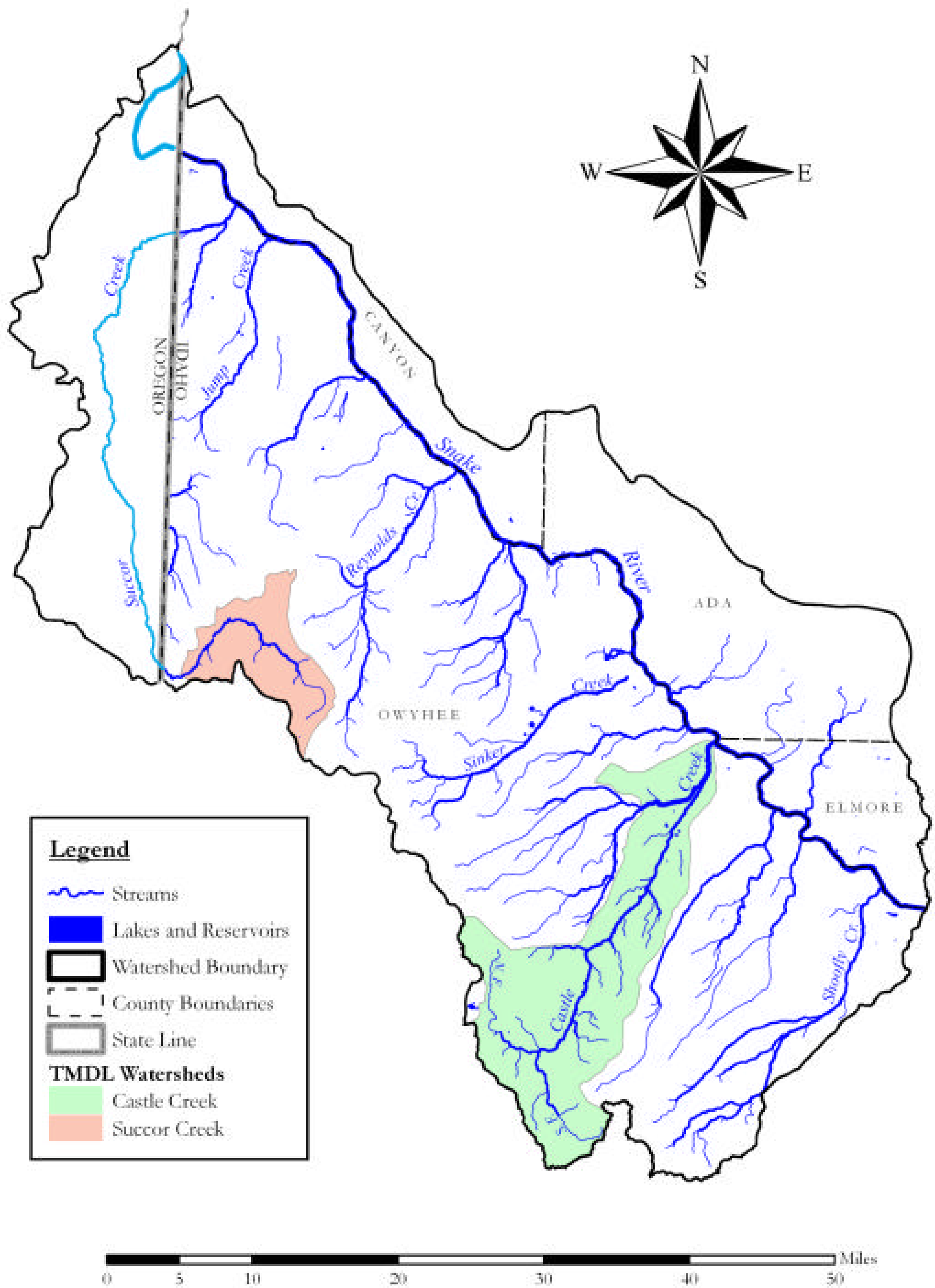
This TMDL analysis has been developed to comply with Idaho's TMDL schedule. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

Subbasin at a Glance

The Mid Snake River/Succor Creek Subbasin (17050103) is located in southwest Idaho in an area that is known as the Owyhee Front, the north facing slopes of the Owyhee Mountains. The subbasin itself includes a section of the Snake River from C.J. Strike Reservoir to the Oregon border (Figure A). Succor Creek drains west into Oregon and then turns north flowing through the State of Oregon before it re-enters Idaho just before it enters the Snake River. Only the upper portion of Succor Creek, between its headwaters and the Idaho/Oregon border, is addressed in this TMDL. The Castle Creek drainage on the eastern end of the subbasin drains north to the Snake River.

Succor Creek and Castle Creek were on the original 1998 303d list for temperature. The Environmental Protection Agency (EPA) added streams to Idaho's 1998 303d list of impaired waters that exceeded Idaho's temperature criteria. In the Mid Snake River/Succor Creek Subbasin the North Fork Castle Creek was among those EPA additions. See *Mid Snake River/Succor Creek Subbasin Assessment and Total Maximum Daily Loads* (IDEQ, 2003) for individual stream assessments.

Figure A. Subbasin at a glance.



Summary of Existing Water Quality Data

Key Findings for South Fork Castle Creek

DEQ recommends de-listing bacteria. South Fork Castle Creek is listed for bacteria due to 1979 BLM data taken during the base flow period. The 1979 sample met both the primary and secondary contact recreation standards with a fecal coliform result of 312 cfu/100mL. This result is well below the old standard which called for less than 500 cfu/100mL instantaneously for primary contact recreation and less than 800 cfu/100mL instantaneously for secondary contact recreation.

The new data show the E. coli count is well below the current standard. The current standard for primary contact recreation requires that an instantaneous sample be less than 406 E. coli organisms/100mL. The DEQ water body assessment process also shows this reach to be fully supporting its beneficial uses.

Table A. South Fork Castle Creek bacteria monitoring results

Location	Date	Result
South Fork Castle Creek	10/1/79	312 fecal cfu/100mL
South Fork Castle Creek	06/26/03	36 E. coli cfu/100mL

Key Findings for Succor Creek and Castle Creek Temperature TMDLs

Succor Creek, Castle Creek and NF Castle Creek were placed on the 1998 303d list of impaired waters by EPA for reasons associated with temperature criteria violations. Additional temperature data was collected in 2002-2004 on Castle, NF Castle and Succor Creeks. The data verify temperature exceedences of the cold water aquatic life and rainbow trout salmonid spawning criteria and, as a result, Potential Natural Vegetation TMDLs have been developed; see section 5 of this document. Summary graphics of the temperature data have been added to this document for accounting purposes and can be located in Appendix C.

Effective shade targets were established for Succor Creek and seven associated tributaries and Castle Creek, NF Castle Creek, SF Castle Creek, and three other tributaries (Table B) based on the concept of maximum shading under potential natural vegetation equals natural background temperature levels. Additional streams were included in the TMDL that were not on a 303d list because major tributaries to a listed water body can be significant sources of excess solar loading. Shade targets were actually derived from effective shade curves developed for similar vegetation types in the Northwest. Existing shade was determined from aerial photo interpretation field verified with solar pathfinder data.

All streams examined exceeded their potential solar load targets by variable amounts (percent reductions vary from 15% to 60%). Mainstem Succor and Castle Creeks and several of the associated tributaries had relatively low excess loading, relative to their size, with percent reductions equal to or less than 33%. The North Fork and South Fork of Castle Creek also had relatively low percent reductions at 35% and 33%, respectively. Many of the tributaries had higher percent reductions, although their actual excess load is small due to their smaller size.

Mainstem Succor and Castle Creeks as well as the North Fork Castle Creek are 1998 303d listed for temperature. However, most of tributaries examined also exceeded appropriate solar loading targets and would be significant sources of heat to these listed water bodies.

Table B. Streams and pollutants for which TMDLs were developed.

Stream Name	Pollutant
Succor Creek, headwater tributary to Succor Cr. from Johnston Lakes, headwater tributary to Succor Cr. East of Johnston Lakes, Crane Creek, Granite Creek, Crows Nest Creek Little Succor Creek, Cottonwood Creek	Temperature
Castle Creek, NF, SF, Alder Creek, Juniper Creek, Clover Creek.	Temperature

Table C. Summary of assessment outcomes.

Water Body and associated Segment/ AU & Order	AU & Order Description	Pollutant	TMDL(s) Completed	Justification
Succor Creek and tributaries ID17050103SW003_02 ID17050103SW003_03	**ID17050103SW003_02** – Mainstem Succor Cr. from Headwaters to Granite Cr. and all tributaries to Succor Cr. ID17050103SW003_03 – Mainstem Succor Cr. from Granite Cr. to the ID/OR border.	Temperature	Yes	Existing Shade
Castle Creek ID17050103SW014_04 ID17050103SW014_04a ID17050103SW014_05	**ID17050103SW014_04 –** Mainstem Castle Cr. from unnamed tributary from Lower Birch Spring to Catherine Cr. **ID17050103SW014_04a** – Main-stem Castle Cr. from NF Castle Cr. to unnamed tributary from Lower Birch Spring **ID17050103SW014_05** – Main-stem Castle Cr. from Catherine Cr. to mouth			
NF Castle Creek & Alder Creek ID17050103SW014_02 ID17050103SW014_02a ID17050103SW014_03	**ID17050103SW014_02** – 1^{st} and 2^{nd} order rangeland tributaries in the Castle Cr. watershed **ID17050103SW014_02a** – 1^{st} and 2^{nd} order forested tributaries in the Castle Cr. watershed **ID17050103SW014_03** – All 3^{rd} order tributaries to main-stem Castle Cr.	Temperature	Yes	Existing Shade
SF Castle Creek, Juniper Creek, Clover Creek ID17050103SW020_02 ID17050103SW020_03	**ID17050103SW020_02** – Main-stem SF Castle Cr from HW to Clover Cr. & all main-stem SF Castle Cr. tributaries HW to mouth **ID17050103SW020_03** – Main-stem SF Castle Cr. from Clover Cr. to mouth			

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5. Total Maximum Daily Loads

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA). Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the margin of safety is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human made pollutant sources. This can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the load capacity is determined. Then the load capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear on the surface.

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. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 In-stream Water Quality Targets

For the Succor Creek and Castle Creek temperature TMDLs we utilize a potential natural vegetation (PNV) approach. The Idaho water quality standards include a provision (IDAPA

58.01.02.200.09) which establishes that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered to be 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 which results from attainment of these conditions is consistent with the water quality standards, even though it may exceed numeric temperature criteria. See Appendix B for further discussion of water quality standards and background provisions.

The PNV approach is described below. Additionally, the procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in this section. For a more complete discussion of shade and its affects on stream water temperature, the reader is referred to the South Fork Clearwater Subbasin Assessment and TMDL (IDEQ, 2004)

Potential Natural Vegetation for Temperature TMDLs

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

Depending on how much vertical elevation also surrounds the stream, vegetation further away from the riparian corridor can provide shade. However, riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. We can measure the amount of shade that a stream enjoys in a number of ways. Effective shade, that shade provided by all objects that intercept the sun as it makes its way across the sky, can be measured in a given spot with a solar pathfinder or with 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 the stream's 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 on aerial photography. All of these methods tell us information about how much the stream is covered and how much of it is exposed to direct solar radiation.

Potential natural vegetation (PNV) along a stream is that intact riparian plant community that has grown to an overall mature state, although some level of natural disturbance is usually included in our development and use of shade targets. The PNV can be removed by disturbance either naturally (wildfire, disease/old age, wind-blown, wildlife grazing) or anthropogenically (domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade producing vegetation. Anything less than PNV results in the stream heating up from anthropogenic solar inputs.

We can estimate PNV from models of plant community structure (shade curves for specific riparian plant communities), and we can measure existing vegetative cover or shade. Comparing the two will tell us how much excess solar load the stream is receiving, and what can be done to decrease solar gain.

Existing shade or cover was estimated for Succor Creek and Castle Creek from visual observations of aerial photos. These estimates were field verified by measuring shade with a solar pathfinder at systematically located points along the streams (see below for methodology). PNV targets were determined from an analysis of probable vegetation at the creeks and comparing that to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows 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. Existing and PNV shade was converted to solar load from data collected on flat plate collectors at the nearest National Energy Research Laboratory weather stations collecting these data. In this case, the Boise station was used. The difference between existing and potential solar load, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (see Appendix B). PNV shade and loads are assumed to be the natural condition, thus stream temperatures under PNV conditions are assumed to be natural (so long as there are no point sources or any other anthropogenic sources of heat in the watershed), and are thus considered to be consistent with the Idaho water quality standards, even though they may exceed numeric criteria.

Pathfinder Methodology

The solar pathfinder is a device that allows one to trace the outline of shade producing objects on monthly solar path charts. The percentage of the sun's path covered by these objects is the effective shade on the stream at the spot that the tracing is made. In order to adequately characterize the effective shade on a reach of stream, ten traces should be taken at systematic or random intervals along the length of the stream in question.

At each sampling location the solar pathfinder should be placed in the middle of the stream about one foot above the water. Follow the manufacturer's instructions (orient to true south and level) for taking traces. Systematic sampling is easiest to accomplish and still not bias the location of sampling. Start at a unique location such as 100 m from a bridge or fence line and then proceed upstream or downstream stopping to take additional traces at fixed intervals (e.g. every 100m, every half-mile, every degree change on a GPS, every 0.5 mile change on an odometer, etc.). One can also randomly locate points of measurement by generating random numbers to be used as interval distances.

It is a good idea to take notes while taking solar pathfinder traces, and to photograph the stream at several unique locations. Pay special attention to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade producing ones) are present. Additionally or as a substitution, one can take densiometer readings at the same location as solar pathfinder traces. This provides the potential to develop relationships between canopy cover and effective shade for a given stream.

Aerial Photo Interpretation

Canopy coverage estimates or expectations of shade based on plant type and density are provided for natural breaks in vegetation density, marked out on a 1:100K hydrography. Each interval is assigned a single value representing the bottom of a 10% canopy coverage or shade class as described below (*adapted from the CWE process, IDL, 2000)*. For example, if we estimate that canopy shade for a particular stretch of stream is somewhere between 50% and 59%, we assign the value of 50% to that section of stream. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, the width of the stream, and any possible topographic shade. The typical vegetation type (below) shows the kind of landscape a particular cover class usually falls into for a stream 5m wide or less. For example, if a section of a small stream is identified as 20% shade class, it is usually because it is in agricultural land, meadows, open areas, or clearcuts. However, that does not mean that the 20% cover class cannot occur in shrublands and forests, because it does on very wide streams.

Shade class	Typical vegetation type on <5m wide stream
0 = 0 – 9% cover	agricultural land, denuded areas
10 = 10 –19%	ag land, meadows, open areas, clearcuts
20 = 20 – 29%	ag land, meadows, open areas, clearcuts
30 = 30 – 39%	ag land, meadows, open areas, clearcuts
40 = 40 – 49%	shrublands/meadows
50 = 50 – 59%	shrublands/meadows, open forests
60 = 60 – 69%	shrublands/meadows, open forests
70 = 70 – 79%	forested
80 = 80 – 89%	forested
90 = 90 –100%	forested

It is important to note that the visual estimates made from the aerial photos are strongly influenced by canopy cover. We assume that canopy coverage and shade are similar based on research conducted by Oregon DEQ. The visual estimates of cover in this TMDL were field verified with a solar pathfinder. The pathfinder measures effective shade and is taking into consideration other physical features that block the sun from hitting the stream surface (e.g. hillsides, canyon walls, terraces, man-made structures). The estimate of shade made visually from an aerial photo does not accurately take into account topography or any shading that may occur from physical features other than vegetation. However, research has shown that shade and cover measurements are remarkably similar (OWEB, 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade.

