Appendix A: Development and Application of the Q2ESHADE Temperature Modeling System to the Lower Eel River

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A.1 Background

The Lower Eel River (LER) is located in northwest California. Its basin extends to the coast and stretches across south-central Humboldt County. The LER has been identified as an important habitat for cold-water fish populations such as the salmonid species. One of the major water quality concerns for these fish species is increased water temperature, which can severely impair their survival and reproduction. Increased temperatures caused the LER to be placed on California's Clean Water Act Section 303(d) list of impaired waterbodies.

A major factor contributing to elevated stream temperatures, especially in the tributary stream networks, is the reduction in stream shading caused by the removal of riparian vegetation. To predict temperatures throughout the LER system and to assess relationships with riparian vegetation characteristics and topography, a QUAL2E-SHADE temperature modeling system was developed. This modeling system is comprised of a Geographical Information System (GIS) - based SHADE model linked to a modified QUAL2E receiving water model (Q2ESHADE). The components of the modeling system are summarized in Figure A-1.

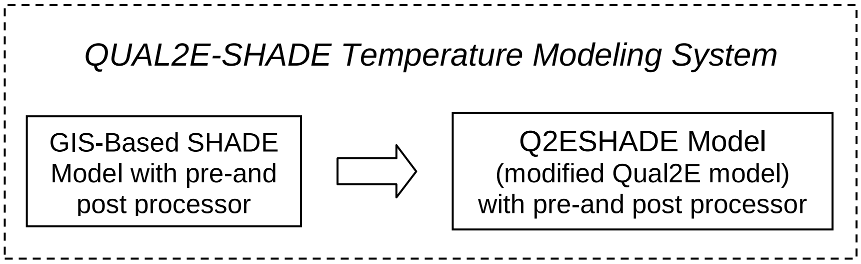

Figure A-1. QUAL2E-SHADE temperature modeling system

QUAL2E is a USEPA-supported, public-domain receiving water model. It has undergone extensive peer review over the past several decades and has been widely used in numerous watersheds throughout the world. The SHADE model linked to QUAL2E is a simplified version of the model developed by Chen et al. (1998a) and applied to the Upper Grande Ronde watershed (Chen et al., 1998b).

The modeling system has been modularized such that the user can run the SHADE model alone or in conjunction with Q2ESHADE. Independently, the SHADE model can provide a screening level view of the influence of shade on in-stream temperatures. Coupled with the QUAL2E model, it provides the ability to simulate all or selected reaches within a particular watershed. This allows more flexibility during modeling and supports the exclusion of reaches that are not considered hydrologically important (i.e., no flow during the summer).

When operated in tandem, the Q2ESHADE modeling system calculates hourly shade-attenuated solar radiation at various locations based on riparian vegetation characteristics, topographic relief, and initial flow conditions and subsequently predicts in-stream temperatures throughout a stream network. The maximum value of the 7-day running average of all recorded temperatures (max7daat) is then calculated from the model output. The effects of riparian-zone vegetation management strategies on stream temperatures during low-flow/critical conditions can also be evaluated.

There were three separate modeling analyses performed for the LER (Table A-1). The integrated Q2ESHADE modeling system was applied to two tributary stream networks, Larabee Creek and creeks draining to Salt River (Figure A-2). These two models were calibrated using observed temperature monitoring data provided by The Pacific Lumber Company (PALCO) (PALCO, 2005) and the Humboldt County Resource Conservation District (RCD) (Humboldt County RCD, 2005), respectively. A third modeling analysis was performed to determine the influence of shade along the LER main stem. For this analysis, the SHADE model (independent of QUAL2E) was applied to the entire length of the main stem (referred to as the main stem SHADE model throughout the remainder of this document).

After all of the models were configured and calibrated, scenarios were performed to support TMDL development. The scenarios included the simulation of various vegetation conditions for the main stem SHADE model, Larabee Creek, and several creeks draining to Salt River (Table A-1).

Table A-1. Modeling Analyses Performed to Support the Lower Eel River Temperature TMDL

Study Area	Model Applied	Scenarios Performed
Main Stem SHADE Model	SHADE Model	Vegetation Scenarios
Larabee Creek	Q2ESHADE (QUAL2E + SHADE Models)	Vegetation Scenarios
Creeks Draining to Salt River	Q2ESHADE (QUAL2E + SHADE Models)	Vegetation Scenarios

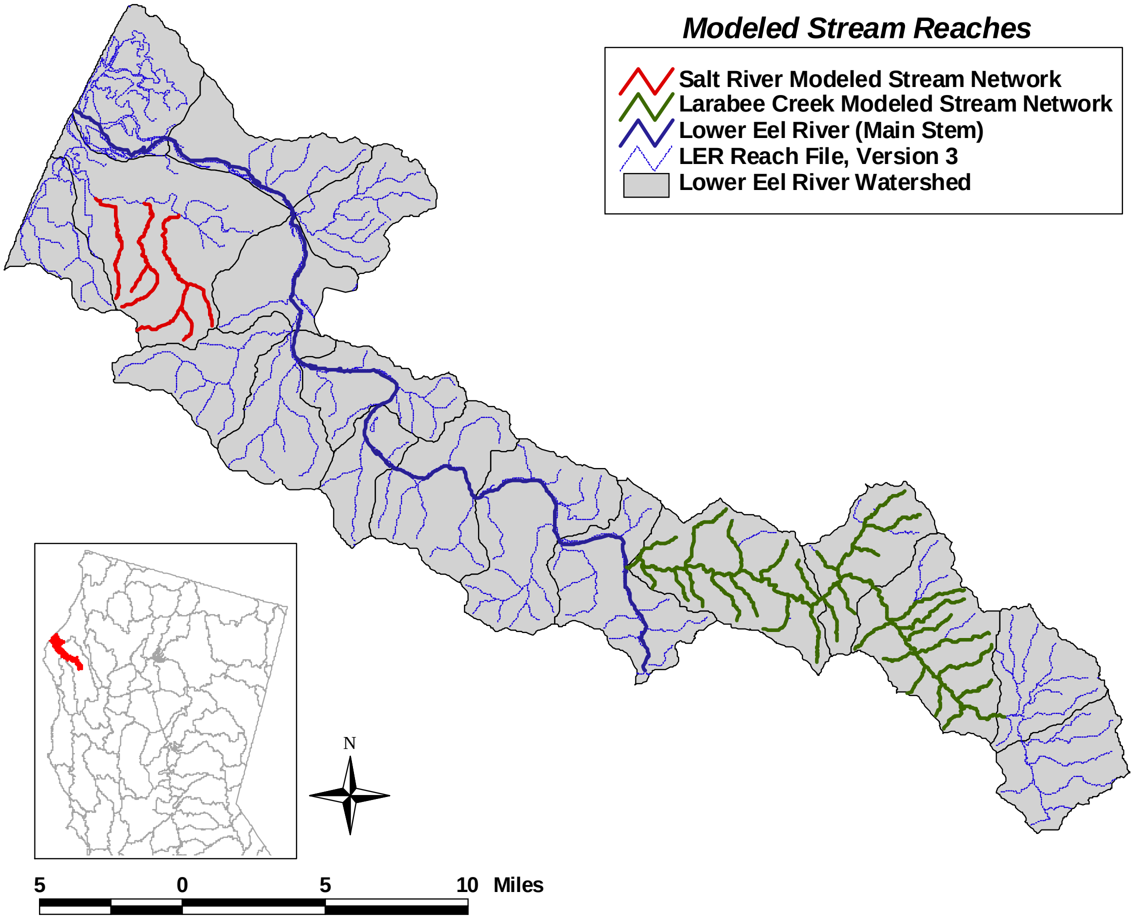

Figure A-2. Lower Eel River modeled watersheds and stream networks

A.2 GIS-Based SHADE Model

The GIS-Based SHADE model, which was applied to all three study areas (Table A-1), consists of two major components: the underlying SHADE model algorithms and a GIS-based preprocessor for the SHADE model. The methodology and data used to parameterize and run the SHADE preprocessor and model are presented in the next two sections and illustrated in Figure A-3.

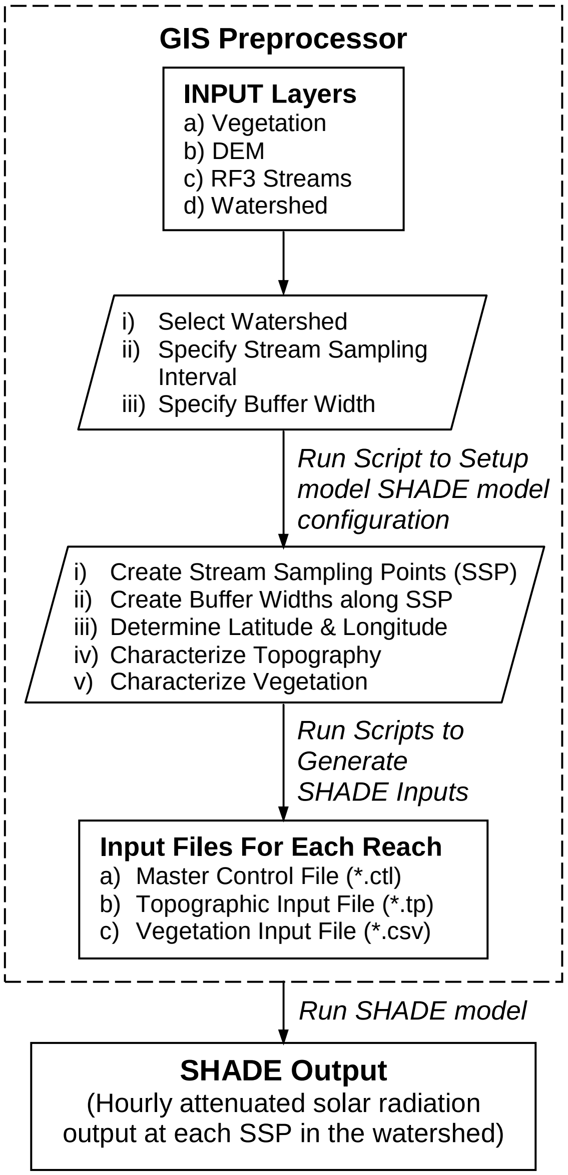

Figure A-3. SHADE GIS preprocessor

A.2.1 SHADE GIS Preprocessor

A preprocessor was developed using a GIS platform to generate three input files required by the SHADE model. User-supplied input data include digital elevation model (DEM) data, site-specific vegetation data, streams (USEPA Reach File, Version 3 [RF3]), time zones, and watershed boundaries. The site-specific data used to represent the LER watersheds and the preprocessing steps are described below and presented in Figure A-3.

A.2.1.1 Data Requirements and Sources

Digital Elevation Model (DEM)

Elevation values were obtained from the 30-meter DEM data distributed by the United States Geological Survey (USGS). These data were used in determining the topographic shading.

Vegetation Data

The California Vegetation theme (CALVEG) from the United States Forest Service (USFS) was used to determine the vegetation related parameters. This data set was chosen due to its completeness and because it contained the required information to parameterize the SHADE model. The California Wildlife Habitat Relationships (WHR) classification system incorporated in the vegetation data provides information on general tree habitat classes. Diameter-at-breast height (DBH) ranges associated with these classes were loosely based on the Northwest Size, included in the CALVEG metadata (Table A-2). Specifically, size classes 0, 2, 3, and 4 had ranges identical to those associated with the Northwest Size. The DBH range for size class 5 was based on the Northwest Size for its lower limit (40 inches) and the second highest DBH class (up to 48.9 inches) in the Pacific Northwest-Forest Inventory Analysis (PNW-FIA) Integrated Database (Pacific Northwest Research Station, 2004) for its upper limit.

To accurately represent the large redwood trees in this watershed, it was necessary to modify the CALVEG theme. Because the SHADE model is based on the pre-defined WHR size class categories, it was necessary to develop an approach based on the existing categories and information. Fortunately, there were no records associated with size class 1 in the model subwatersheds; therefore, this category was available to represent the larger redwood trees. Specific polygons representing the largest trees were assigned to size class 1 using the following decision rules:

1. CALVEG vegetation types “RD” and “RW” for Redwood-Douglas Fir and Redwood, respectively, were selected.
2. Of the above selected polygons, all “MIX” covertypes were excluded. This resulted in a selection of RD and RW vegetation types associated solely with the conifer (CON) covertype.
3. The polygons from Step #2 that were assigned a CALVEG size of 5 were selected (these trees are associated with a crown diameter greater than 40 feet).

The resulting polygons, representing the largest conifer trees, were assigned size class 1 in the CALVEG theme. The DBH range associated with this size class was based on the largest DBH class in the PNW-FIA Integrated Database (greater than 48.9 inches) (Table A-2). In addition, the maximum size class for hardwood cover types in the model subwatersheds was 4. The DBH value incorporated in the SHADE model to represent each size class is the average of the range presented in Table A-2, except for size class 1 in which a DBH of 60 inches (152.4 centimeters [cm]) was used to represent the large conifer trees.

Table A-2. Tree Size Classes

Size Class	DBH Range (inches)	DBH Range (centimeters)
0	0 – 0.9	0 – 2.4
1*	> 48.9	>124.2
2	5 – 11.9	12.7 – 30.4
3	12 – 23.9	30.5 – 60.9
4	24 – 39.9	61 – 101.5
5	40 – 48.9	101.6 – 124.2

* Only represents large conifer trees

Tree density is also required for SHADE model computations. The canopy closure code in the vegetation coverage was used to assign canopy closure ranges (Table A-3). Tree density was then determined in the modeling system by assigning the average density associated with the closure class code. The CALVEG vegetation layer was used to derive the tree height and density data layers, which are necessary inputs to the SHADE model to predict solar radiation.

Table A-3. Canopy Closure Classes

Closure Class	Canopy Closure (%)	Closure Class	Canopy Closure (%)
0	0-9	5	50-59
1	10-19	6	60-69
2	20-29	7	70-79
3	30-39	8	80-89
4	40-49	9	90-100

Watershed Boundary

The CALWTR 2.2 watershed boundaries available from the State of California were used to represent the watershed boundaries. The watershed boundary was used to define the geographic extent of the study areas: the Larabee Creek, Salt River, and main stem SHADE model subwatersheds. All streams within the selected subwatersheds can be simulated or, as in the case for the LER simulations, specific streams were selected during preprocessing.

Stream Network

The RF3 provided by USEPA was used to represent the stream network. This shapefile provides detailed stream connectivity and lengths, which are necessary to ensure that the stream numbering scheme is generated properly for use by both SHADE and Q2ESHADE. This layer was also used to select the specific streams simulated in the model watersheds (Figure A-2).

The stream layers were amended to include the stream-wetted width at the start and end of each simulated reach. Stream width information for each reach is necessary to calculate the surface area for individual reaches and account for the total solar radiation received at the stream surface. Data were available for several locations throughout the LER study areas. Table A-4 identifies the data sources utilized to assign widths to all model reaches.

Table A-4. Source of Wetted Width Information for Each Study Area

Study Area	Source of Wetted Width Information
Main Stem SHADE Model	▪ Wetted width estimates obtained during the 2005 Airborne Thermal Infrared Remote Sensing Study of the Middle Main and Lower Eel Rivers (Watershed Sciences, 2005)
Larabee Creek	▪ Low flow widths available from 2005 stream temperature monitoring performed by PALCO (PALCO, 2005) were supplemented by data for several locations from the California Department of Fish and Game (CDFG) Stream Inventory Reports for Larabee Creek and it's tributaries (CDFG, 1992a, 1992b, 1992c, 1992d, 2000a, 2000b, 2000c, 2000d) ▪ Widths for small/unmeasured tributaries were estimated using previous modeling studies for similarly sized creeks (Tetra Tech, Inc., 2004, 2005)
Creeks Draining to Salt River	▪ Low flow widths available for several locations from the CDFG Stream Inventory Reports for Francis Creek, Unnamed Tributary to Francis Creek, and Williams Creek (CDFG, 2003a, 2003b, 2003c) ▪ Widths for small/unmeasured tributaries were estimated using previous modeling studies for similarly sized creeks (Tetra Tech, Inc., 2004, 2005)

Time Zone

The USGS time zone GIS layer was incorporated into the SHADE model to determine the standard time zone meridian (longitude) of the LER watershed.

A.2.1.2 Preprocessor Methodology

To generate the SHADE model files, the preprocessor creates stream sampling points (SSP) and buffers for each SSP. The distance between SSPs and the buffer widths are user-specified values, which depend on the spatial variability and level of detail desired. Table A-5 identifies the SSP distance and buffer widths for the three LER study areas. The SSP configurations for the main stem SHADE model, Larabee Creek, and several creeks draining to Salt River are shown in Figure A-4 through Figure A-6, respectively.

Table A-5. Stream Sampling Point Distances and Buffer Widths

Study Area	SSP Distance	Buffer Width
Main Stem SHADE Model	500 meters (1,640 feet)	300 meters (984 feet)
Larabee Creek	250 meters (820 feet)	300 meters (984 feet)
Creeks Draining to Salt River	500 meters (1,640 feet)	300 meters (984 feet)

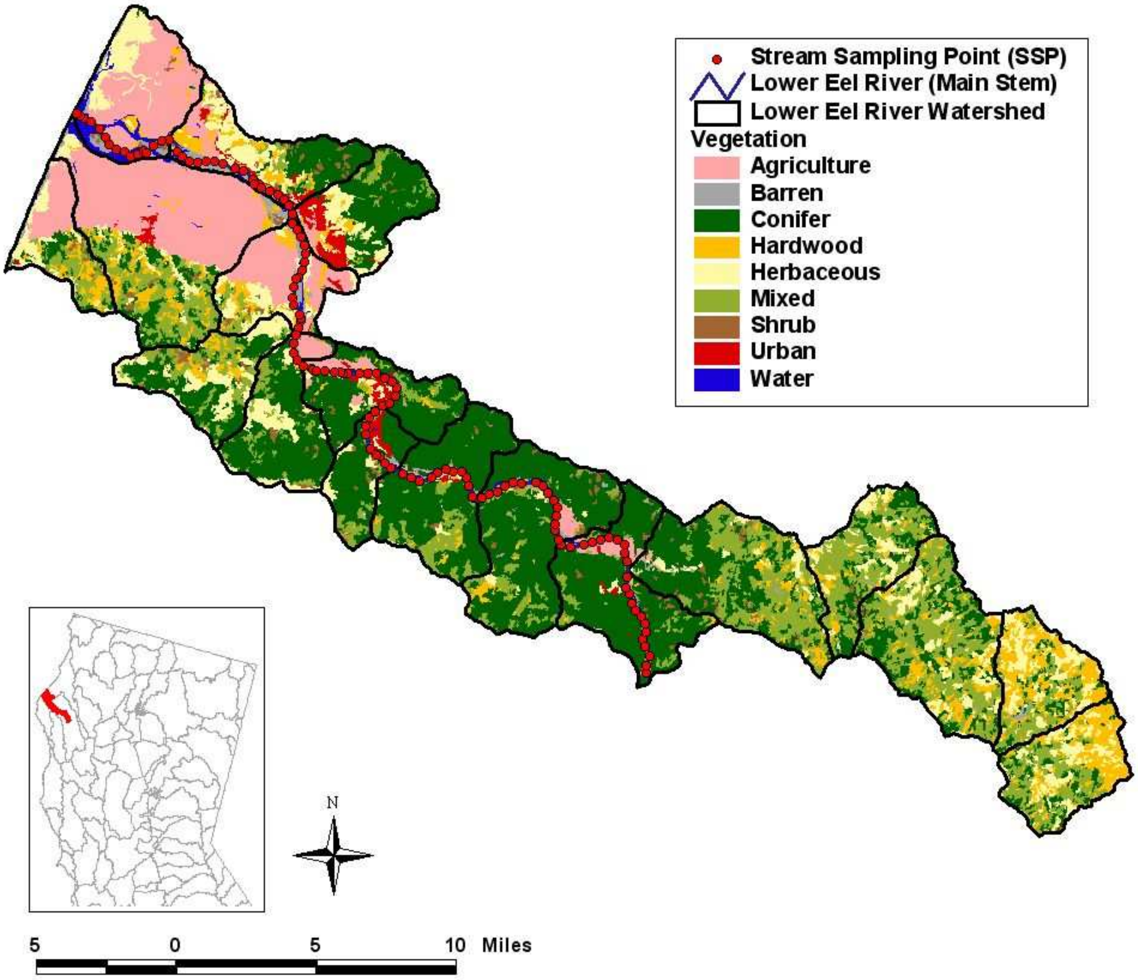

Figure A-4. Stream sampling points and vegetation types for the main stem of the Lower Eel River