Stream Morphology

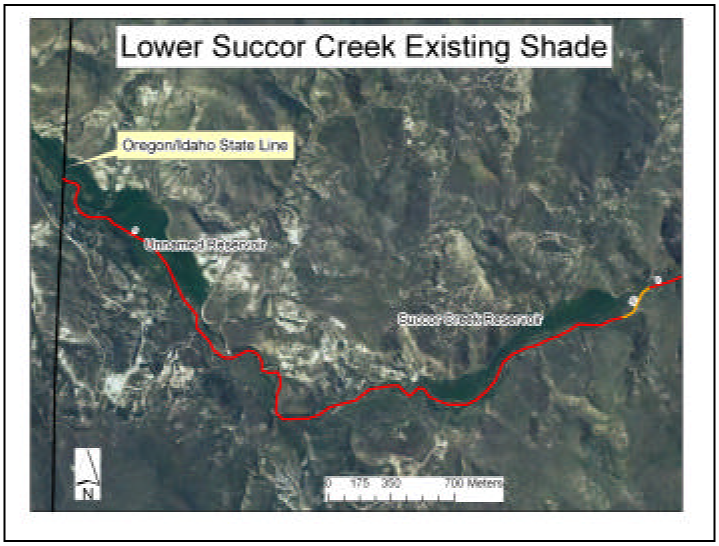
Measures of current bankfull width or near stream disturbance zone width may not reflect widths that were present under PNV. As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase such that streams become wider and shallow. Shadow length produced by vegetation covers a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

Shade target selection, which involves evaluating the amount of shade provided at PNV conditions, necessitates recognition of potential natural stream widths as well. In this TMDL appropriate stream widths for shade target selection were determined from analysis of existing stream widths and the relationship between drainage area and width-to-depth ratios (Rosgen, 1996) (see Appendix B for more discussion on determining appropriate stream widths).

Based on drainage area, the natural stream width for Castle Creek is much larger than existing bankfull width conditions. This is likely due to the unique geology and terrain that may cause flows to subtend below the land surface into alluvial or porous basalt. Additionally, the current climate does not support larger amounts of rainfall that may have existed at one time. And finally, a certain amount of diversion takes place that may prevent flows from reaching the mouth of Castle Creek. Although the mouth of Castle Creek should be 24m wide based on drainage area, the existing bankfull width is 10m. Therefore, existing bankfull conditions will be used for natural stream widths for Castle Creek.

Succor Creek does not have as much alluvium as Castle Creek. Succor Creek appears to be more hard-rock mountainous terrain where flows are more like to stay on the surface. Based on drainage area, the natural width of Succor Creek above the Succor Creek Reservoir is 10m. However, that is still wider than existing bankfull width, which is approximately 8m upstream of the reservoir. Below the reservoir existing widths on Succor Creek are near 10m. Therefore, Succor Creek natural widths are based on existing bankfull widths.

It is important to note that Succor Creek in this analysis is that portion of the stream from its headwaters to the Oregon State line (see inset picture below). Lower Succor Creek before it crosses into Oregon goes through two small reservoirs, the first is Succor Creek reservoir that is the larger of the two, and the second smaller reservoir is unnamed. This second reservoir, as well as the Oregon State Line, is not entirely visible on maps in Figures 1 through 3. The surface areas of these reservoirs is not included in the loading analysis (Table 2), and no shade targets are prescribed for these water bodies as their widths exceed 100 meters. However, existing summer load for these reservoirs have been calculated. Succor Creek Reservoir is 3,200 meters long (960,000 m^2) and contributes 6,124,800 kWh/day. The smaller unnamed reservoir is 1,350 meters long (135,000 m^2) and contributes 861,300 kWh/day to downstream portions of Succor Creek.



Design Conditions

The vegetation of the Owyhee Front uplands is typically sagebrush-bunchgrass communities. The riparian areas tend to be dominated by mixed deciduous shrubs such as red osier dogwood (*Cornus sericea*), willows (*Salix spp.*), alders (*Alnus spp.*), and river birch (*Betula occidentalis*).

Target Selection

To determine potential natural vegetation shade targets for Succor Creek and Castle Creek, effective shade curves from the Alvord Lake Subbasin temperature TMDLs (ODEQ, 2003) was examined. This TMDL had previously used vegetation community modeling to produce these shade curves. For Succor Creek and Castle Creek curves for the most similar vegetation type were selected for shade target determinations. Because no two landscapes are exactly the same, shade targets were derived by taking an average of two shade curves available. Effective shade curves include percent shade on the vertical axis and stream width on the horizontal axis. As a stream becomes wider, a given vegetation type looses its ability to shade wider and wider streams.

The effective shade calculations are based on a six month period from April through September. The site-specific salmonid spawning time period for redband trout in the Mid Snake /Succor Creek subbasin is March 1 through June 15. The critical period for cold water aquatic life is June 22 through September 21. Late July and early August represent a period of highest stream temperatures. Solar gains can begin early in the spring and affect not only the highest temperatures reached later on in the summer, but solar loadings affect salmonids spawning temperatures in spring and fall. Thus, solar loading in these streams is evaluated from spring (April) to early fall (September).

For Succor Creek and Castle Creek an attempt was made to match a mixed deciduous shrub vegetation type. The Alvord Lake TMDL (ODEQ, 2003) provides the closest match to this vegetation type with shade curves for mixed deciduous vegetation of moderate height and density and at comparative elevations. Effective shade curves from the Alvord Lake TMDL are as follows:

1) Willow mix community for the East Steens Low Elevation Ecological Province (4260' – 4100'), average canopy height = 20 feet, average canopy density = 50% (Figure 2-33, ODEQ, 2003),

2) Co-dominant Willow-Alder Community of the Trout Creek Mts. Mid Elevation Ecological Province (6562' – 4500'), average canopy height = 24 feet, average canopy density = 75% (Figure 2-39, ODEQ, 2003).

These shade curves were selected because they provide a mixed deciduous shrub plant community of average heights and densities similar to what is expected in Succor Creek and Castle Creek riparian areas. In general, although various shade TMDLs in the Northwest reflect a wide variety of geomorphologies and topographies, effective shades for similar plant communities at the same stream width are remarkably similar.

Natural bankfull stream widths for Succor Creek and Castle Creek vary from 2m wide in the headwaters to 8m wide and 10m wide, respectively at the mouths. In this case, the mouth of Succor Creek is its termination at the Idaho/Oregon border. Existing bankfull width is considered the same as natural bankfull width in this TMDL. Effective shade targets for various widths are presented in Table 1. It is important to note that existing shade values determined by aerial photo interpretation are presented in 10% class intervals. Shade targets on the other hand are the average of the two curve values.

Table 1. Effective Shade Targets for Various Stream Widths of Succor and Castle Creeks and Associated Tributaries.

Shade Curve	2m width	4m width	5m width	6m width	8m width	10m width
Alvord Figure 2-33	70	50	45	41	35	30
Alvord Figure 2-39	82	68	60	55	45	40
Average & Target	**76**	**59**	**53**	**48**	**40**	**35**

Monitoring Points

Effective shade monitoring can take place on any reach throughout the Succor Creek and Castle Creek watersheds and compared to estimates of existing shade seen on Figures 2 and 4 and described in Tables 2 through 15. Those areas with the lowest existing shade estimates should be monitored with solar pathfinders to verify the existing shade levels and to determine progress towards meeting shade targets. Stream segments for each change in existing shade vary in length depending on land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade towards target levels. Five to ten equally spaced solar pathfinder measurements within that segment should suffice to determine new shade levels in the future.

5.2 Load Capacity

The loading capacity for a stream under PNV is essentially the solar loading allowed under the shade targets specified for the reaches within that stream. These loads are determined by multiplying the solar load to a flat plat 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 1-percent shade). In other words, if a shade target is 60% (or 0.6), then the solar load hitting the stream is 40% under full sun.

We obtained solar load data for flat plate collectors from a National Renewable Energy Laboratory (NREL) weather station in Boise, Idaho. The solar loads used in this TMDL are spring/summer averages, thus, we use an average load for the six month period from April through September. These months coincide with time of year that stream temperatures are increasing and when deciduous vegetation is in leaf. Tables 2 through 15 show the PNV shade targets (identified as Target or Potential Shade) and their corresponding potential summer load (in kWh/m^2/day and kWh/day) that serve as the loading capacities for the streams. Target shade levels are also shown on Figures 1 and 3.

5.3 Estimates of Existing Pollutant Loads

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

Existing loads in this temperature TMDL come from estimates of existing shade as determined from aerial photo interpretations. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat plate collector at the NREL weather stations. Existing shade data are presented in Tables 2 through 15 and Figures 2 and 4.

Like loading capacities (potential loads), existing loads in Tables 2 through 15 are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day). The existing load for Succor Creek from its headwaters to the Idaho/Oregon border is 954,008 kWh/day (Table 2). The seven tributaries to Succor Creek examined have existing loads that vary from 9,940 kWh/day (Table 3) to 141,432 kWh/day (Table 8). The existing load for Castle Creek from the North Fork, South Fork confluence to its mouth is 1,296,582 kWh/day (Table 10). The North Fork Castle Creek and the South Fork Castle Creek have existing loads that are 378,599 kWh/day (Table 12) and 176,554 kWh/day (Table 13), respectively. The three additional tributaries examined in the Castle Creek drainage had existing loads that varied from 33,444 kWh/day (Table 14) to 107,516 kWh/day (Table 11).

Table 2. Existing and Potential Solar Loads for Succor Creek (Headwaters to Oregon State Line).

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Succor Creek
780	0.7	1.914	0.76	1.5312	-0.38	Mixed Shrub 2m
1320	0.4	3.828	0.76	1.5312	-2.30	
4990	0.4	3.828	0.59	2.6158	-1.2122	Mixed Shrub
1220	0.2	5.104	0.59	2.6158	-2.4882	4m width
2610	0.4	3.828	0.53	2.9986	-0.8294	Mixed Shrub
1530	0.3	4.466	0.53	2.9986	-1.4674	5m width
1080	0.1	5.742	0.48	3.3176	-2.4244	Mixed Shrub
5040	0.2	5.104	0.48	3.3176	-1.7864	6m width
1170	0.1	5.742	0.48	3.3176	-2.4244	
1360	0.2	5.104	0.48	3.3176	-1.7864	
1150	0.1	5.742	0.4	3.828	-1.914	Mixed Shrub
1260	0.4	3.828	0.4	3.828	0	8m width
1200	0.1	5.742	0.4	3.828	-1.914	
720	0	6.38	0.4	3.828	-2.552	
180	0.4	3.828	0.4	3.828	0	
300	0.3	4.466	0.4	3.828	-0.638	
350	0.4	3.828	0.4	3.828	0	
410	0.3	4.466	0.4	3.828	-0.638	
170	0.1	5.742	0.4	3.828	-1.914	
950	0	6.38	0.4	3.828	-2.552	
230	0.2	5.104	0.4	3.828	-1.276	
3000	0	6.38	0.35	4.147	-2.233	10m width

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
780	1560	2986	2	2389	-597	
1320	2640	10106	2	4042	-6064	
4990	19960	76407	4	52211	-24196	
1220	4880	24908	4	12765	-12142	
2610	13050	49955	5	39132	-10824	
1530	7650	34165	5	22939	-11226	
1080	6480	37208	6	21498	-15710	
5040	30240	154345	6	100324	-54021	
1170	7020	40309	6	23290	-17019	
1360	8160	41649	6	27072	-14577	
1150	9200	52826	8	35218	-17609	
1260	10080	38586	8	38586	0	
1200	9600	55123	8	36749	-18374	
720	5760	36749	8	22049	-14700	
180	1440	5512	8	5512	0	
300	2400	10718	8	9187	-1531	
350	2800	10718	8	10718	0	
410	3280	14648	8	12556	-2093	
170	1360	7809	8	5206	-2603	
950	7600	48488	8	29093	-19395	
230	1840	9391	8	7044	-2348	
3000	30000	191400	10	124410	-66990	**% Reduction**
Total	**187,000**	**954,008**		**641,990**	**-312,018**	**-33**

Table 3. Existing and Potential Solar Loads for the Headwater Tributary to Succor Creek from Johnston Lakes

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Headwater Trib#1
1330	0.7	1.914	0.76	1.5312	-0.38	Mixed Shrub
950	0.6	2.552	0.76	1.5312	-1.0208	2m width
Segment Length (meters)	Segment Area (m ^{2})	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
1330	2660	5091	2	4073	-1018	
950	1900	4849	2	2909	-1940	**% Reduction**
Total	**4,560**	**9,940**		**6,982**	**-2,958**	**-30**

Table 4. Existing and Potential Solar Loads for the Headwater Tributary to Succor Creek East of Johnston Lakes

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Headwater Trib#2
2410	0.7	1.914	0.76	1.5312	-0.38	Mixed Shrub
370	0.6	2.552	0.76	1.5312	-1.0208	2m width
640	0.7	1.914	0.76	1.5312	-0.3828	
630	0.6	2.552	0.59	2.6158	0.0638	Mixed Shrub 4m
Segment Length (meters)	Segment Area (m ^{2})	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
2410	4820	9225	2	7380	-1845	
370	740	1888	2	1133	-755	
640	1280	2450	2	1960	-490	
630	2520	6431	4	6592	161	**% Reduction**
Total	**9,360**	**19,995**		**17,065**	**-2,930**	**-15**

Table 5. Existing and Potential Solar Loads for Crane Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Crane Creek
1780	0.6	2.552	0.76	1.5312	-1.02	Mixed Shrub
890	0.4	3.828	0.76	1.5312	-2.2968	2m width
650	0.2	5.104	0.59	2.6158	-2.4882	Mixed Shrub 4m
Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
1780	3560	9085	2	5451	-3634	
890	1780	6814	2	2726	-4088	
650	2600	13270	4	6801	-6469	**% Reduction**
Total	**7,940**	**29,169**		**14,978**	**-14,192**	**-49**

Table 6. Existing and Potential Solar Loads for Granite Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Granite Creek
990	0.5	3.19	0.76	1.5312	-1.66	Mixed Shrub
1975	0.2	5.104	0.76	1.5312	-3.5728	2m width
1360	0.5	3.19	0.59	2.6158	-0.5742	Mixed Shrub 4m
Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
990	1980	6316	2	3032	-3284	
1975	3950	20161	2	6048	-14113	
1360	5440	17354	4	14230	-3124	**% Reduction**
Total	**11,370**	**43,831**		**23,310**	**-20,521**	**-47**

Table 7. Existing and Potential Solar Loads for Crows Nest Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Crows Nest Cr.
320	0.4	3.828	0.76	1.5312	-2.30	Mixed Shrub
690	0.1	5.742	0.76	1.5312	-4.2108	2m width
710	0	6.38	0.76	1.5312	-4.8488	
1030	0.1	5.742	0.59	2.6158	-3.1262	Mixed Shrub
420	0.3	4.466	0.59	2.6158	-1.8502	4m width
Segment Length (meters)	Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
320	640	2450	2	980	-1470	
690	1380	7924	2	2113	-5811	
710	1420	9060	2	2174	-6885	
1030	4120	23657	4	10777	-12880	
420	1680	7503	4	4395	-3108	**% Reduction**
Total	**9,240**	**50,593**		**20,439**	**-30,154**	**-60**