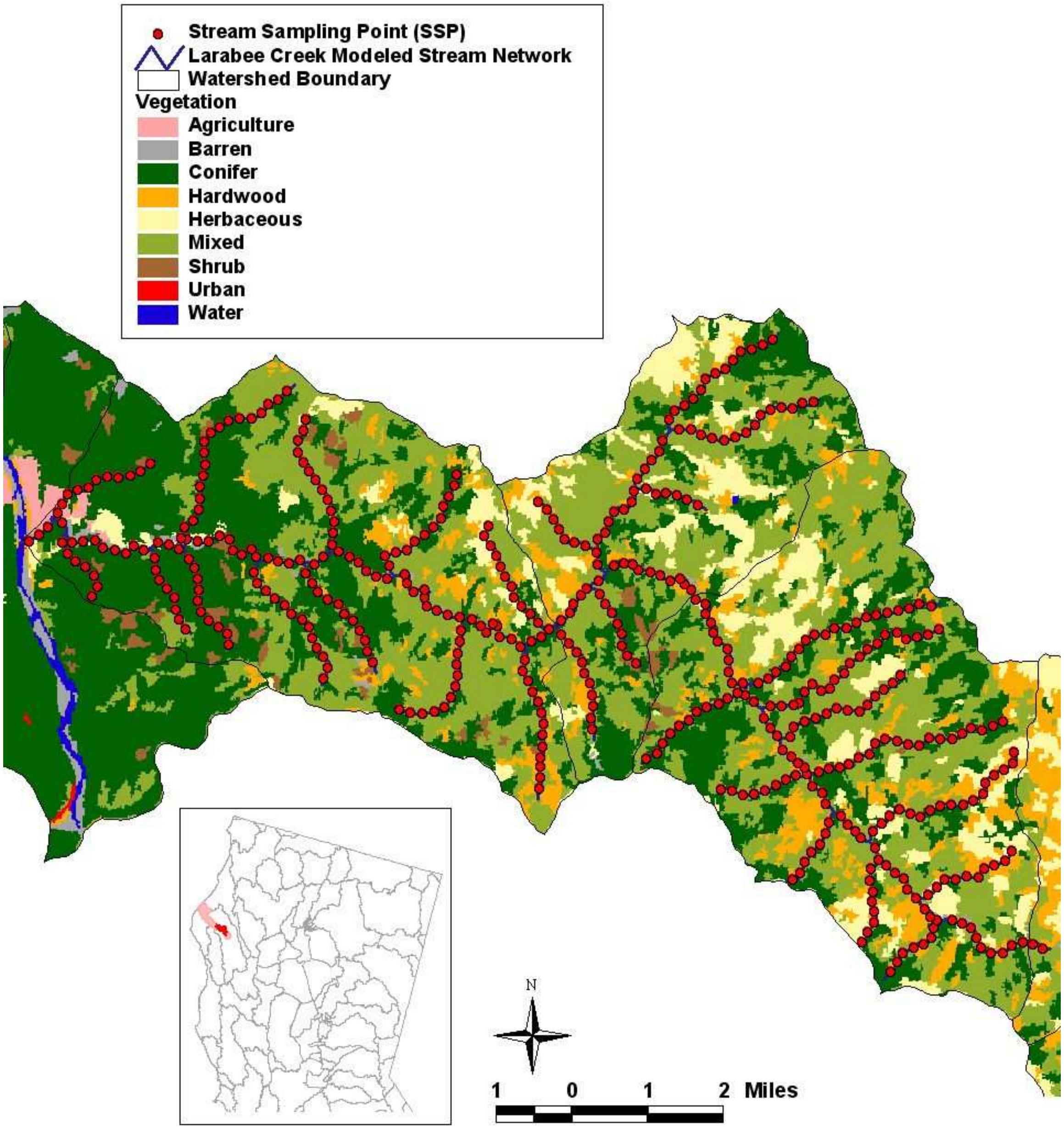

Figure A-5. Stream sampling points and vegetation types for Larabee Creek

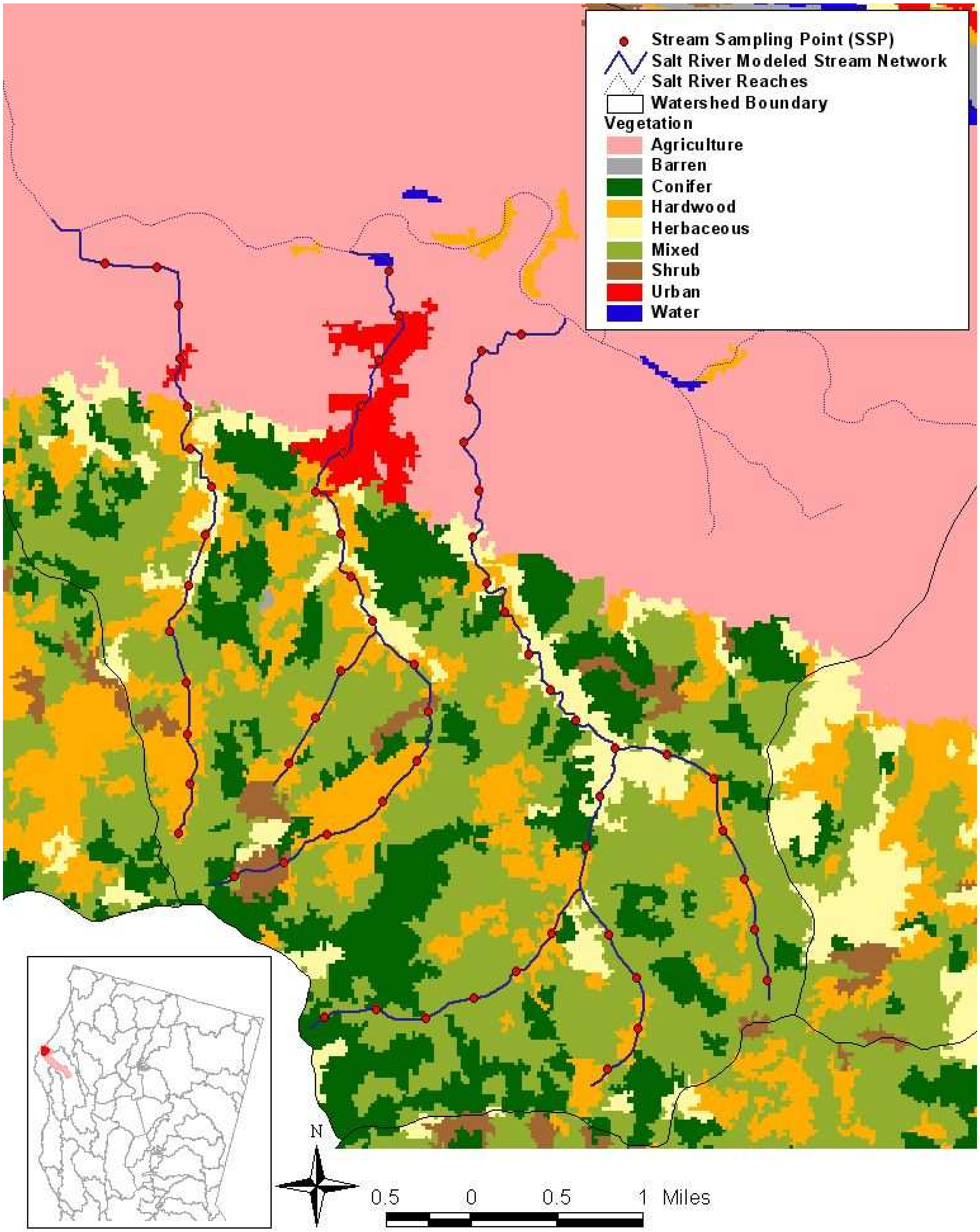

Figure A-6. Stream sampling points and vegetation types for several creeks draining to Salt River

SSPs are automatically identified using an upstream to downstream numbering scheme that is compatible with the Q2ESHADE model. After extracting the latitude and longitude and numbering each SSP, the preprocessor was used to characterize the topography and generate vegetation height and density layers required by the SHADE model.

Tree heights were derived using the asymptotic height-diameter regression equations developed for 24 tree species in Oregon (Garman et al., 1995). Generalized DBH versus tree height relationships were developed for two distinct categories of tree species identified in the California vegetation data layer, conifers and hardwoods. The general form of the asymptotic height-diameter equation is presented in Equation 1:

$$\mathit{Height}\ (m) = 1.37 + (b_0[1 - \exp(b_1 \cdot \mathrm{DBH})]^{b_2}) \qquad (1)$$

where, b_0, b_1, and b_2 are regression coefficients, which are dependent on the type of tree species and site class. The parameter b_0 is the asymptote or maximum height coefficient, b_1 is the steepness parameter coefficient, and b_2 is the coefficient for the curvature parameter.

To determine watershed-specific regression coefficients, the CALVEG vegetation data were first summarized to identify the dominant coniferous and hardwood tree species in the LER model subwatersheds. For the main stem SHADE model, both Douglas Fir and Redwood were determined to be dominant conifers and the dominant hardwood tree species was the Oregon White Oak. Similarly, Douglas Fir and Redwood were the dominant conifer tree species in Larabee Creek, but Tanoaks were the dominant hardwood. In the Salt River watershed, Douglas Fir and Grand Fir were the dominant conifer trees while Red Alders were the dominant hardwood tree species.

DBH and height data for each dominant species were queried from the PNW-FIA Integrated Database (Pacific Northwest Research Station, 2004). For the dominant hardwood species in the main stem SHADE model and the Salt River subwatersheds, there were not enough data for the LER watershed in the database to develop a DBH-height relationship, so additional data were queried. Specifically, to obtain enough data for the main stem SHADE model subwatersheds, data associated with Oregon White Oaks in the LER and the Middle Main Eel River were included. Similarly, for the Salt River watershed, data for Red Alders within 10 miles of the coast in Humboldt County were included.

The data from the PNW-FIA database were fit to the asymptotic height-diameter equation (Equation 1) to determine localized regression coefficients for both conifers and hardwoods (Table A-6), which were subsequently applied to the appropriate study area. The data included from the PNW-FIA Integrated Database and the resulting conifer and hardwood height-diameter relationships are presented in Figure A-7 and Figure A-8, respectively, for the main stem SHADE model, Figure A-7 and Figure A-9, respectively, for the Larabee Creek subwatersheds, and Figure A-10 and Figure A-11, respectively, for the creeks draining to Salt River.

Table A-6. Height-Diameter Coefficients

Study Area	Vegetation Type	Dominant Tree Species	b_0	b_1	b_2
Main Stem SHADE Model	Conifer	Douglas Fir; Redwood	62.12841	-0.01111	0.91681
	Hardwood	Oregon White Oak	13.87481	-0.09914	2.41158
Larabee Creek	Conifer	Douglas Fir; Redwood	62.12841	-0.01111	0.91681
	Hardwood	Tanoak	30.11622	-0.02599	1.00075
Creeks Draining to Salt River	Conifer	Douglas Fir; Grand Fir	57.34705	-0.01501	1.00923
	Hardwood	Red Alder	22.17409	-0.06843	1.06004

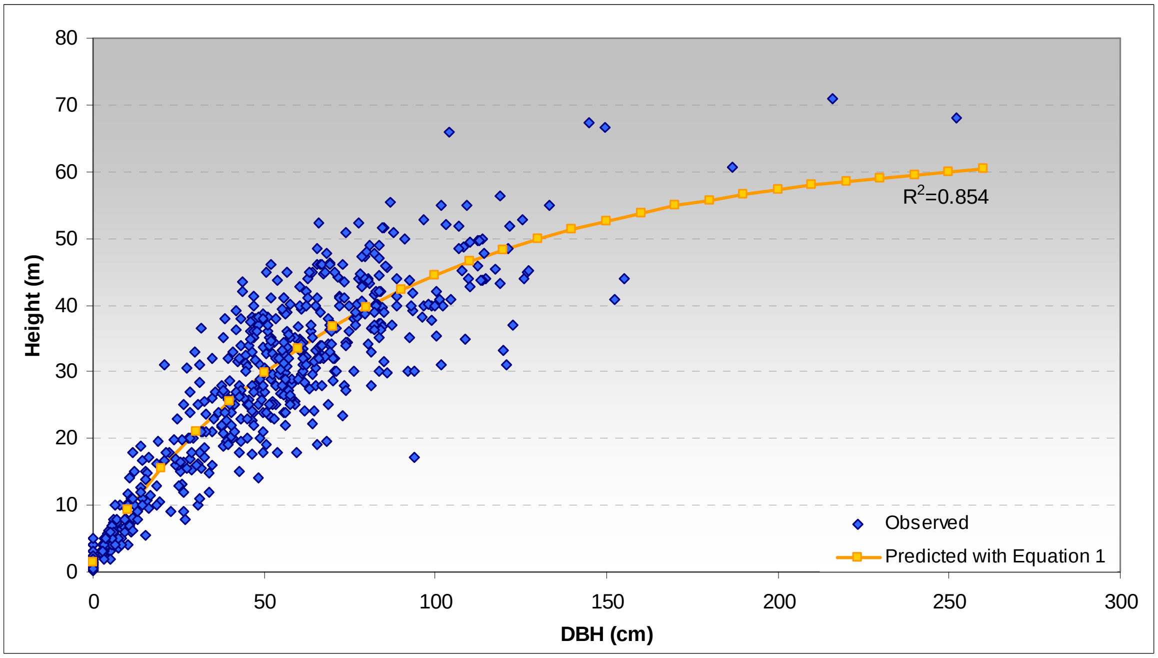

Figure A-7. Tree height-diameter relationship for Douglas Fir and Redwood (conifer) for the main stem SHADE model and Larabee Creek subwatersheds

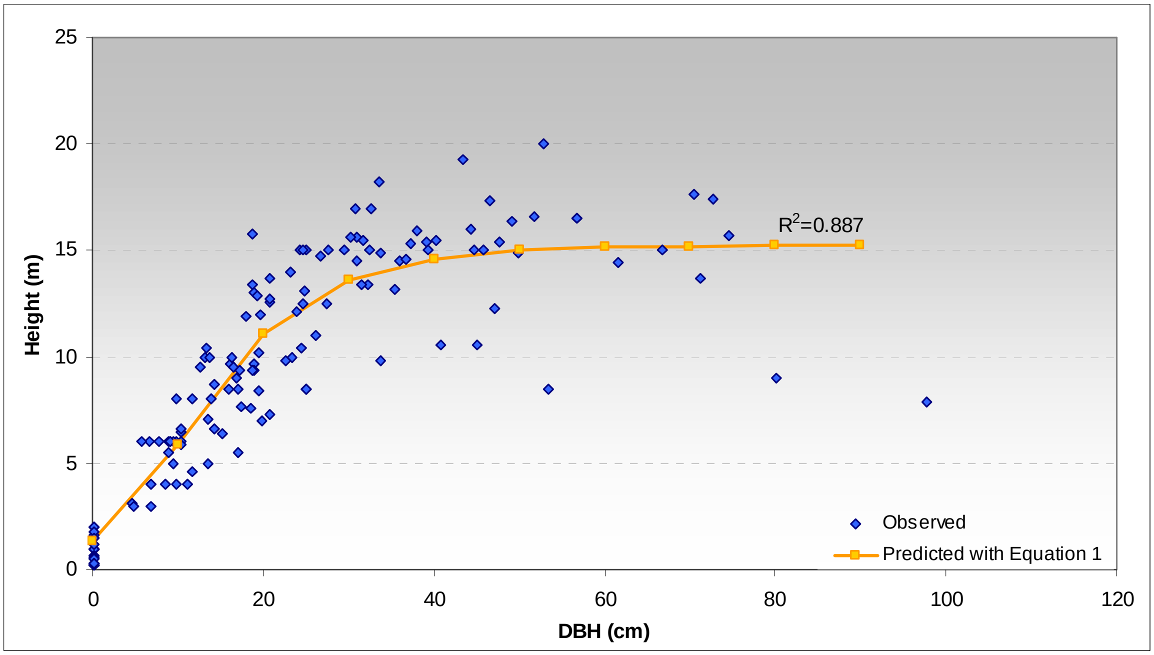

Figure A-8. Tree height-diameter relationship for Oregon White Oak (hardwood) for the main stem SHADE model subwatersheds

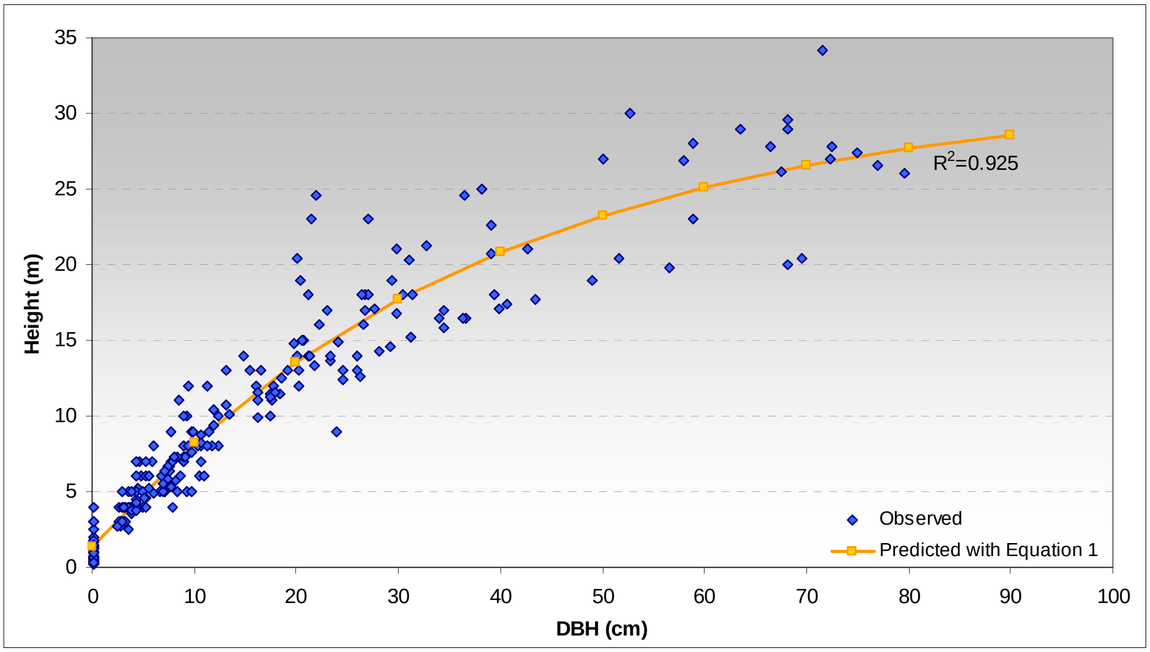

Figure A-9. Tree height-diameter relationship for Tanoak (hardwood) for the Larabee Creek subwatersheds

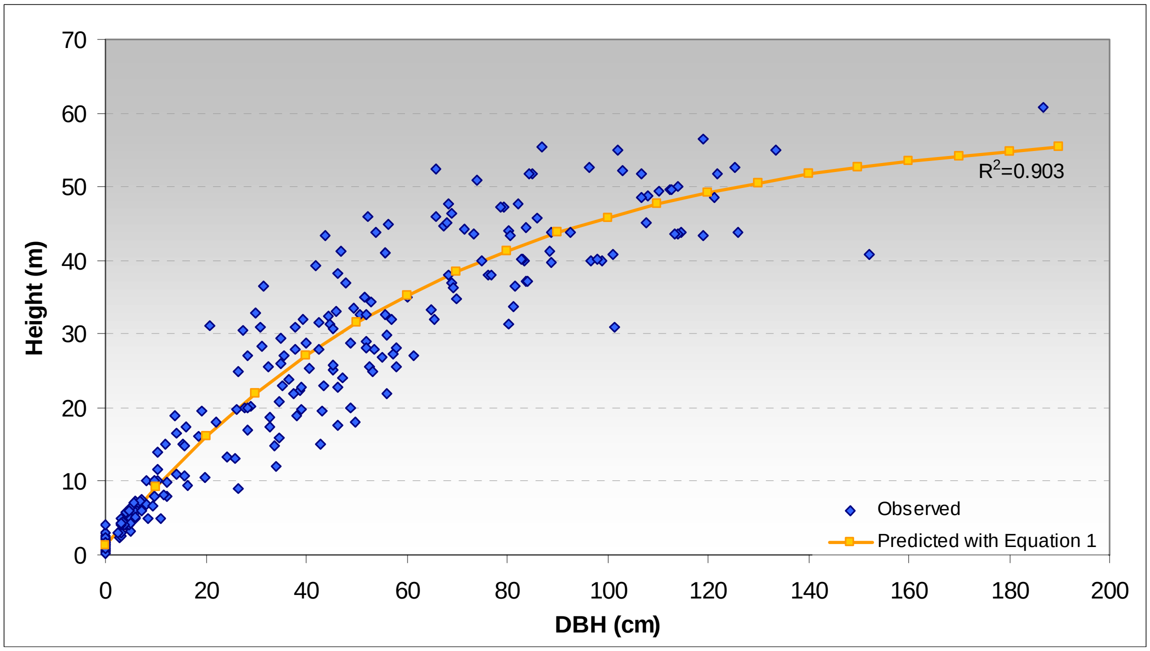

Figure A-10. Tree height-diameter relationship for Douglas Fir and Grand Fir (conifer) for the Salt River subwatershed

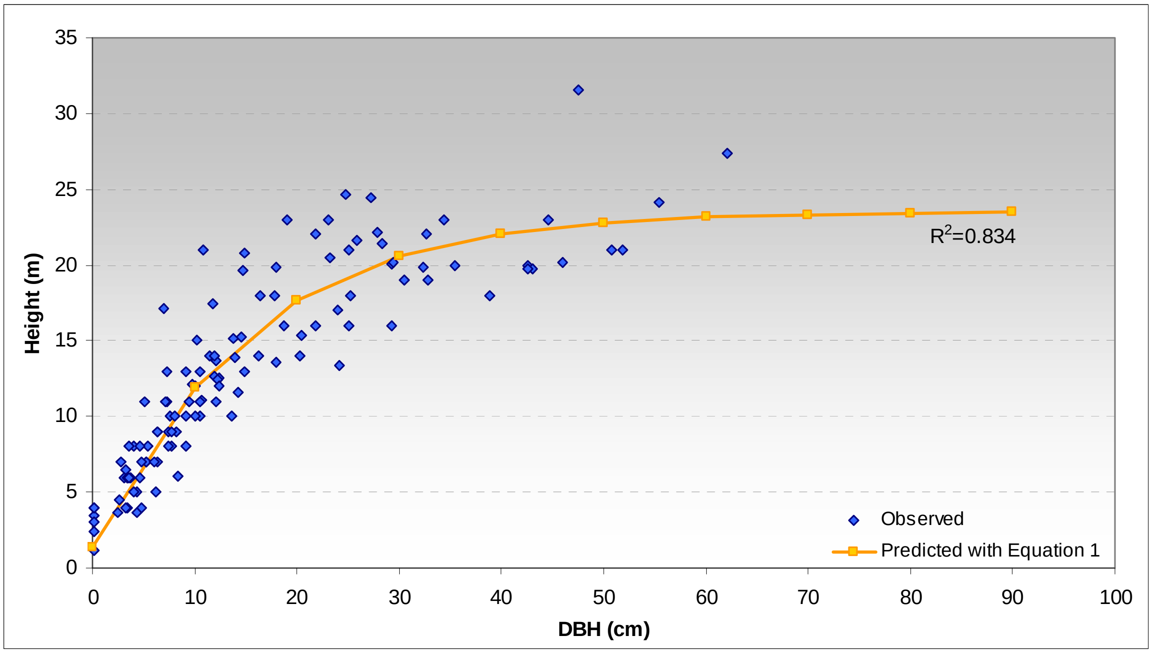

Figure A-11. Tree height-diameter relationship for Red Alder (hardwood) for the Salt River subwatershed

Each vegetation cell in the vegetation layer is assigned a height based on its vegetation type (i.e. conifer, hardwood, herbaceous, etc.) and size class. The vegetation height for each conifer and hardwood grid cell is calculated by applying Equation 1 with the appropriate regression coefficients. The size class field in the vegetation coverage identifies the DBH value (see Table A-2) that is included in Equation 1 to calculate tree height. To address other vegetation types in the LER watershed, a constant minimum height of 0.5 meter (1.6 feet) was assigned to herbaceous plants and 1 meter (3.3 feet) was assigned to other deciduous species.

To test the coefficients, computed tree heights were compared with the observed data. The height-diameter equation resulted in conifer and hardwood heights well within the observed ranges. Table A-7 summarizes the tree heights observed in the PNW-FIA Integrated Database and computed by incorporating the coefficients from Table A-6 into Equation 1 for the DBH associated with the largest size class for each vegetation type in each study area. As indicated in the table, the computed conifer trees were always within the range of observed tree heights for similar DBHs (± 3 cm). For each of the hardwood species, the computed height at a DBH of 81.2 cm was well within the range of observed heights even though there were not enough data within 3 cm of the 81.2 cm DBH to provide a complete observed data range. Specifically, in the main stem SHADE model subwatersheds, the maximum observed Oregon White Oak height was 20 meters and the computed height was 15.23 (Figure A-8). For the Larabee Creek subwatersheds, the maximum observed Tanoak height was 34.2 meters and the computed height at the maximum DBH was 27.83 meters (Figure A-9) and, for the Salt River watersheds, the maximum observed Red Alder height was 31.6 meters, while the computed height was 23.45 meters (Figure A-11).

Table A-7. Computed and Observed Tree Heights at the Maximum DBH

Study Area	Vegetation Type	DBH*	Computed Height at DBH	Observed Range at Maximum DBH (±3 cm)	
				Low	High
Main Stem SHADE Model	Conifer	112.9 cm (44.5 inches)	47.04 meters (154.29 feet)	43.6 meters (143.01 feet)	50 meters (164.00 feet)
	Large Conifer	152.4 cm (60 inches)	52.94 meters (173.64 feet)	44 meters (144.32 feet)	66.7 meters (218.78 feet)
	Hardwood	81.2 cm (31.9 inches)	15.23 meters (49.95 feet)	9 meters (29.52 feet)	none
Larabee Creek	Conifer	112.9 cm (44.5 inches)	47.04 meters (154.29 feet)	43.6 meters (143.01 feet)	50 meters (164.00 feet)
	Large Conifer	152.4 cm (60 inches)	52.94 meters (173.64 feet)	44 meters (144.32 feet)	66.7 meters (218.78 feet)
	Hardwood	81.2 cm (31.9 inches)	27.83 meters (91.28 feet)	26 meters (85.28 feet)	none
Creeks Draining to Salt River	Conifer	112.9 cm (44.5 inches)	48.10 meters (157.77 feet)	43.6 meters (143.01 feet)	50 meters (164.00 feet)
	Hardwood	81.2 cm (31.9 inches)	23.45 meters (76.92 feet)	none	none

*The DBH value is associated with the average of the largest size class range for each vegetation type from Table A-2, except for large conifer trees, which were assigned a maximum DBH of 60 inches (152.4 centimeters [cm]).