Table 8. Existing and Potential Solar Loads for Little Succor Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m²/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m²/day)	Potential Load minus Existing load (kWh/m²/day)	Little Succor Cr.
3250	0.5	3.19	0.76	1.5312	-1.66	Mixed Shrub 2m
1260	0.4	3.828	0.59	2.6158	-1.2122	Mixed Shrub
360	0.2	5.104	0.59	2.6158	-2.4882	4m width
2170	0.1	5.742	0.48	3.3176	-2.4244	Mixed Shrub
720	0.3	4.466	0.48	3.3176	-1.1484	6m width
Segment Length (meters)	Segment Area (m²)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
3250	6500	20735	2	9953	-10782	
1260	5040	19293	4	13184	-6109	
360	1440	7350	4	3767	-3583	
2170	13020	74761	6	43195	-31566	
720	4320	19293	6	14332	-4961	**% Reduction**
Total	**30,320**	**141,432**		**84,430**	**-57,001**	**-40**

Table 9. Existing and Potential Solar Loads for Cottonwood Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Cottonwood Cr.
3310	0.5	3.19	0.76	1.5312	-1.66	Mixed Shrub 2m
2830	0.4	3.828	0.59	2.6158	-1.2122	Mixed Shrub 4m
670	0.2	5.104	0.48	3.3176	-1.7864	Mixed Shrub 6m
Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
3310	6620	21118	2	10137	-10981	
2830	11320	43333	4	29611	-13722	
670	4020	20518	6	13337	-7181	**% Reduction**
Total	**21,960**	**84,969**		**53,084**	**-31,885**	**-38**

Table 10. Existing and Potential Solar Loads for Castle Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Lower Castle
1090	0.2	5.104	0.59	2.6158	-2.49	Mixed Shrub
500	0.6	2.552	0.59	2.6158	0.0638	4m width
710	0.3	4.466	0.59	2.6158	-1.8502	
200	0	6.38	0.59	2.6158	-3.7642	
730	0.2	5.104	0.59	2.6158	-2.4882	
1940	0.6	2.552	0.59	2.6158	0.0638	
890	0.5	3.19	0.59	2.6158	-0.5742	
390	0.2	5.104	0.59	2.6158	-2.4882	
510	0.3	4.466	0.59	2.6158	-1.8502	
360	0.4	3.828	0.59	2.6158	-1.2122	
260	0.5	3.19	0.59	2.6158	-0.5742	
1210	0.4	3.828	0.59	2.6158	-1.2122	
2500	0.6	2.552	0.59	2.6158	0.0638	
550	0.7	1.914	0.59	2.6158	0.7018	
900	0.6	2.552	0.59	2.6158	0.0638	
290	0.7	1.914	0.59	2.6158	0.7018	
230	0.5	3.19	0.59	2.6158	-0.5742	
2060	0.7	1.914	0.59	2.6158	0.7018	
1390	0.6	2.552	0.53	2.9986	0.4466	Mixed Shrub
820	0.4	3.828	0.53	2.9986	-0.8294	5m width
650	0.2	5.104	0.53	2.9986	-2.1054	
1250	0.4	3.828	0.53	2.9986	-0.8294	
870	0.6	2.552	0.53	2.9986	0.4466	
1130	0.5	3.19	0.53	2.9986	-0.1914	
250	0.7	1.914	0.53	2.9986	1.0846	
2340	0.6	2.552	0.53	2.9986	0.4466	
590	0.4	3.828	0.53	2.9986	-0.8294	
1010	0.3	4.466	0.53	2.9986	-1.4674	
250	0.5	3.19	0.53	2.9986	-0.1914	
770	0.1	5.742	0.53	2.9986	-2.7434	
290	0.2	5.104	0.53	2.9986	-2.1054	
330	0.4	3.828	0.53	2.9986	-0.8294	
650	0.5	3.19	0.53	2.9986	-0.1914	
2080	0.3	4.466	0.4	3.828	-0.638	Mixed Shrub
560	0.4	3.828	0.4	3.828	0	8m width
430	0.3	4.466	0.4	3.828	-0.638	
1530	0.2	5.104	0.4	3.828	-1.276	
380	0.3	4.466	0.4	3.828	-0.638	
3040	0.1	5.742	0.4	3.828	-1.914	
730	0.3	4.466	0.4	3.828	-0.638	
620	0	6.38	0.4	3.828	-2.552	
1200	0.2	5.104	0.4	3.828	-1.276	
980	0.1	5.742	0.4	3.828	-1.914	
460	0	6.38	0.35	4.147	-2.233	Mixed Shrub
1900	0.2	5.104	0.35	4.147	-0.957	10m width
1290	0.1	5.742	0.35	4.147	-1.595	
3600	0.2	5.104	0.35	4.147	-0.957	
1220	0.4	3.828	0.35	4.147	0.319	

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
1090	4360	22253	4	11405	-10849
500	2000	5104	4	5232	128
710	2840	12683	4	7429	-5255
200	800	5104	4	2093	-3011
730	2920	14904	4	7638	-7266
1940	7760	19804	4	20299	495
890	3560	11356	4	9312	-2044
390	1560	7962	4	4081	-3882
510	2040	9111	4	5336	-3774
360	1440	5512	4	3767	-1746
260	1040	3318	4	2720	-597
1210	4840	18528	4	12660	-5867
2500	10000	25520	4	26158	638
550	2200	4211	4	5755	1544
900	3600	9187	4	9417	230
290	1160	2220	4	3034	814
230	920	2935	4	2407	-528
2060	8240	15771	4	21554	5783
1390	6950	17736	5	20840	3104
820	4100	15695	5	12294	-3401
650	3250	16588	5	9745	-6843
1250	6250	23925	5	18741	-5184
870	4350	11101	5	13044	1943
1130	5650	18024	5	16942	-1081
250	1250	2393	5	3748	1356
2340	11700	29858	5	35084	5225
590	2950	11293	5	8846	-2447
1010	5050	22553	5	15143	-7410
250	1250	3988	5	3748	-239
770	3850	22107	5	11545	-10562
290	1450	7401	5	4348	-3053
330	1650	6316	5	4948	-1369
650	3250	10368	5	9745	-622
2080	16640	74314	8	63698	-10616
560	4480	17149	8	17149	0
430	3440	15363	8	13168	-2195
1530	12240	62473	8	46855	-15618
380	3040	13577	8	11637	-1940
3040	24320	139645	8	93097	-46548
730	5840	26081	8	22356	-3726
620	4960	31645	8	18987	-12658
1200	9600	48998	8	36749	-12250
980	7840	45017	8	30012	-15006
460	4600	29348	10	19076	-10272
1900	19000	96976	10	78793	-18183
1290	12900	74072	10	53496	-20576
3600	36000	183744	10	149292	-34452
1220	12200	23351	10	31913	8562
Total	**301,330**	**1,296,582**		**1,035,336**	**-261,246**

% Reduction
-20

Table 11. Existing and Potential Solar Loads for Alder Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Alder Creek
2170	0.6	2.552	0.76	1.5312	-1.02	Mixed Shrub
430	0.4	3.828	0.76	1.5312	-2.2968	2m width
570	0.6	2.552	0.76	1.5312	-1.0208	
930	0.4	3.828	0.76	1.5312	-2.2968	
220	0.6	2.552	0.76	1.5312	-1.0208	
490	0.4	3.828	0.76	1.5312	-2.2968	
450	0.6	2.552	0.76	1.5312	-1.0208	
170	0.3	4.466	0.59	2.6158	-1.8502	Mixed Shrub
800	0.6	2.552	0.59	2.6158	0.0638	4m width
520	0.2	5.104	0.59	2.6158	-2.4882	
1960	0.6	2.552	0.59	2.6158	0.0638	
1260	0.5	3.19	0.59	2.6158	-0.5742	
830	0.6	2.552	0.59	2.6158	0.0638	
750	0.5	3.19	0.59	2.6158	-0.5742	
Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
2170	4340	11076	2	6645	-4430	
430	860	3292	2	1317	-1975	
570	1140	2909	2	1746	-1164	
930	1860	7120	2	2848	-4272	
220	440	1123	2	674	-449	
490	980	3751	2	1501	-2251	
450	900	2297	2	1378	-919	
170	680	3037	4	1779	-1258	
800	3200	8166	4	8371	204	
520	2080	10616	4	5441	-5175	
1960	7840	20008	4	20508	500	
1260	5040	16078	4	13184	-2894	
830	3320	8473	4	8684	212	
750	3000	9570	4	7847	-1723	**% Reduction**
Total	**35,680**	**107,516**		**81,922**	**-25,594**	**-24**

Table 12. Existing and Potential Solar Loads for North Fork Castle Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	NF
2200	0.3	4.466	0.76	1.5312	-2.93	Mixed Shrub
630	0.2	5.104	0.76	1.5312	-3.5728	2m width
2000	0.3	4.466	0.76	1.5312	-2.9348	
840	0.2	5.104	0.76	1.5312	-3.5728	
910	0.4	3.828	0.76	1.5312	-2.2968	
1120	0.3	4.466	0.59	2.6158	-1.8502	Mixed Shrub
1990	0.2	5.104	0.59	2.6158	-2.4882	4m width
1810	0.4	3.828	0.59	2.6158	-1.2122	
550	0.2	5.104	0.59	2.6158	-2.4882	
410	0.5	3.19	0.59	2.6158	-0.5742	
830	0.4	3.828	0.59	2.6158	-1.2122	
925	0.3	4.466	0.53	2.9986	-1.4674	Mixed Shrub
1670	0.5	3.19	0.53	2.9986	-0.1914	5m width
1550	0.4	3.828	0.53	2.9986	-0.8294	
560	0	6.38	0.53	2.9986	-3.3814	
2270	0.4	3.828	0.53	2.9986	-0.8294	
1090	0.5	3.19	0.53	2.9986	-0.1914	
2400	0.4	3.828	0.53	2.9986	-0.8294	

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
2200	4400	19650	2	6737	-12913	
630	1260	6431	2	1929	-4502	
2000	4000	17864	2	6125	-11739	
840	1680	8575	2	2572	-6002	
910	1820	6967	2	2787	-4180	
1120	4480	20008	4	11719	-8289	
1990	7960	40628	4	20822	-19806	
1810	7240	27715	4	18938	-8776	
550	2200	11229	4	5755	-5474	
410	1640	5232	4	4290	-942	
830	3320	12709	4	8684	-4025	
925	4625	20655	5	13869	-6787	
1670	8350	26637	5	25038	-1598	
1550	7750	29667	5	23239	-6428	
560	2800	17864	5	8396	-9468	
2270	11350	43448	5	34034	-9414	
1090	5450	17386	5	16342	-1043	
2400	12000	45936	5	35983	-9953	**% Reduction**
Total	**92,325**	**378,599**		**247,260**	**-131,338**	**-35**

Table 13. Existing and Potential Solar Loads for South Fork Castle Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	SF
2450	0.4	3.828	0.76	1.5312	-2.30	Mixed Shrub
690	0.3	4.466	0.76	1.5312	-2.9348	2m width
2050	0.2	5.104	0.76	1.5312	-3.5728	
720	0.6	2.552	0.76	1.5312	-1.0208	
440	0.2	5.104	0.76	1.5312	-3.5728	
490	0.3	4.466	0.59	2.6158	-1.8502	Mixed Shrub
1000	0.5	3.19	0.59	2.6158	-0.5742	4m width
430	0.3	4.466	0.59	2.6158	-1.8502	
325	0.1	5.742	0.59	2.6158	-3.1262	
570	0.3	4.466	0.59	2.6158	-1.8502	
670	0.5	3.19	0.53	2.9986	-0.1914	Mixed Shrub
470	0.2	5.104	0.53	2.9986	-2.1054	5m width
1370	0.6	2.552	0.53	2.9986	0.4466	
1340	0.5	3.19	0.53	2.9986	-0.1914	
740	0.4	3.828	0.53	2.9986	-0.8294	

Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
2450	4900	18757	2	7503	-11254	
690	1380	6163	2	2113	-4050	
2050	4100	20926	2	6278	-14648	
720	1440	3675	2	2205	-1470	
440	880	4492	2	1347	-3144	
490	1960	8753	4	5127	-3626	
1000	4000	12760	4	10463	-2297	
430	1720	7682	4	4499	-3182	
325	1300	7465	4	3401	-4064	
570	2280	10182	4	5964	-4218	
670	3350	10687	5	10045	-641	
470	2350	11994	5	7047	-4948	
1370	6850	17481	5	20540	3059	
1340	6700	21373	5	20091	-1282	
740	3700	14164	5	11095	-3069	**% Reduction**
Total	**46,910**	**176,554**		**117,718**	**-58,836**	**-33**

Table 14. Existing and Potential Solar Loads for Clover Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Clover Creek
2520	0.4	3.828	0.76	1.5312	-2.30	Mixed Shrub
1750	0.5	3.19	0.76	1.5312	-1.6588	2m width
390	0.4	3.828	0.76	1.5312	-2.2968	
Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
2520	5040	19293	2	7717	-11576	
1750	3500	11165	2	5359	-5806	
390	780	2986	2	1194	-1792	**% Reduction**
Total	**9,320**	**33,444**		**14,271**	**-19,173**	**-57**

Table 15. Existing and Potential Solar Loads for Juniper Creek.

Segment Length (meters)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Juniper Creek
1410	0	6.38	0.76	1.5312	-4.85	Mixed Shrub
1410	0.1	5.742	0.76	1.5312	-4.2108	2m width
2220	0.2	5.104	0.76	1.5312	-3.5728	
680	0.4	3.828	0.59	2.6158	-1.2122	Mixed Shrub
900	0.5	3.19	0.59	2.6158	-0.5742	4m width
680	0.6	2.552	0.59	2.6158	0.0638	
Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)	
1410	2820	17992	2	4318	-13674	
1410	2820	16192	2	4318	-11874	
2220	4440	22662	2	6799	-15863	
680	2720	10412	4	7115	-3297	
900	3600	11484	4	9417	-2067	
680	2720	6941	4	7115	174	**% Reduction**
Total	**19,120**	**85,683**		**39,081**	**-46,602**	**-54**

Figure 1. Target Shade for Succor Creek, Headwaters to Oregon State Line (see photo next page).