Vegetation density is an additional parameter required by the SHADE model. The tree density was determined by assigning the appropriate average density based on the canopy closure ranges (Table A-3) for each closure class in the vegetation layer. The vegetation layer was also used to determine the two-character vegetation cover code required for the vegetation shade input file (*.csv). This code is generated automatically based on the cover type in the vegetation layer.

The result of the above processing is the generation of three required input files that supply the SHADE model with information on each reach. These files include master input files (*.inp), topographic input files (*.tp), and vegetation input files (*.csv).

A.2.2 SHADE Model

Chen et al. (1998a, 1998b) have incorporated a series of computational procedures identifying the geometric relationships between sun position, stream location and orientation, and riparian shading characteristics into a computer program called SHADE. This model has the capability of predicting shade–attenuated solar radiation on a watershed scale.

A.2.2.1 SHADE Model Inputs

The output files from the SHADE GIS preprocessor (Section A.2.1) are incorporated directly into the SHADE model. In addition to this information, SHADE requires daily solar radiation data. Hourly solar radiation data for several stations near the LER were available from the California Data Exchange Center (CDEC), which is operated by the California Department of Water Resources (CDEC, 2006). Table A-8 identifies the solar radiation stations assigned to each study area while Figure A-12 presents the stations and their proximity to the LER. A daily time series containing cloud attenuated solar radiation for the modeling period of July 15, 2004 to August 14, 2005 was generated for each weather station, as per SHADE model requirements. All SHADE model inputs are summarized in Table A-9.

Table A-8. Solar Radiation Stations

Study Area	Solar Radiation Station
Main Stem SHADE Model	Maple Creek (MPC)
Larabee Creek	Eel River Camp (ERC)
Creeks Draining to Salt River	Maple Creek (MPC)

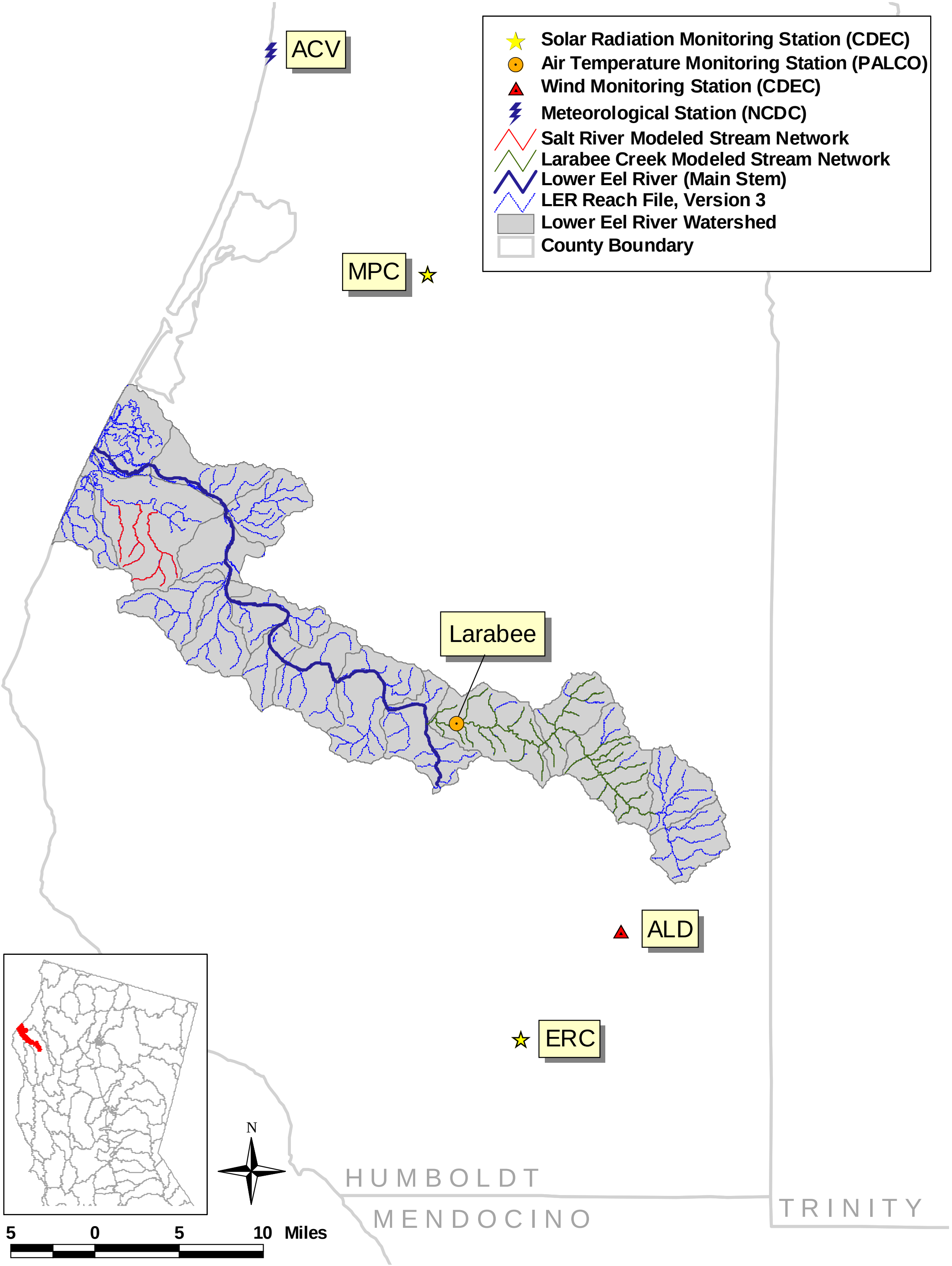

Figure A-12. Climatological stations near the Lower Eel River watershed

Table A-9. SHADE Model Inputs

Input Parameter	Description
Watershed location	▪ Watershed latitude ▪ Watershed longitude ▪ Time zone standard meridian where the watershed is located
Stream width	Wetted stream width at the start and end of each reach
SSP coordinates	Universal Transverse Mercator (UTM) coordinates of all stream sampling points (topographic and vegetation shading characteristics will be defined at each of these locations)
Topographic shading characteristics	Topographic shade angles (degrees) measured from the stream surface to up to the topographic features that obstruct the sunbeam (Input in 12 standard azimuth directions at each SSP)
Vegetation shading characteristics	Includes vegetation characteristics at each SSP: ▪ Distance from the edge of the stream to riparian buffer (m) ▪ Average absolute height of vegetation canopy (m) ▪ Average height of vegetation canopy with respect to the stream surface (m) ▪ Average canopy density (%)
Global solar radiation	Time series of daily global solar radiation at watershed location (Langleys) for entire simulation period

A.2.2.2 SHADE Model Methodology

SHADE computes a time-series of the effective solar radiation reaching the stream surface after accounting for the effects of riparian vegetation and topography. A detailed description of the SHADE model can be found in the paper *Streams Temperature Simulation of Forested Riparian Areas*: I. Watershed-Scale Model Development (Chen et.al.,1998a). The methodology employed in SHADE is summarized below:

1. A watershed's location is determined by latitude and longitude. The latitude is used to compute the solar path (the sun's position over the day defined by two angles: the solar altitude and the solar zenith) and half-day length at a location. The longitude and standard meridian where the watershed time zone is centered is used to convert standard time to local time in the watershed.

2. The daily global radiation is disaggregated into hourly direct-beam and diffuse radiation based on the watershed latitude using a number of theoretical considerations and empirical relationships.

3. Using an hourly time step, the topographic and vegetation shading effects on direct-beam radiation are computed from sunrise to sunset by relating the solar path geometry to shade angles provided by the topography and vegetation. Computations are performed at every SSP. The final direct-beam radiation with shading effects is calculated as a function of the stream width.

4. Shading effects on diffuse radiation are assumed to be controlled by sky openness (the fraction of the sky not blocked by riparian vegetation or topography), which is considered constant over time and estimated at each SSP from topographic and vegetation shade angles.

5. Direct-beam and diffuse radiation are further reduced by the albedo (reflectivity) of the moving water surface. The albedo of direct-beam radiation is assumed to be a function of the solar zenith angle, while a constant value is assumed for diffuse radiation albedo.

6. Direct-beam and diffuse radiation are summed to obtain the effective solar radiation absorbed by the stream water at each SSP. The solar radiation factor (effective radiation for heating divided by the incoming radiation) is also computed at each SSP.

Using this methodology, the SHADE model can be used to evaluate various riparian management scenarios, such as logging and fire management.

A.2.2.3 SHADE Model Output and Post-Processing

SHADE calculates adjusted global solar radiation and a solar radiation factor, which are used by the Q2ESHADE model. These output parameters are described in Table A-10.

Table A-10. SHADE Model Output

Output Parameter	Description
Adjusted global solar radiation	Time series of hourly global solar radiation (Langleys) reaching the stream surface and available for elevating the stream temperature
Solar radiation factor	Ratio (dimensionless) of effective radiation for stream heating divided by the incoming radiation on the top of the channel valley

To evaluate data at each SSP, a post-processing tool was developed to generate a statistical summary of the maximum, minimum, and average shade attenuated solar radiation for the simulation period at each SSP. These values were then used to estimate the amount of effective shade at each SSP (i.e. the percent reduction in solar radiation after being attenuated by the topography and vegetation). Post-processing tools also calculated an average heat load for the entire watershed (Langley/day).

The output of the SHADE model can be evaluated independently or incorporated into the Q2ESHADE model to calculate stream temperatures, as described in Section A.3. The SHADE model output was directly evaluated for the main stem SHADE model (Table A-1). The results of this analysis and the associated scenarios are presented in Section A.4.1. In addition, the SHADE model output was incorporated into the Q2ESHADE model for further analyses in Larabee Creek and several creeks draining to Salt River (Table A-1). The Q2ESHADE methodology is described in Section A.3.

A.3 Q2ESHADE Model

A customized SHADE version of USEPA's QUAL2E (Brown, et. al., 1987) in-stream model was developed (Q2ESHADE) and applied to select reaches in the Larabee Creek and Salt River subwatersheds (Table A-1). The Q2ESHADE model uses all of the underlying algorithms of QUAL2E and is linked with the SHADE model. The Q2ESHADE enhancements provide interpretation of hourly solar radiation time series data from the SHADE GIS model output, as well as heat balance calculations. A preprocessor was developed to reformat SHADE hourly solar radiation data into a format that can be read by Q2ESHADE. The Q2ESHADE model along with its post-processing features and required data files are discussed below and illustrated in Figure A-13.

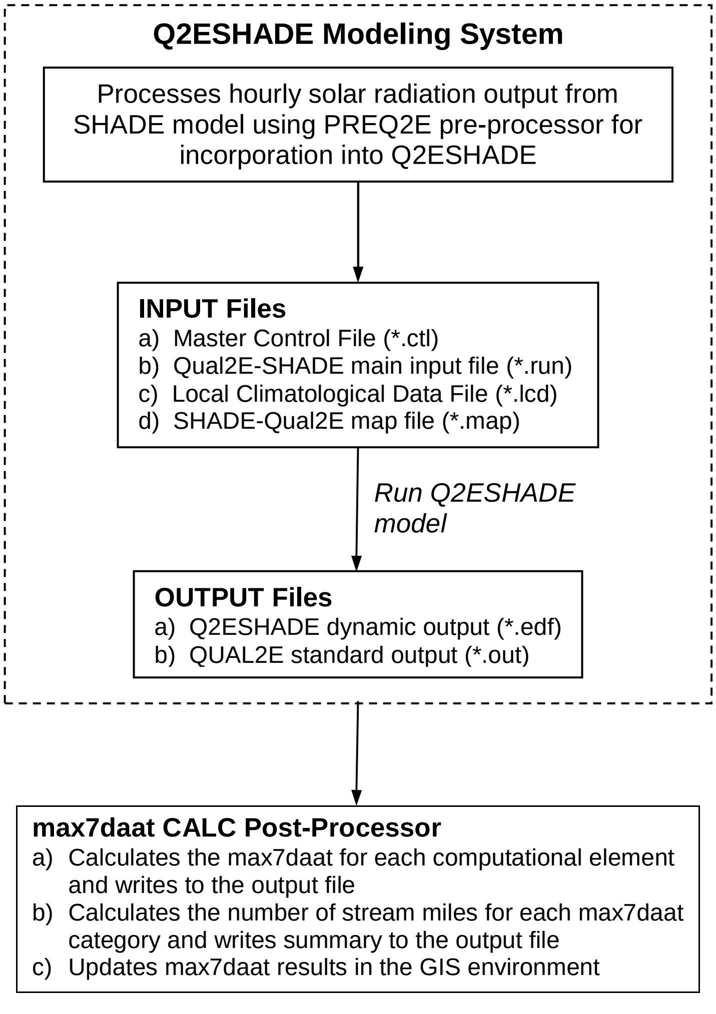

Figure A-13. Q2ESHADE model functionality

A.3.1 Q2ESHADE Development and Methodology

The Q2ESHADE model was used to predict in-stream temperatures for different segments throughout the model stream networks. The model is applicable to dendritic streams that are well mixed and assume a constant stream flow at the headwaters. Q2ESHADE is a one-dimensional model in which the main transport mechanisms are significant only in the major direction of flow. The highest temperature conditions are typically observed during low-flow periods and this model can be used for critical condition temperature modeling.