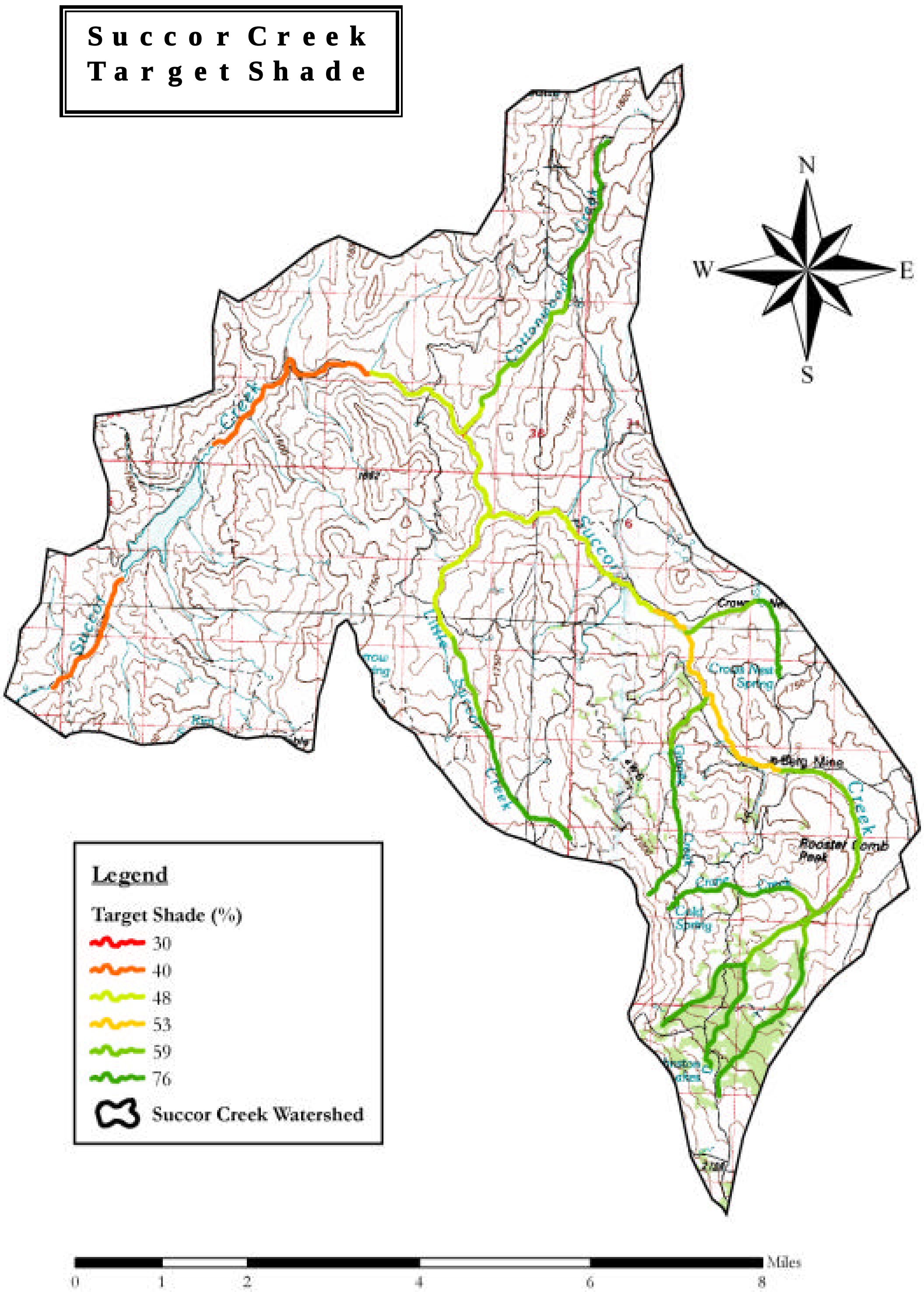


Figure 1 (cont). View of Succor Creek Reservoir to Stateline.

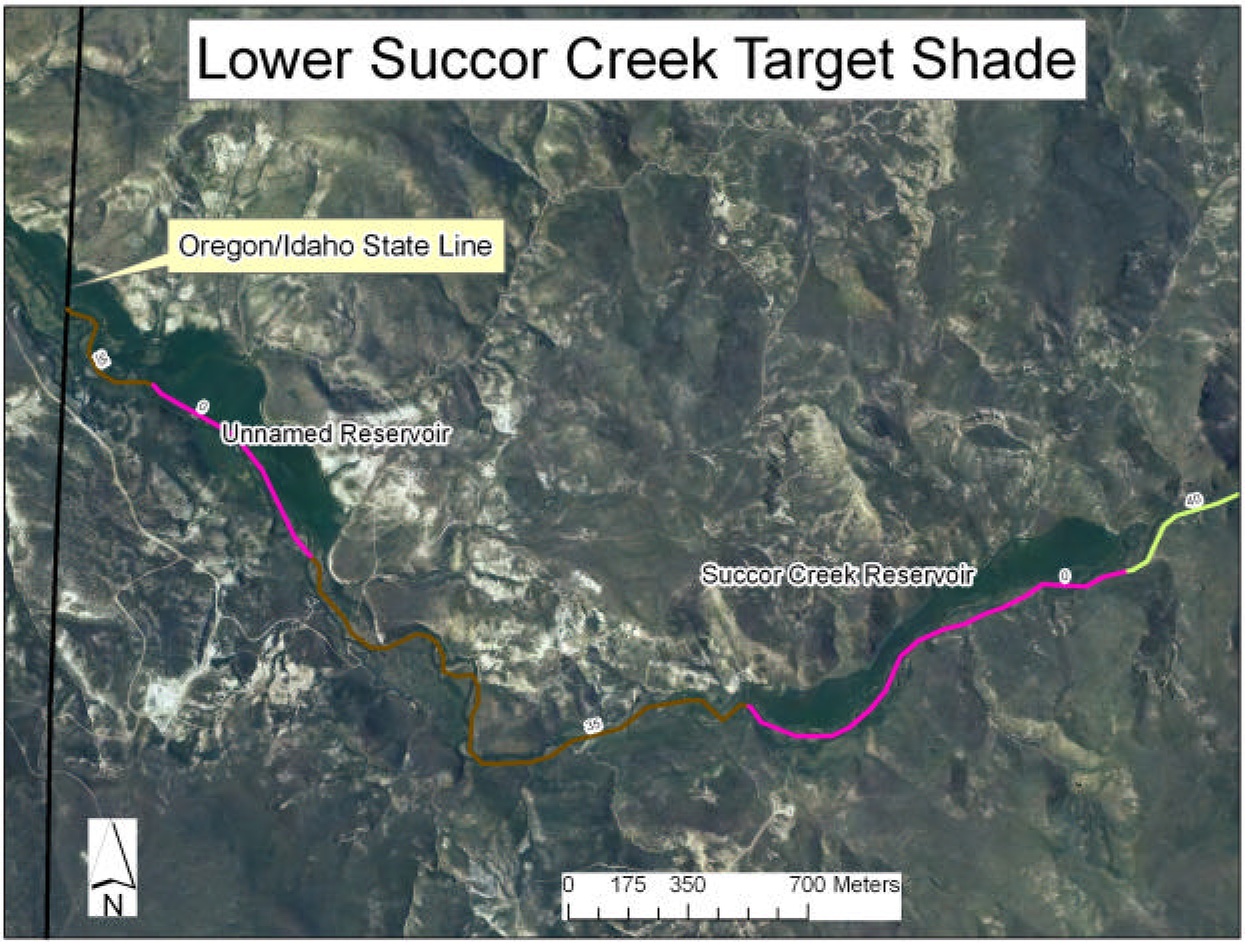


Figure 2. Existing Shade Estimated for Succor Creek by Aerial Photo Interpretation.

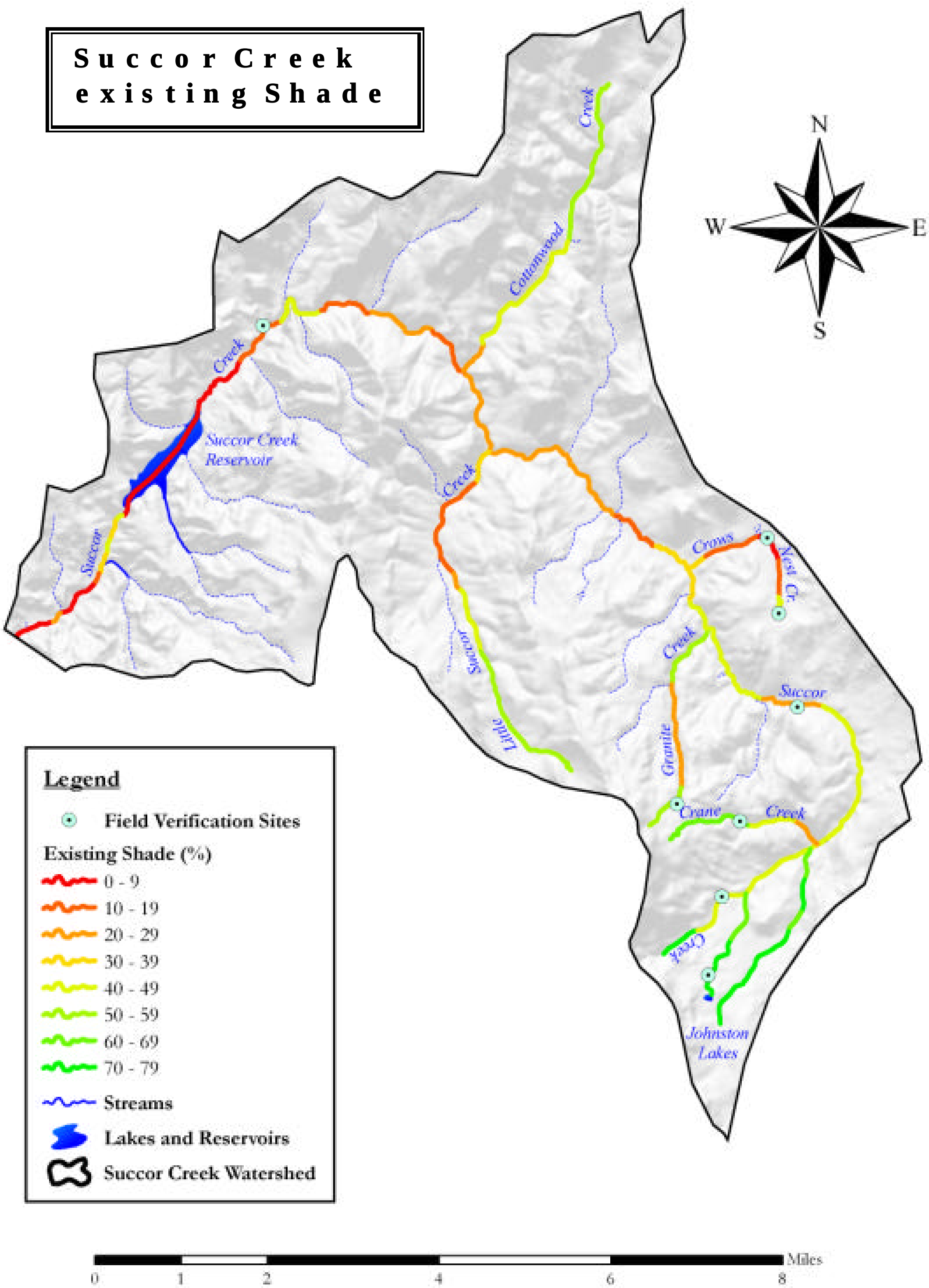


Figure 3. Difference Between Existing and Target Shade for Succor Creek.

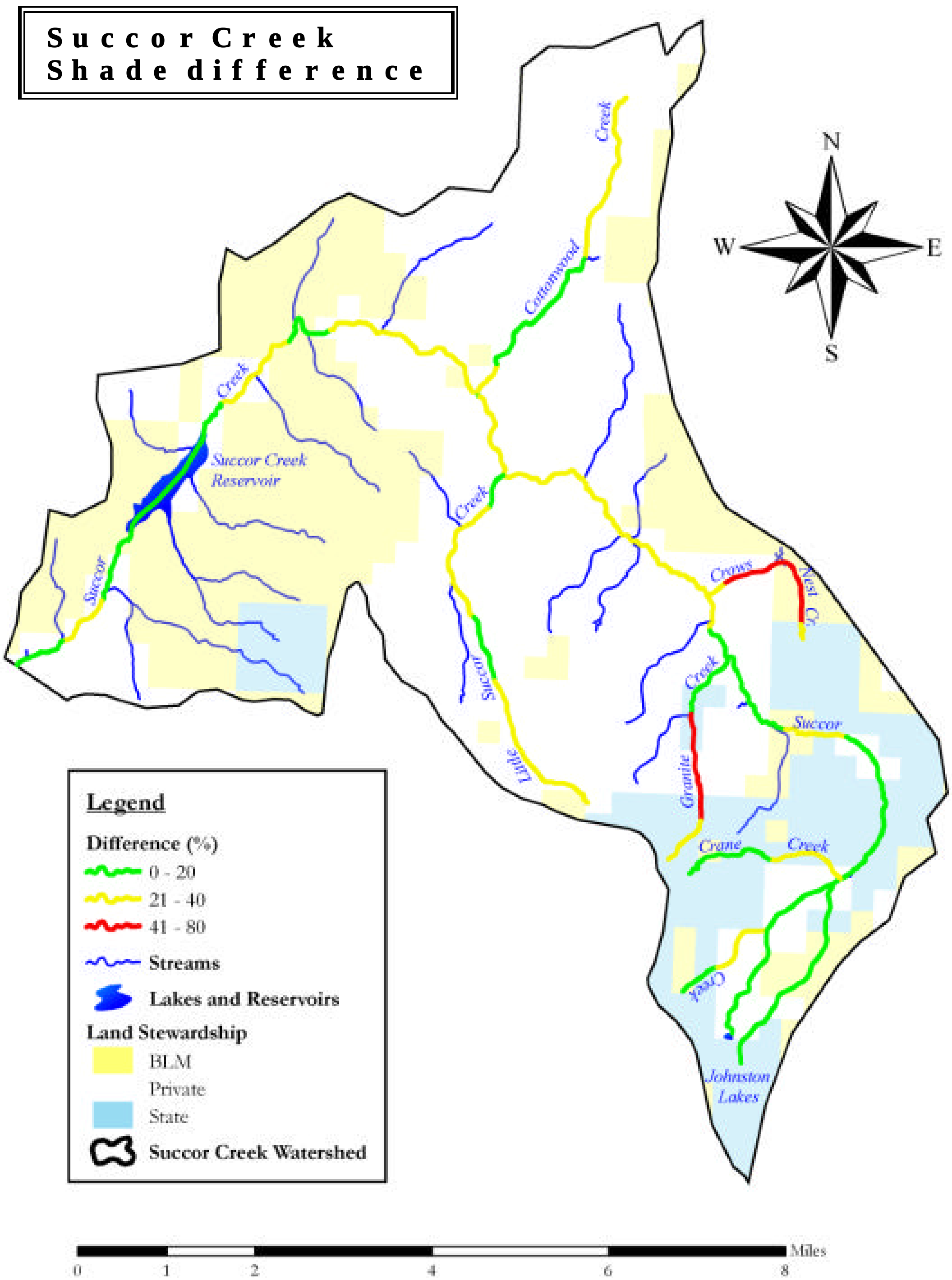


Figure 4. Target Shade for Castle Creek.