In Q2ESHADE, the stream is conceptualized as a series of computational elements (completely mixed batch reactors) that have the same hydrogeometric properties within a reach. Flow is routed via transport and dispersion mechanisms and mass balance is performed for the constituent of concern. A link is made with the SHADE model by keeping the computational element spacing identical to the SHADE SSP spacing.

Although the in-stream model algorithms are used to represent a single flow condition, the model can be operated quasi-dynamically to simulate temperature fluctuations. Based on available hourly local climatological data, the model can update the source/sink term for the heat balance over time. Therefore, the diurnal response of the steady-state hydraulic system to changing temperature conditions can be simulated.

For constant headwater inflows, the model can currently simulate temperature dynamically for a period of 31 days (744 hours). This limitation was stipulated because the model stores hourly solar radiation in memory for each computational element and the array size grows very large as the length of time modeled increases. One month was determined to be reasonable since the model is not dynamic with respect to flow. This time period appropriately represents the critical period (July 15, 2005 through August 14, 2005) with regard to temperature (constant low flow conditions).

A.3.2 Q2ESHADE Data Requirements

Q2ESHADE utilizes SHADE model output with channel hydraulics, stream temperature, and climatological data during its simulation process. These data sources are described below.

Channel Hydraulics

Because Q2ESHADE is a steady-state model, it requires a constant stream flow at all headwaters. Headwater flows were estimated using area-weighted averages based on discrete summertime flow measurements (CDFG, 1992a, 1992b, 1992c, 1992d, 2000a, 2000b, 2000c, 2000d, 2003a, 2003b, 2003c). Some of the headwater flows were adjusted during model calibration.

To describe the hydraulic characteristics of the system, the functional representation option within Q2ESHADE was used. This involved calculating the velocity and depth for the system using power equations. The power equations are in the form of $v = aQ^b$ and $d = cQ^d$; where:

v = velocity,
d = depth,
Q = flow,
a and c = coefficients, and
^{b} and ^{d} = exponents.

Coefficients a, c and exponents b, d were derived from different sources for the two Q2ESHADE study areas, as identified in Table A-11. Rating curves were established using these coefficients and exponents and were subsequently adjusted during model calibration to ensure that the range of summer base flow conditions were covered for all modeled watersheds.

Table A-11. Channel Hydraulics Information Sources

Study Area	Source of Channel Hydraulics Information
Larabee Creek	Flow and depth measurements from the CDFG Stream Inventory Reports (CDFG, 1992a, 1992b, 1992c, 1992d, 2000a, 2000b, 2000c, 2000d)
Creeks Draining to Salt River	Flow and depth measurements from the CDFG Stream Inventory Reports (CDFG, 2003a, 2003b, 2003c)

Climatological Data

The Q2ESHADE model requires time-series climatological data including atmospheric pressure, dry bulb temperature, wet bulb temperature, wind speed, and cloud cover data for simulating the diurnal variation in stream temperature. A complete dataset with hourly time-series data by month was available for the Arcata Eureka Airport, California weather station (ACV) in Arcata, California for the summer of 2005 from the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) (see Figure A-12 for a map of climatological stations) (NOAA-NCDC, 2006). This station is located approximately 42 miles (67.6 kilometers [km]) northwest of the Larabee Creek and 29 miles (46.7 km) north of the Salt River subwatersheds. Data from ACV were supplemented with more localized air temperature and wind speed data, where available (Table A-12).

To represent local conditions in Larabee Creek, local air temperature and wind speed data were used to replace some of the Arcata (ACV) NCDC climatological parameters (Table A-12). Specifically, air temperature data for the Larabee PALCO station, which is located in the most downstream Larabee subwatershed, were used to represent dry bulb temperature in the majority of the Larabee Creek reaches, while dry bulb temperatures from the Alder Point (ALD) CDEC station (Figure A-12) were used to represent the remaining upstream tributary reaches. Similarly, local wind data from the ALD station were used to represent wind speed. To further supplement the local weather data, wet bulb temperature was calculated based on the relative humidity, atmospheric pressure, and dry bulb temperature at ALD. These calculated data were used to replace the ACV wet bulb temperatures.

The ACV NCDC station was assumed to represent the Salt River subwatersheds well. No other meteorological stations with similar characteristics (i.e. heavily influenced by coastal fog) were available; therefore, no additional information was used to replace the data associated with the ACV station.

The Q2ESHADE model allows for the clear-sky solar radiation to be adjusted by the observed cloud cover. However, since solar radiation used in the SHADE model was cloud cover attenuated (and not clear sky), this option was disabled.

Table A-12. Local Weather Stations

Study Area	**Local Weather Station(s)***	**Data Included in Q2ESHADE Model (*to replace ACV values*)**
Larabee Creek	Larabee (PALCO station)	Dry Bulb Temperature
	Alder Springs (ALD) (CDEC station)	Dry Bulb Temperature Wind Speed Wet Bulb Temperature (calculated)
Creeks Draining to Salt River	none	none

*Station locations are illustrated in Figure A-12.

Headwater Temperatures

Similar to the channel hydraulics information, Q2ESHADE requires constant water temperatures at the headwaters. For the models of Larabee Creek and the creeks draining to Salt River, the headwater temperatures were estimated based on stream temperature or spring data presented in the applicable Stream Inventory Reports (CDFG, 1992a, 1992b, 1992c, 1992d, 2000a, 2000b, 2000c, 2000d, 2003a, 2003b, 2003c) and were adjusted during model calibration.

A.3.3 Q2ESHADE Model Output and Post-Processing

The Q2ESHADE model creates two output files: the Q2ESHADE dynamic output file (*.edf) and the QUAL2E standard model output (*.out). To evaluate the time series Q2ESHADE model output at each SSP, post-processors were developed to quantify and summarize the time series data for TMDL analysis (Figure A-13).

The post-processors read the output data and then generate the max7daat during the critical period at each SSP. In addition to producing max7daat values, the stream mileage associated with different stream temperature categories is calculated. These categories include: Good <15^{o}C, Fair 15^{o}C – 16.99^{o}C, Marginal 17^{o}C – 18.99^{o}C, Stressful 19^{o}C – 23.99^{o}C, and Lethal Conditions >24^{o}C.

The output of the Q2ESHADE model was evaluated for Larabee Creek and several creeks draining to Salt River (Table A-1). The results of these analyses and their associated scenarios are presented in Sections A.4.2 and A.4.3, respectively.

A.4 Model Calibration and Scenarios

After the SHADE and Q2ESHADE models were configured, model simulations were performed for baseline conditions (described in Sections A.2.1.1, A.2.1.2, A.2.2.1, and A.3.2), which were used for calibrating the Q2ESHADE models, and several different vegetation scenarios. SHADE and Q2ESHADE can be used to perform scenarios to quantify the change to stream shading and/or in-stream temperature. Specifically, SHADE parameters were modified to simulate several vegetation-specific scenarios, which are described below.

The SHADE model allows the user to simulate changes to stream shading and in-stream temperatures by altering the vegetation characteristics. Scenarios varying the DBH and resulting tree height conditions were simulated for the main stem SHADE model, Larabee Creek, and several creeks draining to Salt River. The six vegetation scenarios are: no vegetation (topographic shading only), 18 inch DBH, 24 inch DBH, 48 inch DBH, 60 inch DBH, and historical riparian vegetation with 60 inch DBH trees. Table A-13 identifies the DBH and vegetation heights associated with each vegetation scenario for all three study areas. The process used to determine tree height is described below:

- Conifer and hardwood heights associated with each scenario were calculated by changing the DBH in Equation 1.
- Shrub and herbaceous heights remained unchanged from baseline conditions, except for the no vegetation (topographic shading only) and historical riparian vegetation scenarios.
- The heights presented in Table A-13 were assigned to all respective vegetation types, regardless of seral stage in the watershed.
- Tree density remained unchanged from baseline conditions.

Table A-13. Tree Heights Associated with Vegetation Scenarios

Study Area	Scenario Name	Conifer Height	Hardwood Height	Shrub Height	Herbaceous Height
Main Stem SHADE Model	No Vegetation (Topographic Shading Only)	0 meters (0 feet)	0 meters (0 feet)	0 meters (0 feet)	0 meters (0 feet)
	Private Land Management with 18 inch (45.7 cm) DBH	28.08 meters (92.10 feet)	14.89 meters (48.84 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Private Land Management with 24 inch (61 cm) DBH	33.82 meters (110.93 feet)	15.17 meters (49.76 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Natural Vegetation (48 inch [121.9 cm] DBH)	48.63 meters (159.51 feet)	15.24 meters (49.99 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Natural Vegetation (60 inch [152.4 cm] DBH)	52.94 meters (173.64 feet)	15.24 meters (49.99 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)

Study Area	Scenario Name	Conifer Height	Hardwood Height	Shrub Height	Herbaceous Height
Larabee Creek	No Vegetation (Topographic Shading Only)	0 meters (0 feet)	0 meters (0 feet)	0 meters (0 feet)	0 meters (0 feet)
	Private Land Management with 18 inch (45.7 cm) DBH	28.08 meters (92.10 feet)	22.30 meters (73.14 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Private Land Management with 24 inch (61 cm) DBH	33.82 meters (110.93 feet)	25.31 meters (83.02 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Natural Vegetation (48 inch [121.9 cm] DBH)	48.63 meters (159.51 feet)	30.22 meters (99.12 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Natural Vegetation (60 inch [152.4 cm] DBH)	52.94 meters (173.64 feet)	30.91 meters (101.38 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Historical Riparian Vegetation (with 60 inch [152.4 cm] DBH trees)	52.94 meters (173.64 feet)	30.91 meters (101.38 feet)	9.15 meters (30 feet)*	
Creeks Draining to Salt River	No Vegetation (Topographic Shading Only)	0 meters (0 feet)	0 meters (0 feet)	0 meters (0 feet)	0 meters (0 feet)
	Private Land Management with 18 inch (45.7 cm) DBH	29.66 meters (97.28 feet)	22.51 meters (73.83 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Private Land Management with 24 inch (61 cm) DBH	35.60 meters (116.77 feet)	23.18 meters (76.03 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Natural Vegetation (48 inch [121.9 cm] DBH)	49.44 meters (162.16 feet)	23.54 meters (77.21 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Natural Vegetation (60 inch [152.4 cm] DBH)	52.85 meters (173.35 feet)	23.54 meters (77.21 feet)	1 meter (3.3 feet)	0.5 meter (1.6 feet)
	Historical Riparian Vegetation (with 60 inch [152.4 cm] DBH trees)	52.85 meters (173.35 feet)	23.54 meters (77.21 feet)	9.15 meters (30 feet)*	

*Agricultural and urban vegetation heights were also assigned a value of 9.15 meters (30 feet).