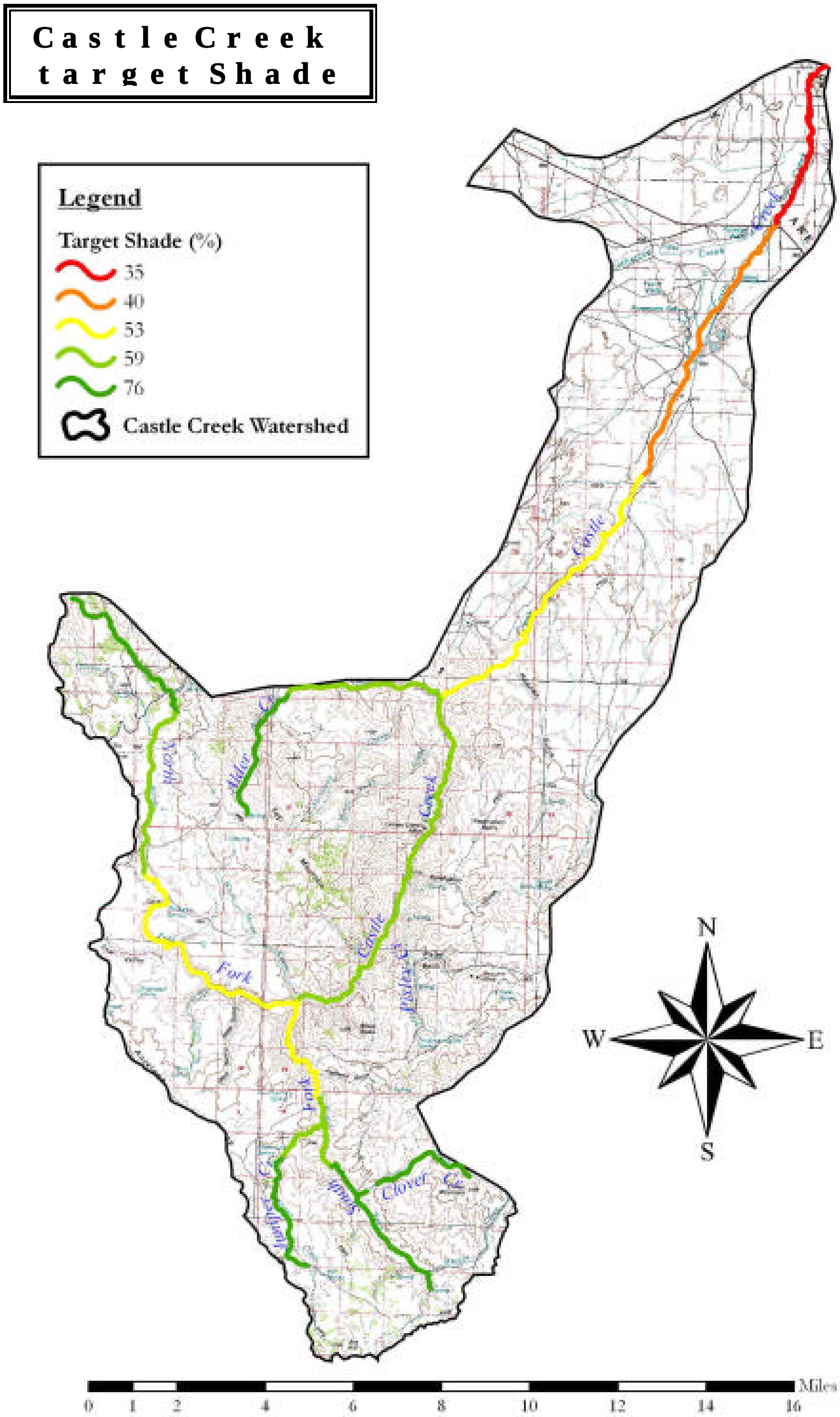


Figure 5. Existing Shade Estimated for Castle Creek by Aerial Photo Interpretation.

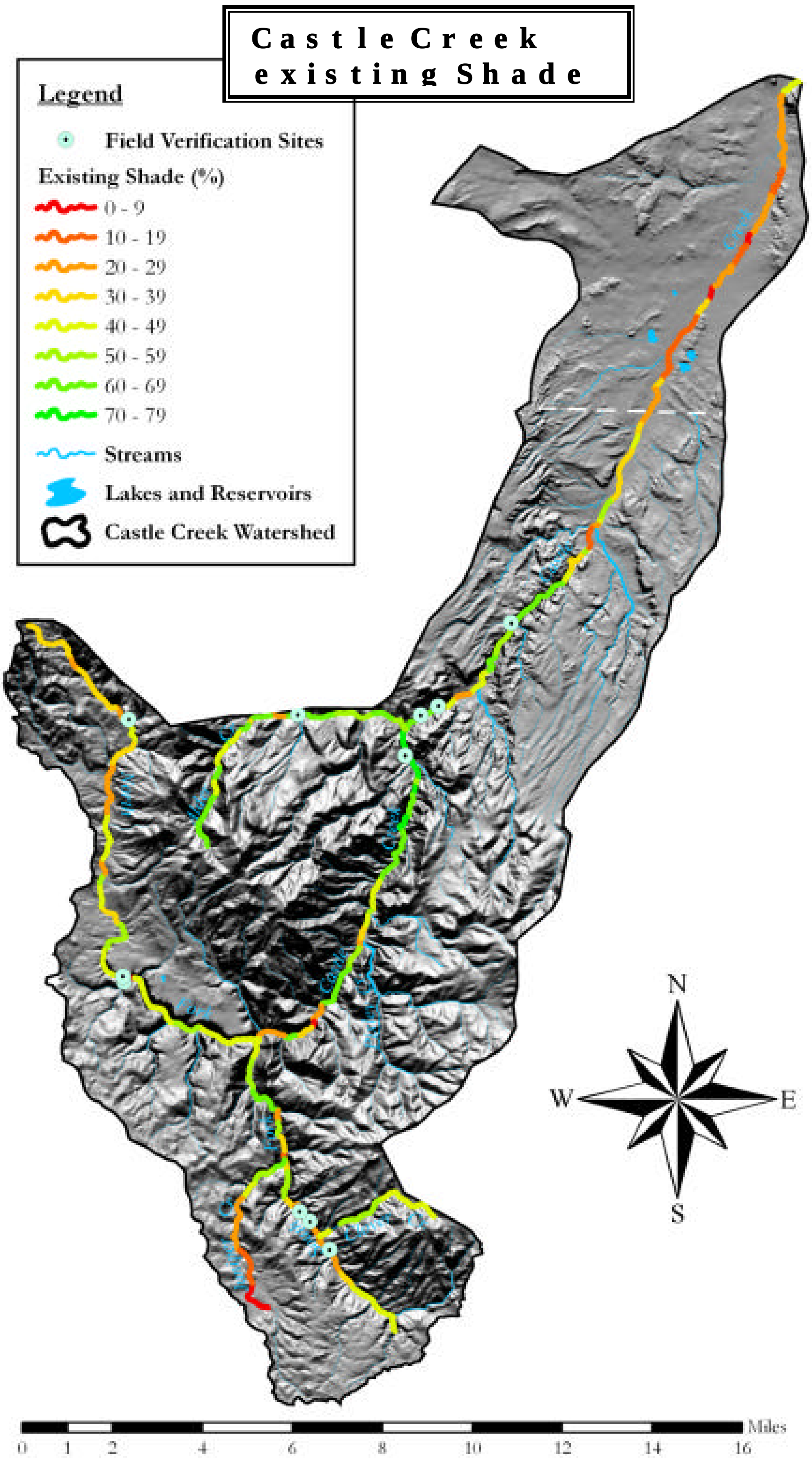
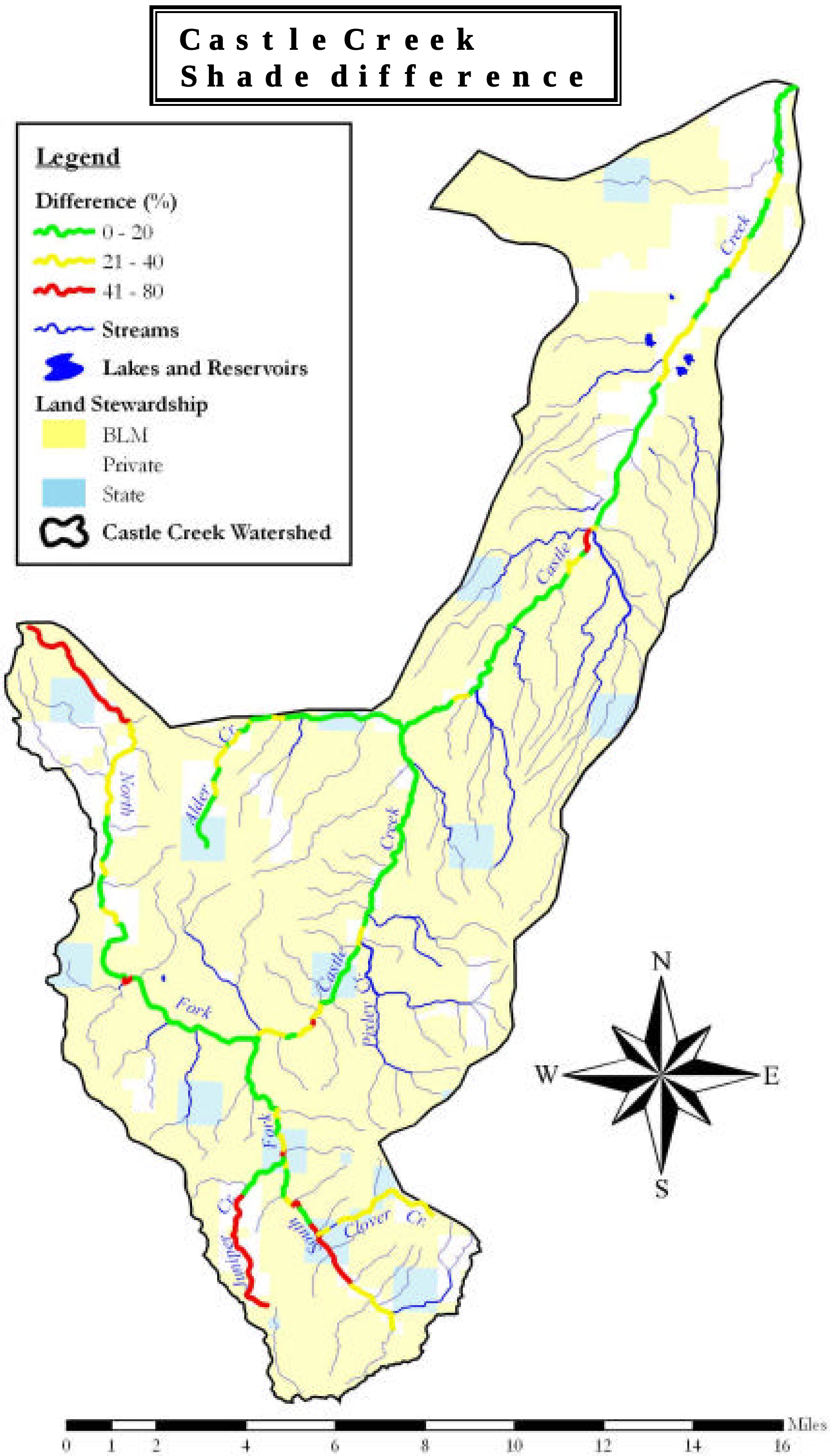


Figure 6. Difference Between Existing and Target Shade for Castle Creek.



5.4 Load Allocation

Because this TMDL is based on potential natural vegetation, 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 non point source activities that have or may affect riparian vegetation and shade. Load allocations are therefore stream reach specific and are dependent upon the target load for a given reach. Tables 2 through 15 show the target or potential shade which is converted to a potential summer load by multiplying the inverse fraction (1-shade fraction) by the average loading to a flat plate collector for the months of April through September. That is the loading capacity of the stream, and reaching that loading capacity is necessary to achieve background conditions. There is no opportunity to allocate shade removal to an activity. Additionally, because this TMDL is dependent upon background conditions for achieving WQS, all tributaries to the waters examined here need to be in natural conditions in order to prevent excess heat loads to the system.

All streams examined exceeded their potential load targets by variable amounts (Table 16). Mainstem Succor and Castle Creeks and several of the associated tributaries had relatively low excess loading, relative to their size, with percent reductions at 33% and 20%. Succor Creek reductions do not account for thermal load contributed by the two reservoirs. The North Fork and South Fork of Castle Creek also had relatively low percent reductions at 35% and 33%, respectively. Many of the tributaries had higher percent reductions, although their actual excess load is small due to their smaller size.

Table 16. Excess Solar Load and Percent Reduction to Achieve Loading Capacity for Succor Creek and Castle Creek and Associated Tributaries.

Water Body	Excess Load (kWh/day)
Succor Creek	-312,018
Headwater Tributary to Succor Cr. From Johnston Lakes	-2,958
Headwater Tributary to Succor Cr. East of Johnston Lakes	-2,930
Crane Creek	-14,192
Granite Creek	-20,521
Crows Nest Creek	-30,154
Little Succor Creek	-57,001
Cottonwood Creek	-31,885
Castle Creek	-261,246
North Fork Castle Creek	-131,338
South Fork Castle Creek	-58,836
Alder Creek	-25,594
Clover Creek	-19,173
Juniper Creek	-46,602

Although the following analysis dwells on total heat loads for streams in this TMDL, it is important to note that differences between existing shade and target shade, as depicted in Figures 3 and 6, are the key to successfully restoring these waters to achieving WQS. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should key in on the largest differences between existing and target shade as locations to prioritize implementation efforts. It is assumed that if shade targets listed in Tables 2 through 15 are achieved on these water bodies, then excess loads will be reduced to zero and streams will be at background solar loads as expected under potential natural vegetation conditions. Nonpoint source activities in the subbasin are allocated the percent reductions specified in Table 16 by water body, not by activity. Thus, each watershed needs to be examined for whatever activities influence riparian conditions and shade in particular.

This temperature loading analysis assumes there are no point sources in the affected watersheds. Thus, there are no wasteload allocations either. Wasteload allocations for any existing or future point source discharge should be developed based on mass balance approach. Thus, the permitted temperature of the discharge will depend on the volume of water discharged, the volume of the receiving water and applicable water quality standards. Should a point source be proposed after shade targets are achieved 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 & IDAPA 58.01.02.401.03) should be involved (see Appendix B).

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 is measured as a 10% class interval and target shade is reported as a specific integer. Thus, there will always be a slight (>10%) difference between existing shade at the target class level and the target itself that contributes to the margin of safety. Although the loading analysis used in this TMDL involves gross estimations that are likely to have large variances, there are no load allocations that may benefit or suffer from that variance.

Seasonal Variation

This TMDL is based on average summer loads. All loads have been calculated to be inclusive of the six month period from April through September. This time period was chosen because it represents the time period when the combination of increasing air and water temperatures coincides with increasing solar inputs and increasing vegetative shade. The critical time period is April through June when spring salmonids spawning is occurring, July and August when maximum temperatures exceed cold water aquatic life criteria, and September during fall salmonids spawning. Water temperature is not likely to be a problem for beneficial uses outside of this time period because of cooler weather and lower sun angle.

5.5 Implementation Strategies

Implementation strategies for TMDLs produced using potential natural vegetation-based shade and solar loading should incorporate the loading tables presented in this TMDL. DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that the TMDL goals are not being met or significant progress is not being made toward achieving the goals.