Table A-1 identifies the model and scenario types for each study area. Model calibration (for the Q2ESHADE models), baseline results, and scenario results for the main stem SHADE model, Larabee Creek, and several creeks draining to Salt River are presented in Sections A.4.1, A.4.2, and A.4.3, respectively.

A.4.1 Main Stem SHADE Model

As shown in Table A-1, the SHADE model was run for the entire main stem of the LER. Subsequent to the initial model run using the baseline conditions described in Sections A.2.1.1, A.2.1.2, and A.2.2.1, five vegetation scenarios were simulated: no vegetation (topographic shading only), 18 inch DBH, 24 inch DBH, 48 inch DBH, and 60 inch DBH (Table A-13).

Table A-14 presents the average percent shading and solar radiation results for the vegetation scenarios compared to baseline conditions for the main stem SHADE model. Figure A-14 presents the percent average shading associated with baseline conditions (see Sections A.2.1.1, A.2.1.2, and A.2.2.1) for the main stem, while Figure A-15 through Figure A-19 illustrate the percent average shading at each SSP for the five vegetations scenarios described above (Table A-13). As expected, the percent average shading for the vegetation scenarios do not vary significantly from baseline conditions because the LER main stem is very wide for much of its length, so tree height has a smaller impact on shading than overall topographic shading (which is impacted by both topography and land use) and stream orientation. When comparing the vegetation scenario results (Figure A-15 through Figure A-19) with the baseline conditions (Figure A-14), there are rarely any percent average shading changes along the last half of the main stem (most downstream). This is caused by a shift in land use from mostly forest to mostly agriculture (Figure A-4) in addition to increased stream widths.

Table A-14. Model Results for the Main Stem SHADE Model Vegetation Scenarios

Model Result	Baseline Conditions	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH
Percent Average Shading	18.9%	14.1%	17.8%	18.3%	19.3%	19.6%
Solar Radiation (Langley/day)	505.3	534.8	512.5	509.6	503.3	501.8

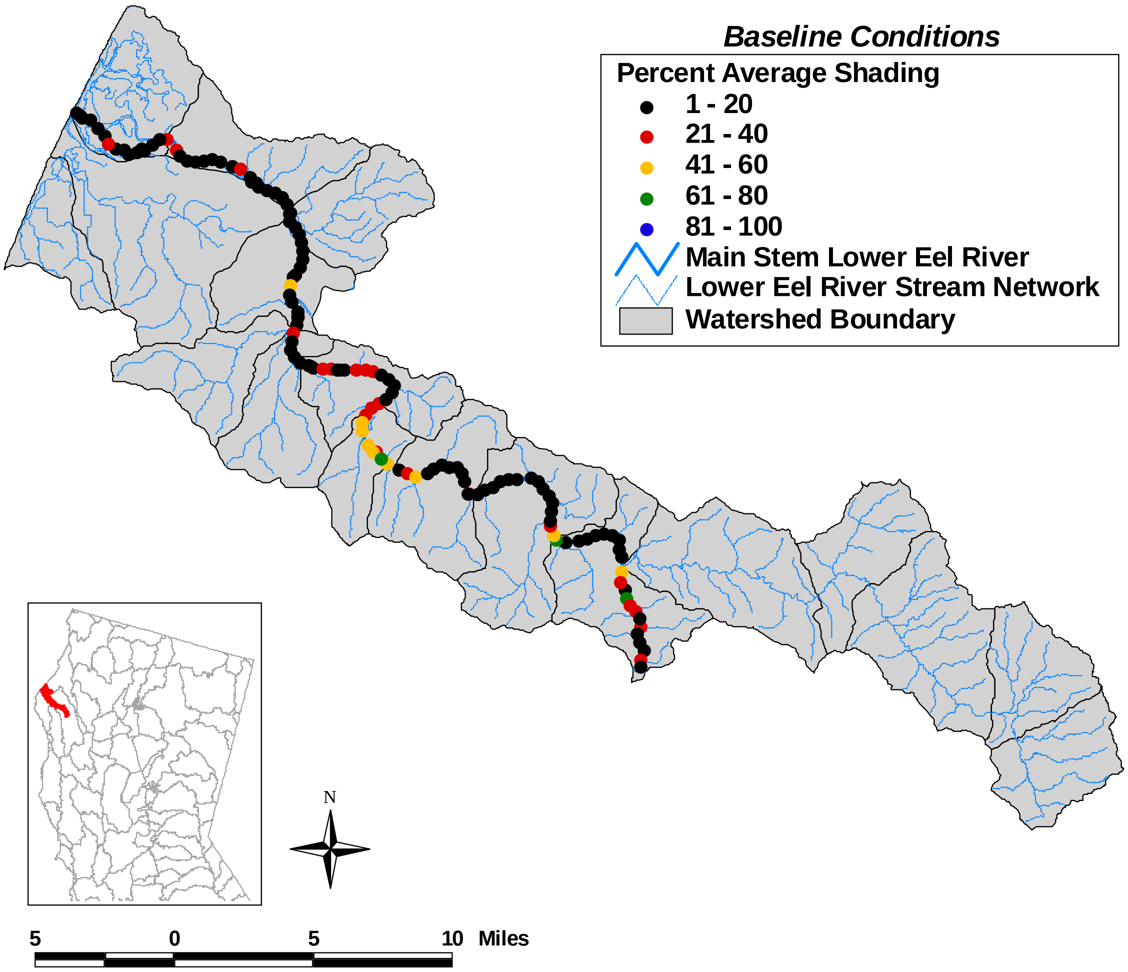

Figure A-14. Percent average shading for baseline conditions in the main stem SHADE model

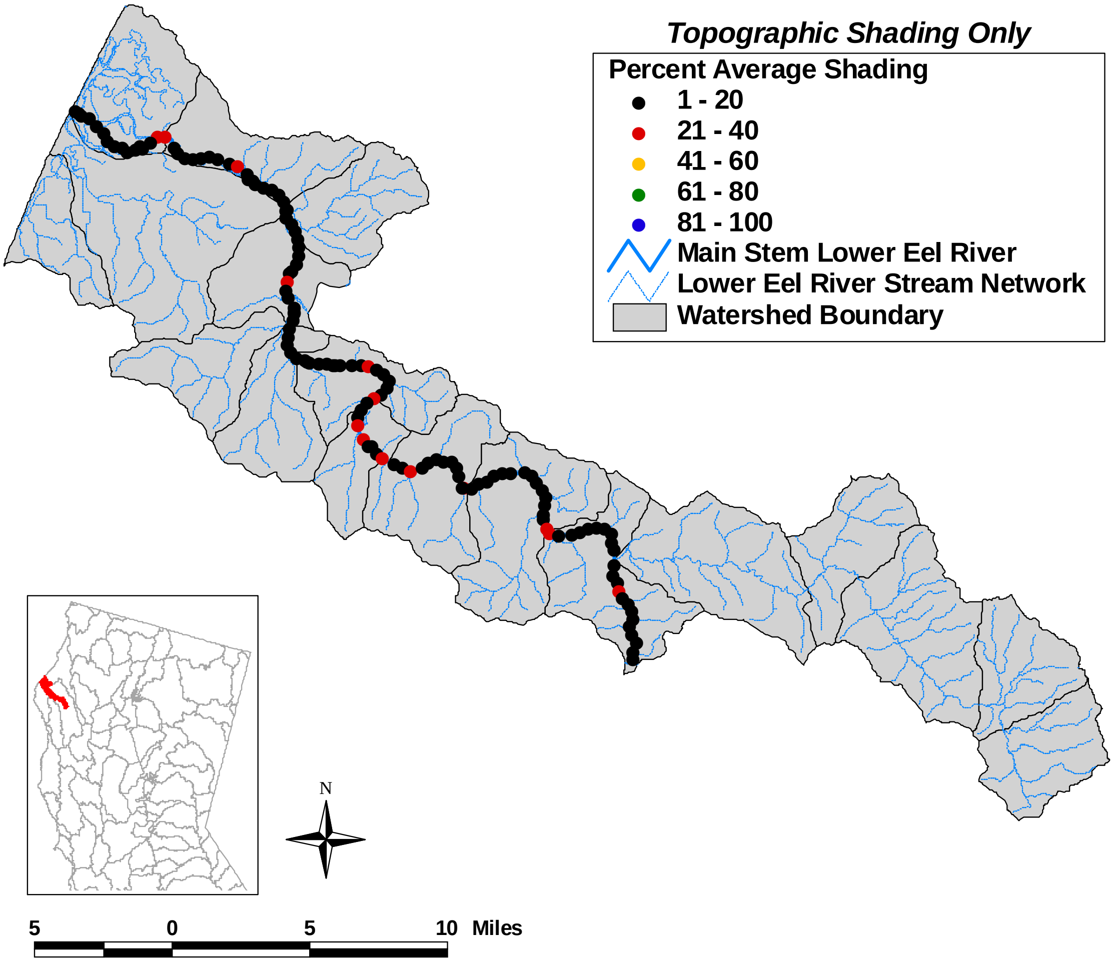

Figure A-15. Percent average shading for the topographic shading scenario for the main stem SHADE model

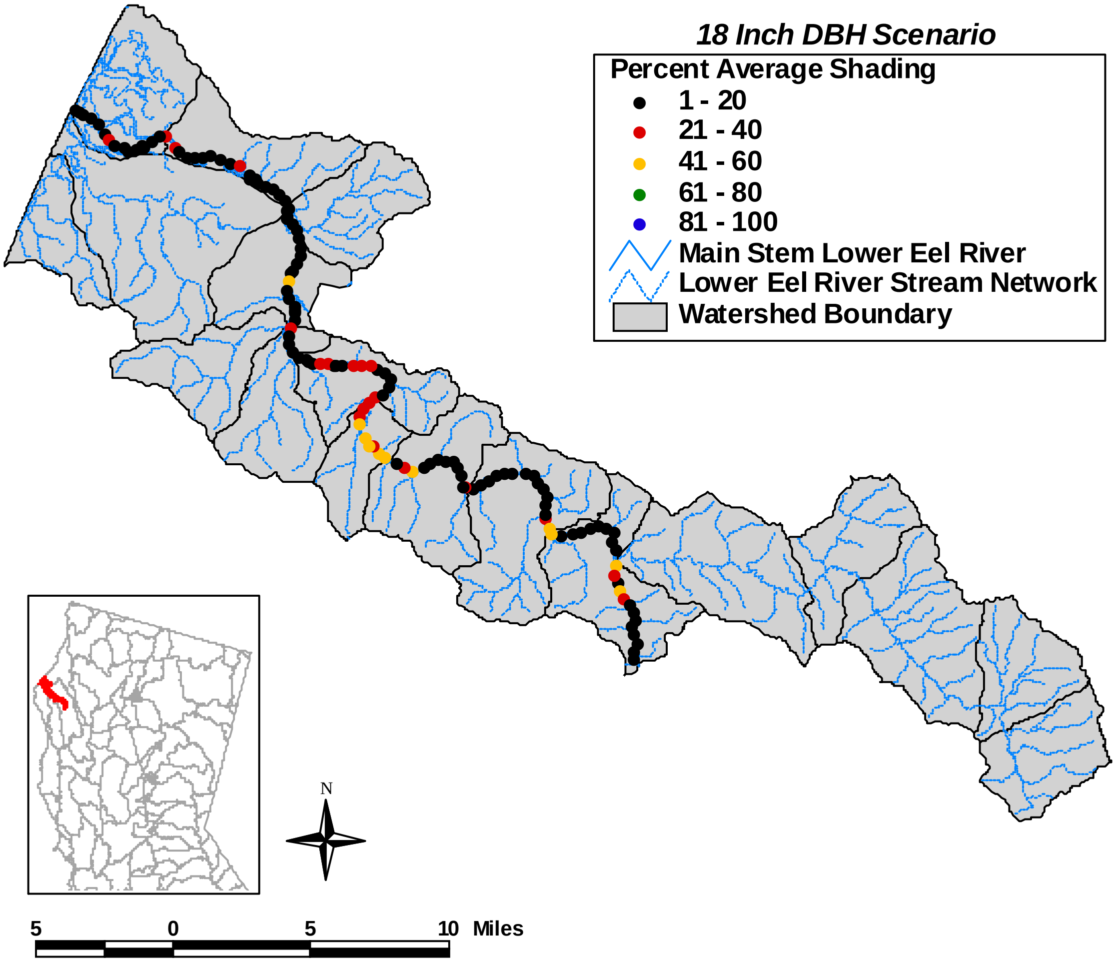

Figure A-16. Percent average shading for the 18 inch DBH vegetation scenario for the main stem SHADE model