Time Frame

See Mid Snake River /Succor Creek Subbasin Assessment and TMDL page 183

Approach

See Mid Snake River /Succor Creek Subbasin Assessment and TMDL page 185

Responsible Parties

See Mid Snake River /Succor Creek Subbasin Assessment and TMDL page 183

Monitoring Strategy

The loading tables need to be updated, first to field verify the existing shade levels that have not yet been field verified, and secondly to monitor progress towards achieving reductions and the goals of the TMDL. Using the solar pathfinder to measure existing shade levels in the field is important to achieving both objectives. It is likely that further field verification will find discrepancies with reported existing shade levels in the loading tables. Due to the inexact nature of the aerial photo interpretation technique, these tables should not be viewed as complete until verified. Implementation strategies should include solar pathfinder monitoring to simultaneously field verify the TMDL and mark progress towards achieving desired reductions in solar loads. Also see Mid Snake River /Succor Creek Subbasin Assessment and TMDL page 187

5.6 Conclusions

The 303d listed water bodies of Succor Creek, Castle Creek and North Fork Castle Creek all had excess solar loading above potential natural vegetation targets. Percent reductions to meet these targets for these water bodies are relatively low, less than 35%. Some tributaries had higher percent reductions although the actual loadings were small given the smaller size of these tributaries.

This temperature loading analysis assumes there are no point sources in the affected watersheds. Thus, there are no wasteload allocations either. It is assumed that if shade targets are achieved on these water bodies, then excess loads will be reduced to zero and streams will be at background solar loads as expected under potential natural vegetation conditions. At this point stream temperatures will be considered natural as well, and natural background provisions of Idaho WQS will apply. Nonpoint source activities in the subbasin are allocated the percent reductions specified in this TMDL by water body, not by activity. Thus, each watershed needs to be examined for whatever activities influence riparian conditions and shade in particular.

Table 17. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Succor Creek and tributaries ID17050103SW003_02 ID17050103SW003_03	Temperature	Yes	n.a.	Existing shade
Castle Creek ID17050103SW014_04 ID17050103SW014_04a ID17050103SW014_05 NF Castle Creek & Alder Creek ID17050103SW014_02 ID17050103SW014_02a ID17050103SW014_03 SF Castle Creek, Juniper Creek, Clover Creek ID17050103SW020_02 ID17050103SW020_03	Temperature	Yes	n.a.	Existing shade

Table 18. Shade Analysis by Assessment Units.

	A	B	D	E	F	G
1	Assessment Unit	STREAM	Existing Shade (%)	Target Shade (%)	Difference (%)	Average Difference/AU
2	ID17050103SW014_02	Alder Creek	60	59	1	
3			60	76	-16	
4			40	76	-36	
5			60	76	-16	
6			20	59	-39	
7			60	59	1	
8			60	59	1	
9			30	59	-29	
10			60	76	-16	
11			40	76	-36	
12			40	76	-36	
13			60	76	-16	
14			60	76	-16	
15			40	76	-36	-21
16	ID17050103SW014_03	Alder Creek	50	59	-9	
17			60	59	1	
18			60	59	1	
19			50	59	-9	
20			60	59	1	
21			50	59	-9	-4
22	ID17050103SW014_04	Castle Creek	10	40	-30	
23			20	40	-20	
24			20	40	-20	
25			20	35	-15	
26			0	35	-35	
27			10	40	-30	
28			10	40	-30	
29			0	40	-40	
30			20	40	-20	
31			0	40	-40	
32			30	40	-10	
33			10	40	-30	
34			10	40	-30	
35			30	40	-10	
36			30	40	-10	
37			20	40	-20	
38			30	40	-10	
39			40	40	0	
40			30	40	-10	
41			40	53	-13	
42			20	53	-33	
43			40	53	-13	
44			50	53	-3	-21

	A	B	D	E	F	G
45	Assessment Unit	STREAM	Existing Shade (%)	Target Shade (%)	Difference (%)	Average Difference/AU
46	ID17050103SW014_04a	Castle Creek	70	53	17	
47			40	53	-13	
48			20	53	-33	
49			70	59	11	
50			70	59	11	
51			60	59	1	
52			60	59	1	
53			40	59	-19	
54			40	59	-19	
55			20	59	-39	
56			60	59	1	
57			20	59	-39	
58			20	59	-39	
59			20	59	-39	
60			10	53	-43	
61			40	53	-13	
62			20	53	-33	
63			40	53	-13	
64			60	53	7	
65			40	59	-19	
66			40	59	-19	
67			50	59	-9	
68			20	59	-39	
69			50	59	-9	
70			60	59	1	
71			60	59	1	
72			20	59	-39	
73			20	59	-39	
74			70	59	11	
75			50	59	-9	
76			70	59	11	
77			60	59	1	
78			60	59	1	
79			70	59	11	
80			30	59	-29	
81			40	59	-19	
82			0	59	-59	
83			30	59	-29	
84			60	59	1	
85			60	59	1	
86			20	59	-39	
87			40	53	-13	
88			60	53	7	
89			50	53	-3	
90			70	53	17	
91			60	53	7	
92			30	53	-23	
93			50	53	-3	
94			10	53	-43	-14

	A	B	D	E	F	G
95	Assessment Unit	STREAM	Existing Shade (%)	Target Shade (%)	Difference (%)	Average Difference/AU
96	ID17050103SW014_05	Castle Creek	40	35	5	
97			20	35	-15	
98			20	35	-15	
99			10	35	-25	-13
100	ID17050103SW020_02	Clover Creek	40	76	-36	
101			50	76	-26	
102			40	76	-36	-33
103	ID17050103SW003_02	Cottonwood Creek	50	76	-26	
104			20	48	-28	
105			40	59	-19	-24
106	ID17050103SW003_02	Crane Creek	20	59	-39	
107			40	76	-36	
108			60	76	-16	-30
109	ID17050103SW003_02	Crows Nest Creek	0	76	-76	
110			30	59	-29	
111			10	59	-49	
112			0	76	-76	
113			10	76	-66	
114			40	76	-36	-55
115	ID17050103SW003_02	East Johnson Lake Trib	60	59	1	
116			70	76	-6	
117			70	76	-6	
118			60	76	-16	-7
119	ID17050103SW003_02	Granite Creek	50	59	-9	
120			20	76	-56	
121			50	76	-26	-30
122	ID17050103SW003_02	Johnson Lake Trib	70	76	-6	
123			60	76	-16	-11
124	ID17050103SW020_02	Juniper Creek	0	76	-76	
125			0	76	-76	
126			60	59	1	
127			50	59	-9	
128			40	59	-19	
129			40	59	-19	
130			20	76	-56	
131			10	76	-66	-40
132	ID17050103SW003_02	Little Succor Creek	30	48	-18	
133			10	48	-38	
134			10	48	-38	
135			10	48	-38	
136			10	48	-38	
137			20	59	-39	
138			40	59	-19	
139			50	76	-26	-32
140	ID17050103SW014_02	North Fork Castle Creek	20	76	-56	
141			30	76	-46	
142			20	76	-56	
143			0	53	-53	
144			40	53	-13	-45

	A	B	D	E	F	G
145	Assessment Unit	STREAM	Existing Shade (%)	Target Shade (%)	Difference (%)	Average Difference/AU
146	ID17050103SW014_02a	North Fork Castle Creek	20	59	-39	
147			30	59	-29	
148			50	53	-3	
149			50	53	-3	
150			30	53	-23	
151			40	59	-19	
152			20	59	-39	
153			40	53	-13	
154			0	53	-53	
155			50	59	-9	
156			20	59	-39	
157			40	59	-19	
158			40	59	-19	
159			20	59	-39	
160			20	76	-56	
161			30	76	-46	
162			30	76	-46	
163			40	76	-36	
164			30	59	-29	-29
165	ID17050103SW014_03	North Fork Castle Creek	40	53	-13	
166			50	53	-3	
167			40	53	-13	-10
168	ID17050103SW020_02	South Fork Castle Creek	20	76	-56	
169			20	76	-56	
170			40	76	-36	
171			40	76	-36	
172			20	76	-56	
173			20	76	-56	
174			30	76	-46	
175			30	76	-46	
176			40	76	-36	
177			40	76	-36	-46
178	ID17050103SW020_03	South Fork Castle Creek	60	53	7	
179			10	59	-49	
180			30	59	-29	
181			40	53	-13	
182			60	53	7	
183			20	53	-33	
184			50	53	-3	
185			30	59	-29	
186			30	59	-29	
187			50	59	-9	
188			20	76	-56	
189			60	76	-16	
190			20	76	-56	
191			50	53	-3	
192			40	53	-13	
193			50	53	-3	
194			60	53	7	
195			20	76	-56	-21

	A	B	D	E	F	G
196	Assessment Unit	STREAM	Existing Shade (%)	Target Shade (%)	Difference (%)	Average Difference/AU
197	ID17050103SW003_02	Succor Creek	40	53	-13	
198			40	53	-13	
199			40	59	-19	
200			40	59	-19	
201			20	59	-39	
202			40	59	-19	
203			40	53	-13	
204			20	53	-33	
205			40	59	-19	
206			40	59	-19	
207			70	76	-6	
208			40	76	-36	-21
209	ID17050103SW003_03	Succor Creek	40	40	0	
210			20	48	-28	
211			20	48	-28	
212			20	48	-28	
213			20	48	-28	
214			30	53	-23	
215			0	40	-40	
216			10	40	-30	
217			10	40	-30	
218			40	40	0	
219			40	40	0	
220			10	40	-30	
221			20	48	-28	
222			10	48	-38	
223			10	30	-20	
224			20	48	-28	
225			10	48	-38	
226			30	53	-23	
227			30	53	-23	
228			40	53	-13	
229			0	0	0	
230			0	40	-40	
231			40	40	0	
232			0	35	-35	
233			0	35	-35	
234			40	40	0	
235			30	40	-10	
236			30	40	-10	
237			30	40	-10	
238			0	40	-40	
239			10	40	-30	
240			20	40	-20	
241			0	0	0	-21
242	ID17050103SW003_03L	Succor Creek Reservoir	0	0	0	
243			0	0	0	
244			0	0	0	
245			0	0	0	
246			0	0	0	
247			0	0	0	0

References Cited

The following references are references cited in the boilerplate language and in the glossary. Do not delete any of these references. Add all references you cite using the references listed below as examples or following the Council of Biology Editors (CBE) or another common format, as discussed in the guidance document.

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GIS Coverages

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Glossary

305(b)	Refers to section 305 subsection "b" of the Clean Water Act. The term "305(b)" generally describes a report of each state's water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.
§303(d)	Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
Aquatic	Occurring, growing, or living in water.
Aquifer	An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs.
Assemblage (aquatic)	An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996).
Assessment Unit (AU)	A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit.
Beneficial Use	Any of the various uses of water, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

Benthic

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

Best Management Practices (BMPs)

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

Clean Water Act (CWA)

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

Community

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

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Criteria

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

Cubic Feet per Second

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

Designated Uses

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

Discharge

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

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

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

Effluent
A discharge of untreated, partially treated, or treated wastewater into a receiving water body.

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

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

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

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

Flow
See *Discharge*.

Geographical Information Systems (GIS)
A georeferenced database.

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

Habitat
The living place of an organism or community.

Headwater
The origin or beginning of a stream.

Hydrologic Basin	The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).
Hydrologic Unit	One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.
Hydrologic Unit Code (HUC)	The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.
Hydrology	The science dealing with the properties, distribution, and circulation of water.
Load Allocation (LA)	A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Load(ing) Capacity (LC)	A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.
Margin of Safety (MOS)	An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL

(generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.

Metric

1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.

Milligrams per Liter (mg/L)

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

Million Gallons per Day (MGD)

A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

Monitoring

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

Mouth

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

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

Not Attainable

A concept and an assessment category describing water bodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).

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).

Not Fully Supporting Cold Water

At least one biological assemblage has been significantly modified beyond the natural range of its reference condition.

Parameter

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

Phased TMDL

A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a water body. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.

Point Source

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

Pollutant

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

Pollution

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

Quantitative

Descriptive of size, magnitude, or degree.

Reach

A stream section with fairly homogenous physical characteristics.

Reference

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

Reference Condition	1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).
Reference Site	A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.
Riparian	Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.
River	A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.
Runoff	The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.
Spring	Ground water seeping out of the earth where the water table intersects the ground surface.
Stream	A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A first-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.
Subbasin	A large watershed of several hundred thousand acres. This is the name commonly given to 4th field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)

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

Subwatershed

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

Surface Water

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

Total Maximum Daily Load (TMDL)

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

Tributary

A stream feeding into a larger stream or lake.

Toxic Pollutants

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Tributary

A stream feeding into a larger stream or lake.

Wasteload Allocation (WLA)

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

Water Body

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

Water Quality

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

Water Quality Criteria

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

Water Quality Limited

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

Water Quality Standards

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

Water Table

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

Watershed

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

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Appendix A. Unit Conversion Chart

Table A-1. Metric - English unit conversions.

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

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

Appendix B. State and Site-Specific Standards and Criteria

Water Quality Standards Applicable to Salmonid Spawning Temperature

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

> 13^{o}C as a daily maximum water temperature,
>
> 9^{o}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 highest annual MWMT air temperatures) is compared to the daily maximum criterion of 13^{o}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 these 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. As per IDAPA 58.01.02.200.09:

> *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, pollutant levels shall not exceed the natural background conditions, except that temperature levels may be increased above natural background conditions when allowed under Section 401.*

Section 401 relates to point source wastewater treatment requirements. In this case if temperature criteria for any aquatic life use is exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3^{o}C (IDAPA 58.01.02.401.03.a.v.).

Estimate of Bankfull Channel Width

The only factor not developed from the aerial photo work presented above is channel width (i.e., NSDZ or Bankfull Width). Accordingly, this parameter must be estimated from available information. We use two figures to try to estimate bankfull width from drainage area size. The first figure (Figure B-1) was developed by Peter Lienenbach of EPA for the Crooked Creek TMDL (IDEQ, 2002). The second figure (Figure B-2) consulted is a combination of regional curves published by various researchers and combined by Rosgen (1996).

For each stream evaluated in the loading analysis, bankfull width is estimated based on drainage area using these two figures. Additionally, existing width is evaluated from available data. If the stream's existing width is wider than that predicted by these two figures, then the Figure estimate of bankfull width is used in the loading analysis. If existing width is smaller, then existing width is used in the loading analysis.

Figure B-1. Bankfull Width as a Function of Width to Depth Ratio and Drainage Area

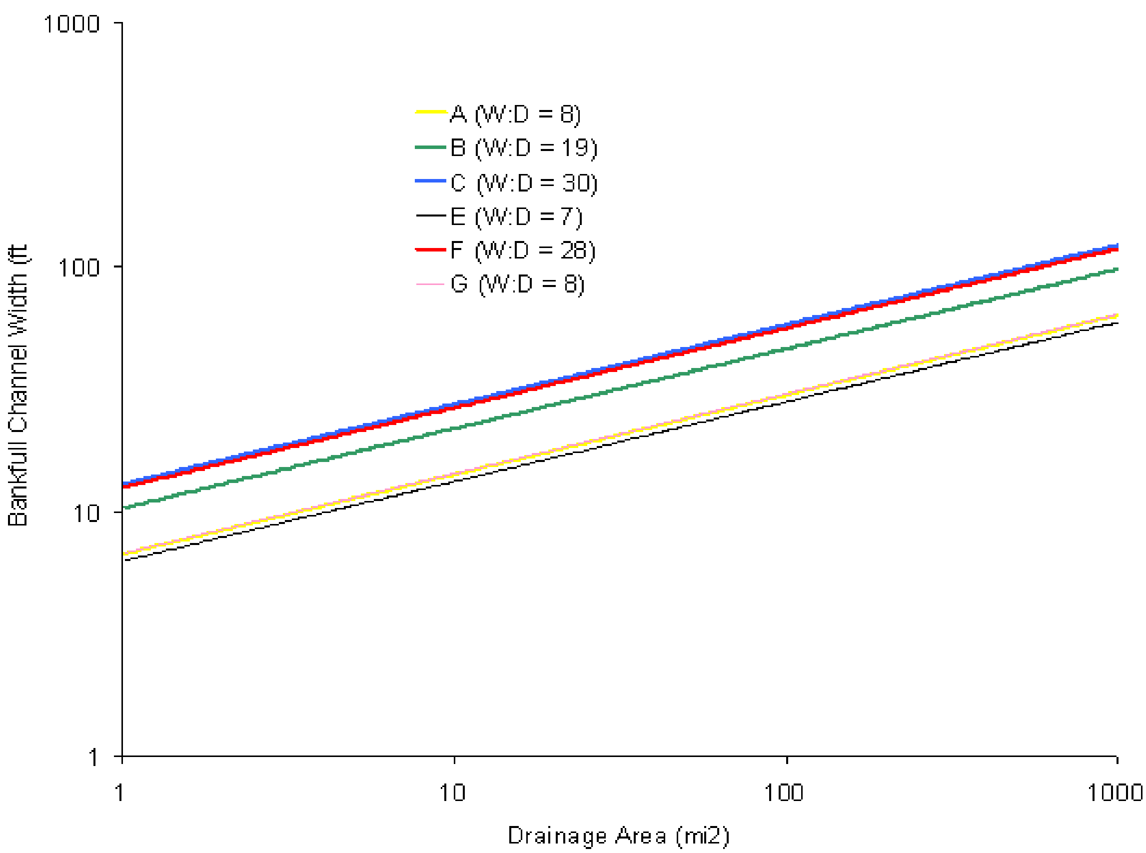
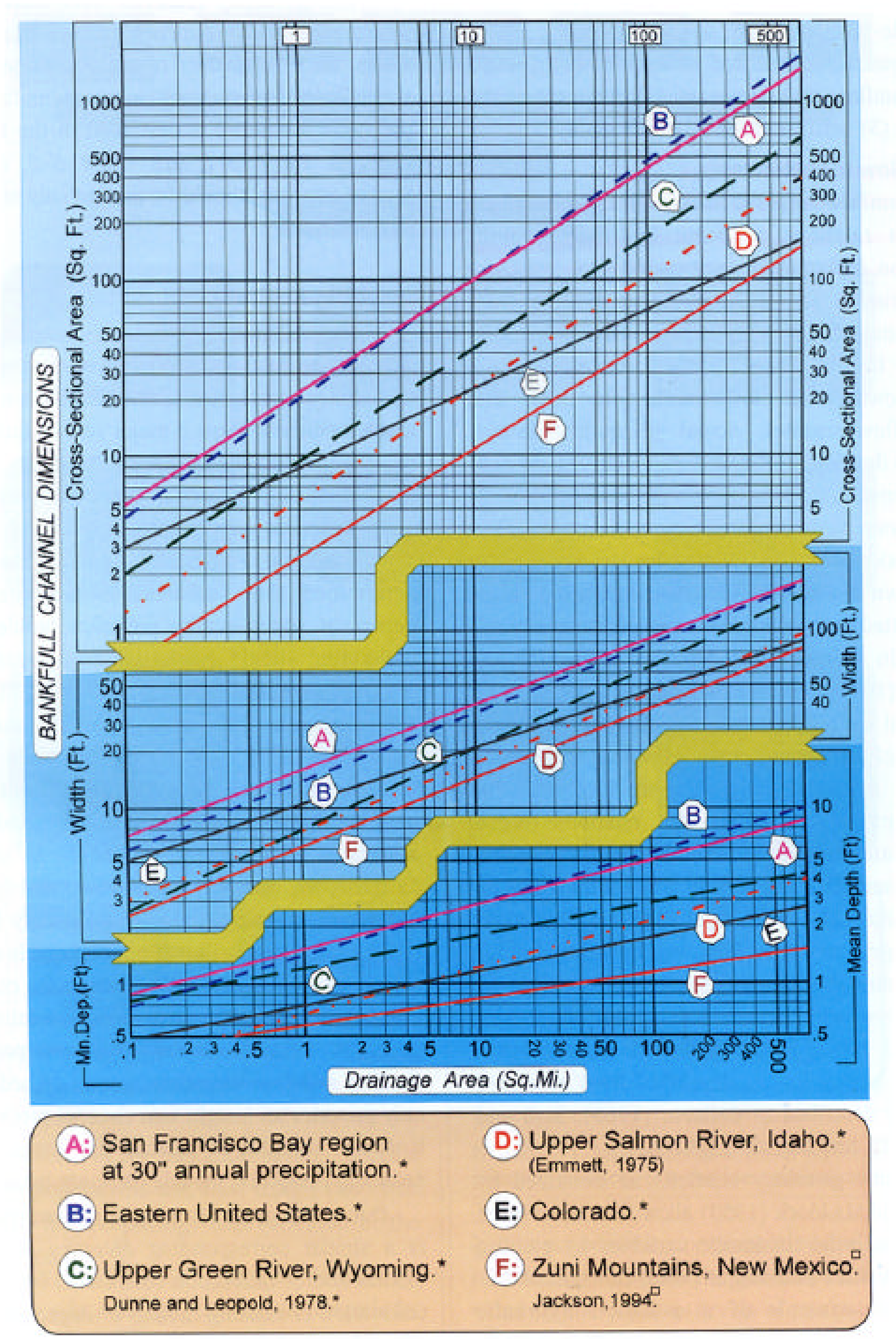


Figure B-2. Bankfull Channel Dimensions as a Function of Drainage Area (Rosgen, 1996).



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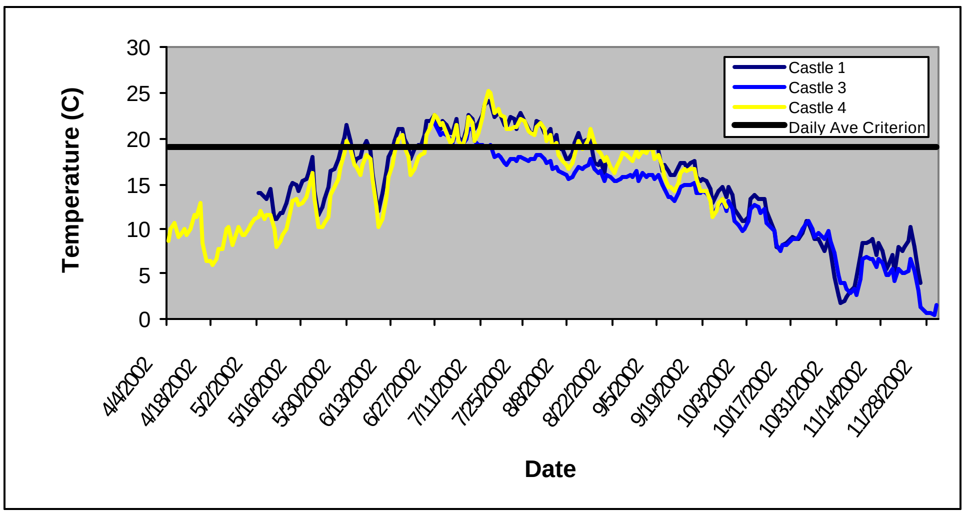
Appendix C. Data Sources and Temperature Data

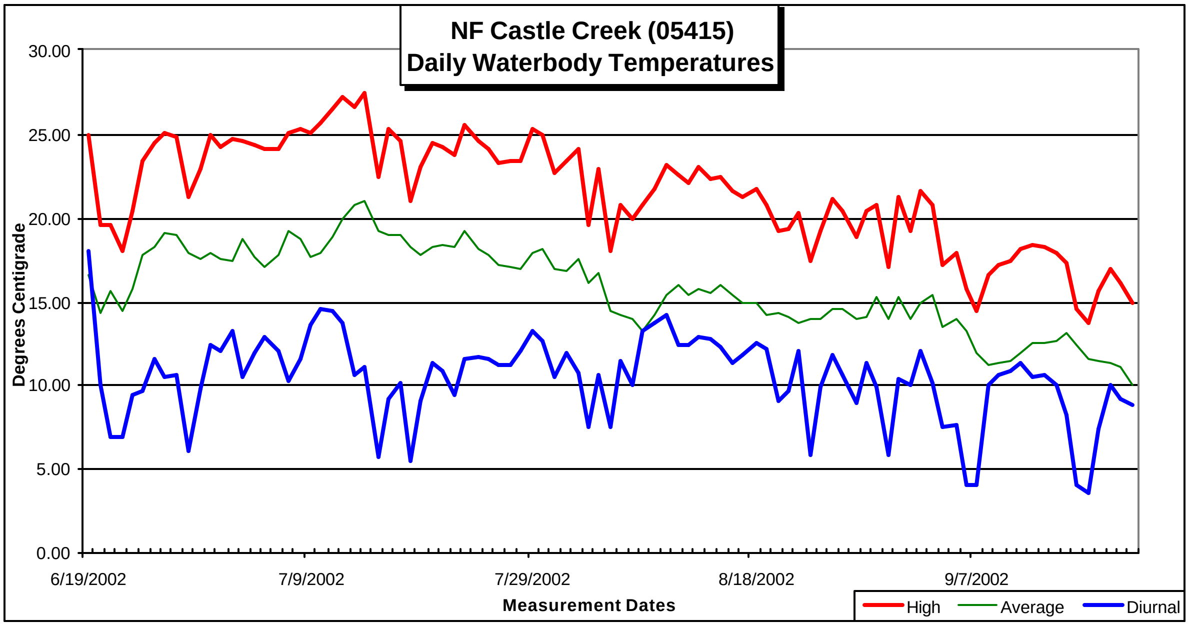
Table C-1. Data sources for Succor Creek, Castle Creek and NF Castle Creek TMDLs.

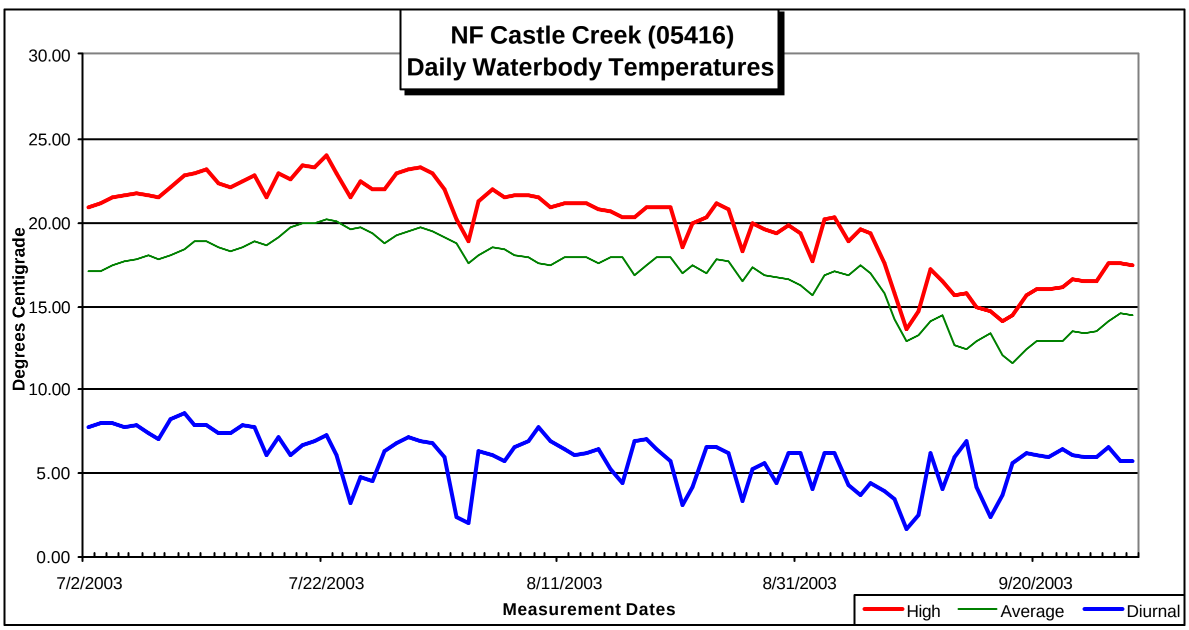
Water Body	Data Source	Type of Data	When Collected
Succor Creek, Castle Creek and associated tributaries	DEQ Regional Office	Pathfinder effective shade and stream width	October 2005
Succor Creek, Castle Creek and associated tributaries	DEQ State Technical Services Office	Aerial Photo Interpretation of existing shade and stream width estimation	October 2005 (based on photos taken in 2004)
Castle Creek, Succor Creek	DEQ IDASA Database	Temperature	2002-2004
NF Castle Creek, Castle Creek	BLM	Temperature	2002-2004

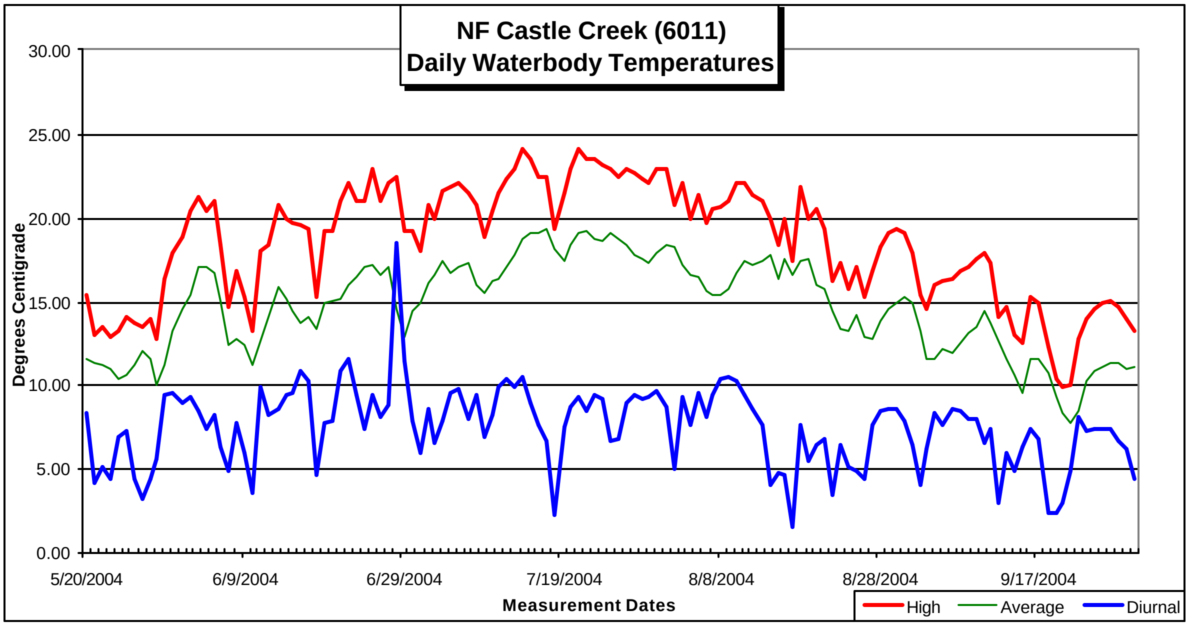
Castle Creek Watershed



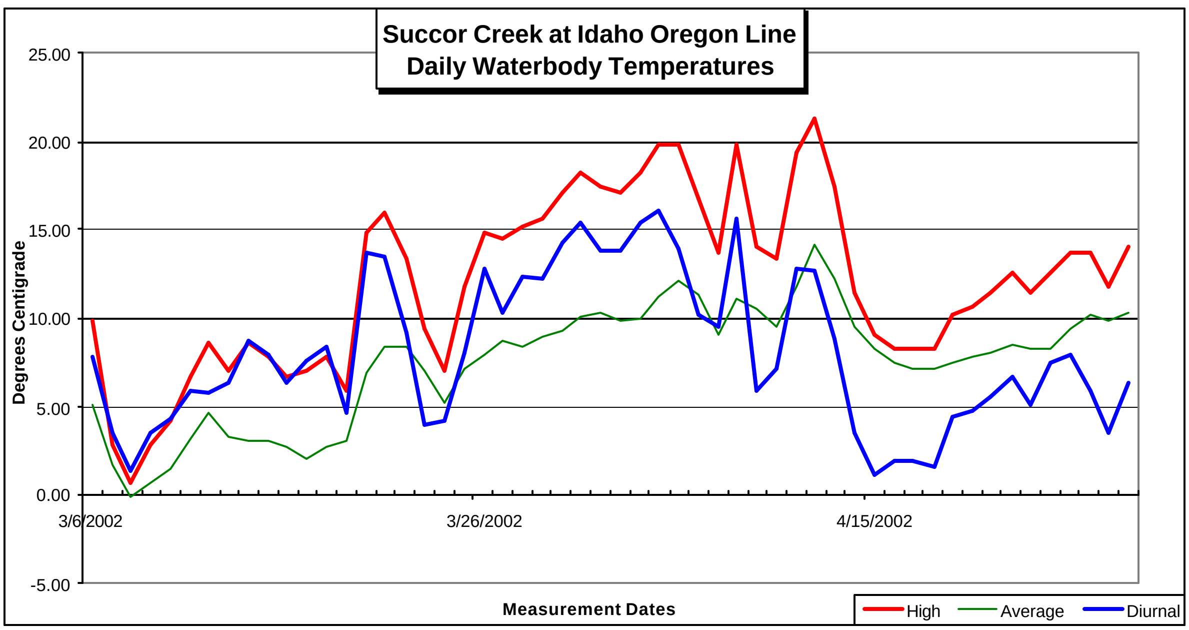
NF Castle Creek Watershed

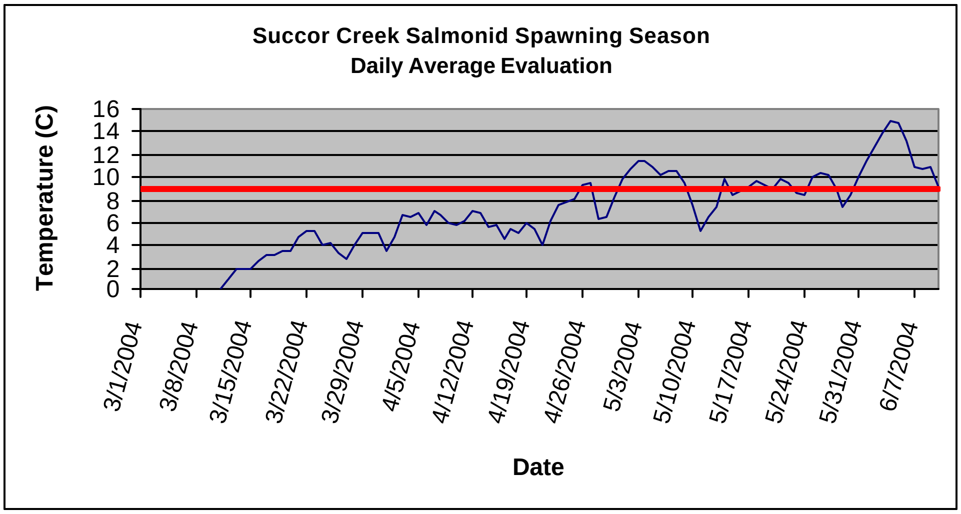


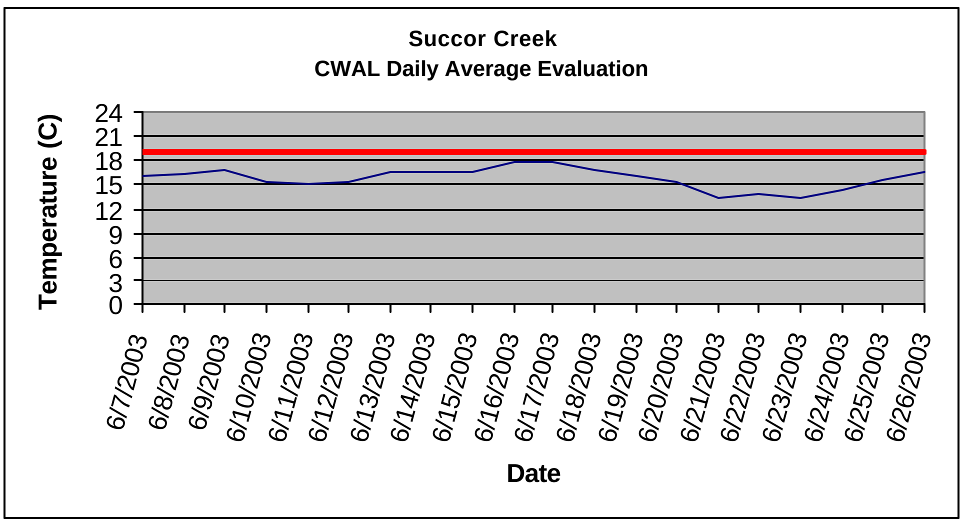




2002-2004 Succor Creek Temperature Data




Succor Creek Salmonid Spawning Season
Daily Average Evaluation
Temperature (C)
16
14
12
10
8
6
4
2
0
3/1/2004
3/8/2004
3/15/2004
3/22/2004
3/29/2004
4/5/2004
4/12/2004
4/19/2004
4/26/2004
5/3/2004
5/10/2004
5/17/2004
5/24/2004
5/31/2004
6/7/2004
Date


Succor Creek
CWAL Daily Average Evaluation
Temperature (C)
24
21
18
15
12
9
6
3
0
6/7/2003
6/8/2003
6/9/2003
6/10/2003
6/11/2003
6/12/2003
6/13/2003
6/14/2003
6/15/2003
6/16/2003
6/17/2003
6/18/2003
6/19/2003
6/20/2003
6/21/2003
6/22/2003
6/23/2003
6/24/2003
6/25/2003
6/26/2003
Date

Appendix D. Distribution List

March 2006

RON PARKS
233 RODEO AVE
CALDWELL ID 83605
208-455-4834

BOB THOMAS
HC 79 BOX 2060
OREANA ID 83650
208-250-5674

CHUCK KIESTER
RT 1 BOX 235
MARSING ID 83639
208-337-5612

BUREAU OF LAND MANAGEMENT
3948 DEVELOPMENT AVE
BOISE ID 83705
208-384-3396

BRIAN HOELSCHER
PO BOX 70
BOISE ID 83707
208-388-2591

REX BARRIE
PO BOX 67
HOMEDALE ID 83628
208-337-3760

JERRY HOAGLAND
HC 79 BOX 44
MELBA ID 83641
208-495-2810

CONNIE BRANDAU
HC 79 BOX 61
MELBA ID 83641
208-495-2529

BRIAN COLLETT
HC 79 BOX 2197
OREANA ID 83650
208-834-2062

KENT FRISCH
HC 85 BOX 366
GRAND VIEW ID 83624
208-834-2610

BILL PARKER
PO BOX 626
BRUNDEAU ID 83604
208-845-2056

ELIAS JACE
817 BLAINE AVE
NAMPA ID 83651

DUANE LAFAYETTE
PO BOX 590
BRUNEAU ID 83604

ELMORE COUNTY COURTHOUSE
150 S 4TH E SUITE 5
MOUNTAIN HOME ID 83647

OWYHEE COUNTY COURTHOUSE
PO BOX 128
MURPHY ID 83650

BOISE PUBLIC LIBRARY
715 S CAPITOL BLVD
BOISE ID 83702

HOMEDALE PUBLIC LIBRARY
25 W OWYHEE AVE
HOMEDALE ID 83628

LEIGH WOODRUFF
USEPA IDAHO OPERATIONS OFFICE
1435 N ORCHARD
BOISE ID 83706

REBECCA BEAVERS
8355 W STATE ST
BOISE ID 83703

JOHN ROMERO
17000 Z-X RANCH ROAD
MURPHY ID 83650

GWEN MILLER
PO BOX 175
MARSING ID 83639

June 2007

RON PARKS
233 RODEO AVE
CALDWELL ID 83605
208-455-4834

BOB THOMAS
HC 79 BOX 2060
OREANA ID 83650
208-250-5674

CHUCK KIESTER
RT 1 BOX 235
MARSING ID 83639
208-337-5612

BUREAU OF LAND MANAGEMENT
3948 DEVELOPMENT AVE
BOISE ID 83705
208-384-3396

BRIAN HOELSCHER
PO BOX 70
BOISE ID 83707
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CONNIE BRANDAU
HC 79 BOX 61
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Appendix E. Public Comments

Public involvement in the development of this TMDL includes the following events:

May 2002 The Mid-Snake River /Succor Creek WAG was informed that there would need to be a temperature TMDL for the North Fork Castle Creek and a bacteria Delisting for South Fork Castle Creek.

October 2005 The Mid-Snake River /Succor Creek WAG members were invited to the Owyhee Watershed Council Meeting to hear presentations describing how shade can be used as a surrogate measure of temperature. The DEQ presented the potential natural vegetation (PNV) approach to developing a TMDL.

March 2006 WAG members were informed that the State of Idaho had chosen the PNV method to address temperature in the Mid-Snake River /Succor Creek watershed. A Draft PNV TMDL was distributed for review and comment by the Mid-Snake River /Succor Creek WAG.

April 2006 The Mid-Snake River /Succor Creek WAG met at the University of Idaho Extension Center in Marsing to address questions or concerns regarding the TMDL, to agree on the document going out to public comment.

December 2006 The Addendum to the Mid-Snake/Succor Subbasin Assessment and TMDL: South Fork Castle Creek Bacteria Analysis and Succor Creek and Castle Creek Temperature Total Maximum Daily Loads was sent out for 30 day public comment. The comment period extended from December 1, 2006 to January 5, 2007. No public comments were submitted.

After submitting the final The Addendum to the Mid-Snake/Succor Subbasin Assessment and TMDL: South Fork Castle Creek Bacteria Analysis and Succor Creek and Castle Creek Temperature Total Maximum Daily Loads to EPA noted that a listed portion of Succor Creek had not been assessed.

June 2007 The TMDL was put back out to public comment to receive input on the previously unassessed portions of Succor Creek.

The matrix below documents the comments received during the 30-day comment period for the addendum to the Mid-Snake /Succor Subbasin Assessment and Total Maximum Daily Load. The comment period extended from June 1, 2007 through July 2, 2007. In some instances the comment is summarized. In others, the exact comment is given.

Comments From: Brian Hoelscher, Biologist II Idaho Power Company Received mail July 2, 2007	**DEQ Response:**
1) IPC requests the formation of a Technical Advisory Group to discuss the technical merits of the Potential Natural Vegetation (PNV) methodology and how it will be applied to the un-assessed stream reach, particularly large waters like reservoirs.	Diversions and reservoirs are notoriously difficult to assess and DEQ has a limited amount of information on agricultural diversions in the Succor Creek drainage. DEQ Believes that to quantify the effect of agricultural diversions would require

	modeling. We are open to the use of computer modeling. However, at this time, DEQ has limited data, few staff or financial resource to address this issue. DEQ agrees that IPC can form a technical advisory group to discuss the application of the PNV approach on agricultural reservoirs and diversions.
2)IPC has commented that by strictly focusing on riparian shading ignores other anthropogenic activities affecting heat or thermal loading reaching waters (including surface water diversions, reservoir storage and dyking and stream alterations). This approach can arbitrarily and inequitably increase the load allocations to those the DEQ has chosen to be responsible for the thermal loads of the watershed.	PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade producing vegetation. Anything less than PNV may result in the stream heating up from solar inputs. While no shade targets have been derived for the previously un-assessed agriculture diversion or storage structures on Succor Creek, their solar loading is now accounted for in the system. DEQ has no authority to control agricultural diversions and therefore considers them to be an uncontrollable load akin to natural background.
3) IPC does not necessarily disagree with the PNV methodology, however, disagrees with the selection of an appropriate recovery target. IPC believes the selection of an April through September solar radiation target inappropriately accounts for the amount of heat a water body contributes to the Snake River and river's ability to comply with numeric criteria.	It should be noted that changing the averaging period will not change potential shade targets, only heat load calculations. DEQ has been using a 6 month averaging period for shade analysis in the PNV approach because it encompasses spring and fall salmonid spawning and covers the leaf out period of deciduous vegetation. DEQ will consider, from a technical standpoint, using peak loading from July or August in future PNV TMDLs. However, work that has already been completed in both the Succor Creek and Castle Creek subwatersheds will remain consistent with the States' current PNV approach.
Comments From: Charles Kiester, Owyhee Soil Conservation District Received via e-mail: June 28, 2007	**DEQ Response:**
1) It is my understanding that Cottonwood Creek, Little Succor Creek, and the section of Succor Creek from Succor Creek Reservoir upstream to Chipmunk Cabin were to be de-listed in the Mid Snake River/ Succor Creek SBA and TMDL development process. Those creeks are intermittent and begin and end on private ground.	Cottonwood Creek does meet the state temperature standard for cold water aquatic life. However, Cottonwood Creek is included in the Assessment Unit 17050103SW003_02 which includes other segments that do not meet the temperature standard. The Cottonwood PNV shading analysis will remain in this temperature TMDL to inform the implementation process. Little Succor Creek was not addressed in the Mid Snake River/ Succor Creek SBA and TMDL. The DEQ has taken a watershed approach in treating temperature using PNV. Our data and analysis show that Little Succor Creek contributes a

	significant thermal load to Succor Creek and will therefore be included in the final document. Succor Creek above the reservoir was not de-listed. There was insufficient data to develop a TMDL. The Mid Snake River/ Succor Creek SBA and TMDL, page 143, paragraph 5, "*Upper Succor Creek exceeds the temperature criteria for cold water aquatic life directly above the reservoir and at the Idaho/Oregon line… Additionally, the salmonid spawning criteria are exceeded at all locations above the Oregon line. DEQ recommends temperature TMDLs at these locations.*"

August 2007 The Addendum to the Mid-Snake/Succor Subbasin Assessment and TMDL was resubmitted to EPA with PNV assessments on reaches of Succor Creek previously overlooked in the original analysis.

November 2007 Revised November 2007 Mid-Snake/Succor Subbasin Assessment and TMDL was resubmitted to EPA with reservoirs removed from the loading calculation for Succor Creek. Thermal loading from the reservoirs were acknowledged and documented. Extent of TMDL was clarified.