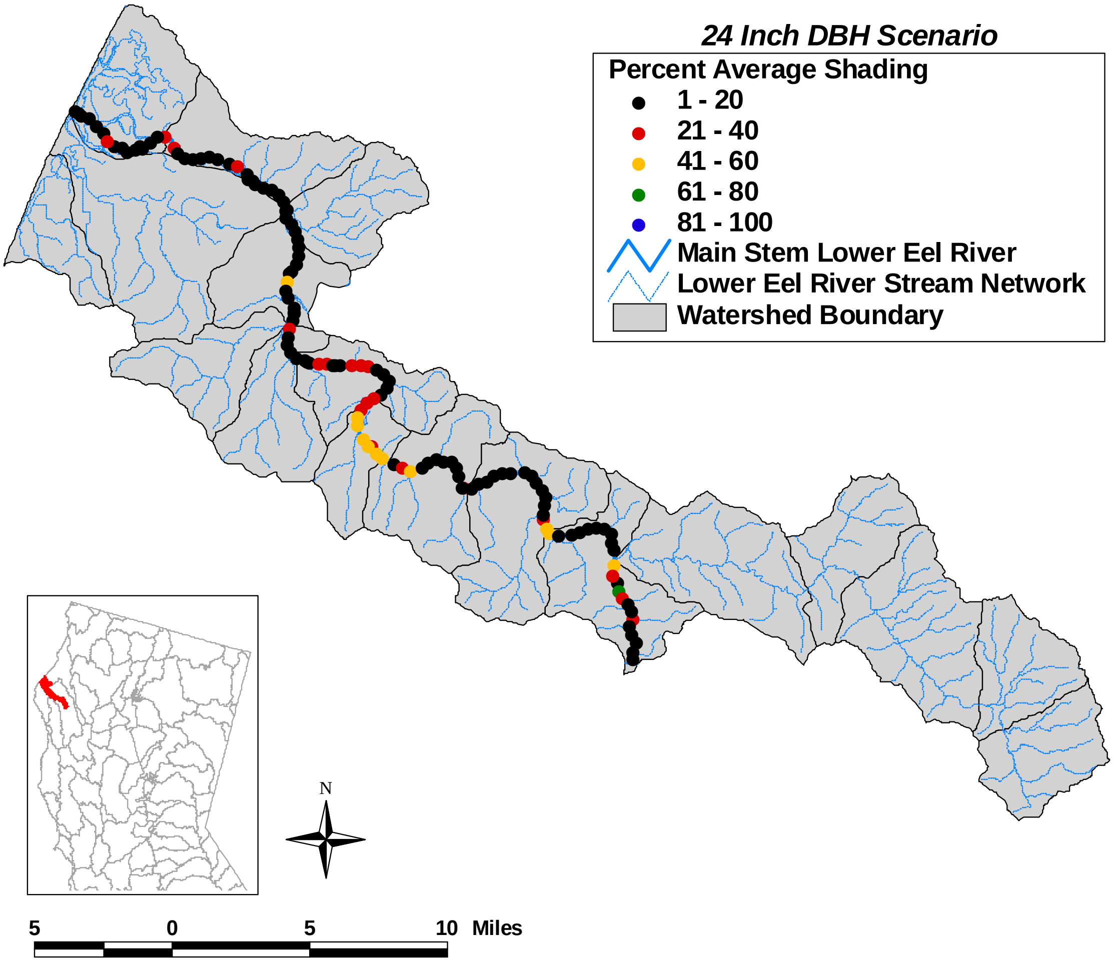

Figure A-17. Percent average shading for the 24 inch DBH vegetation scenario for the main stem SHADE model

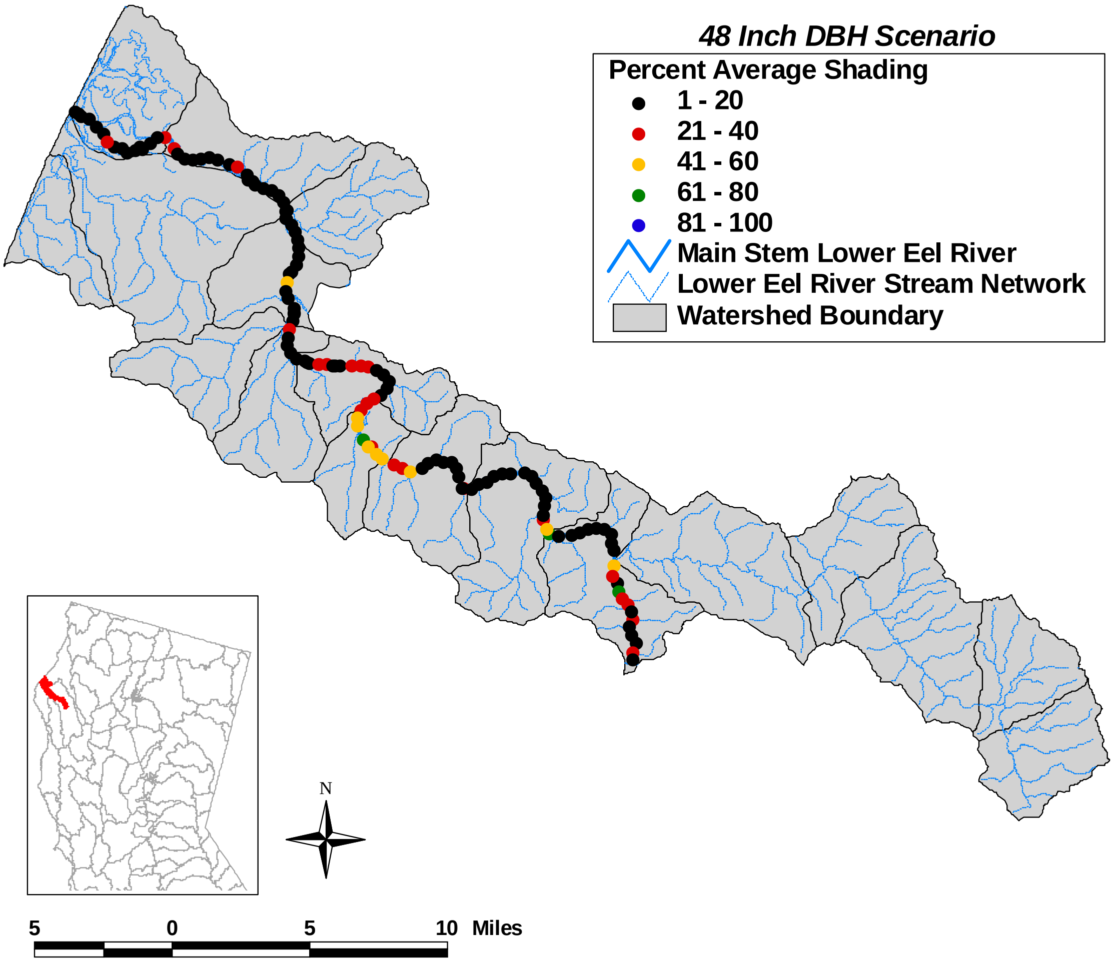

Figure A-18. Percent average shading for the 48 inch DBH vegetation scenario for the main stem SHADE model

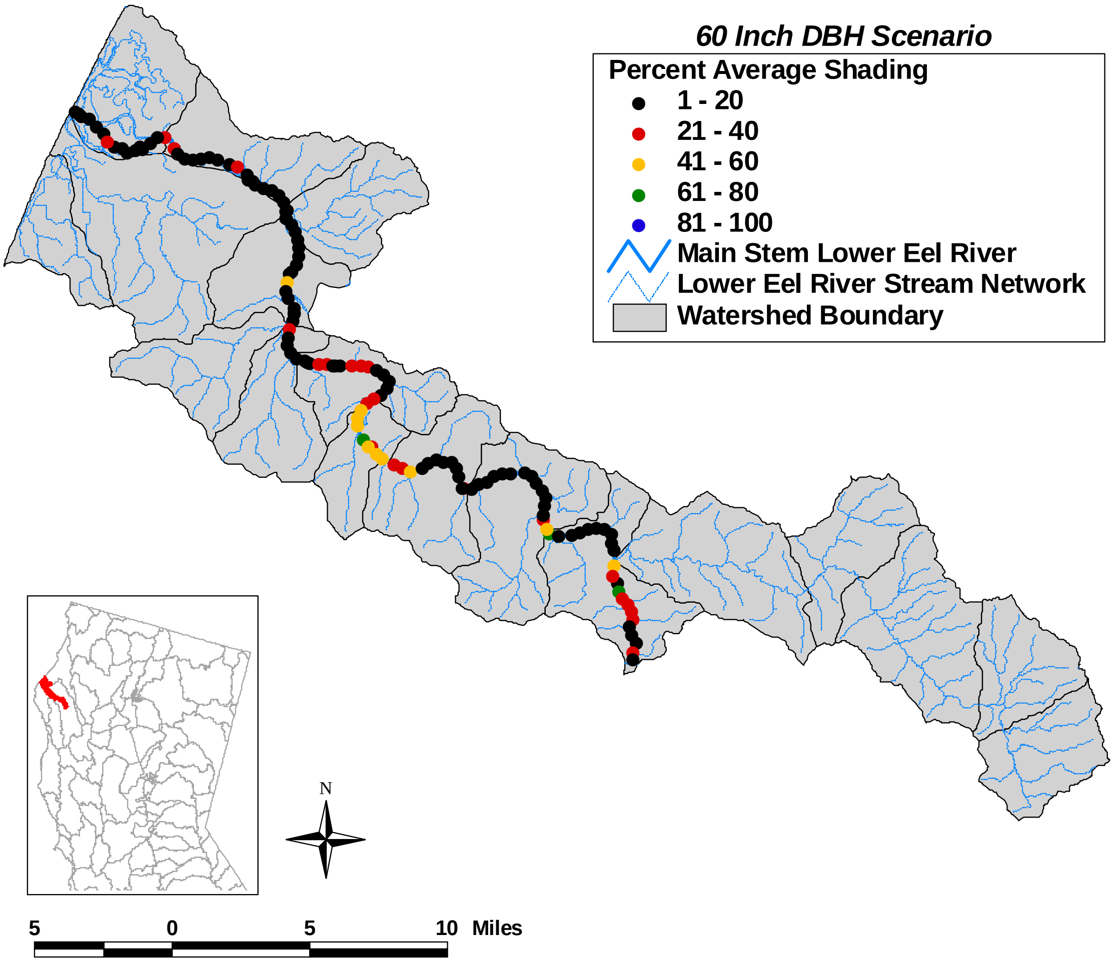

Figure A-19. Percent average shading for the 60 inch DBH vegetation scenario for the main stem SHADE model

In addition to the SHADE model simulations along the main stem, on August 12, 2005, a Thermal Infrared (TIR) Remote Sensing project was conducted on the LER (Watershed Sciences, 2005). The project mapped spatial temperature patterns along the main channel and illustrated the location of thermal influences such as tributaries and surface springs. The results from this study are provided in Figure A-20 and Figure A-21. Figure A-20 presents a spatially continuous longitudinal temperature profile and Figure A-21 is a map of the watershed with the temperatures along the main channel. This figure can be compared with the percent average shading along the main stem (Figure A-14) to characterize the relationship between shading on the main stem and stream temperature. In general, in areas with higher shading or just downstream of these areas, the stream temperatures temporarily decrease. This is particularly evident at the start of the LER, downstream of the confluence of the South Fork Eel River, and just past the middle of the length of the main stem (near mile 20). While these decreased temperatures may be due to higher shading, other factors such as tributary inputs or surface springs may also play a role.

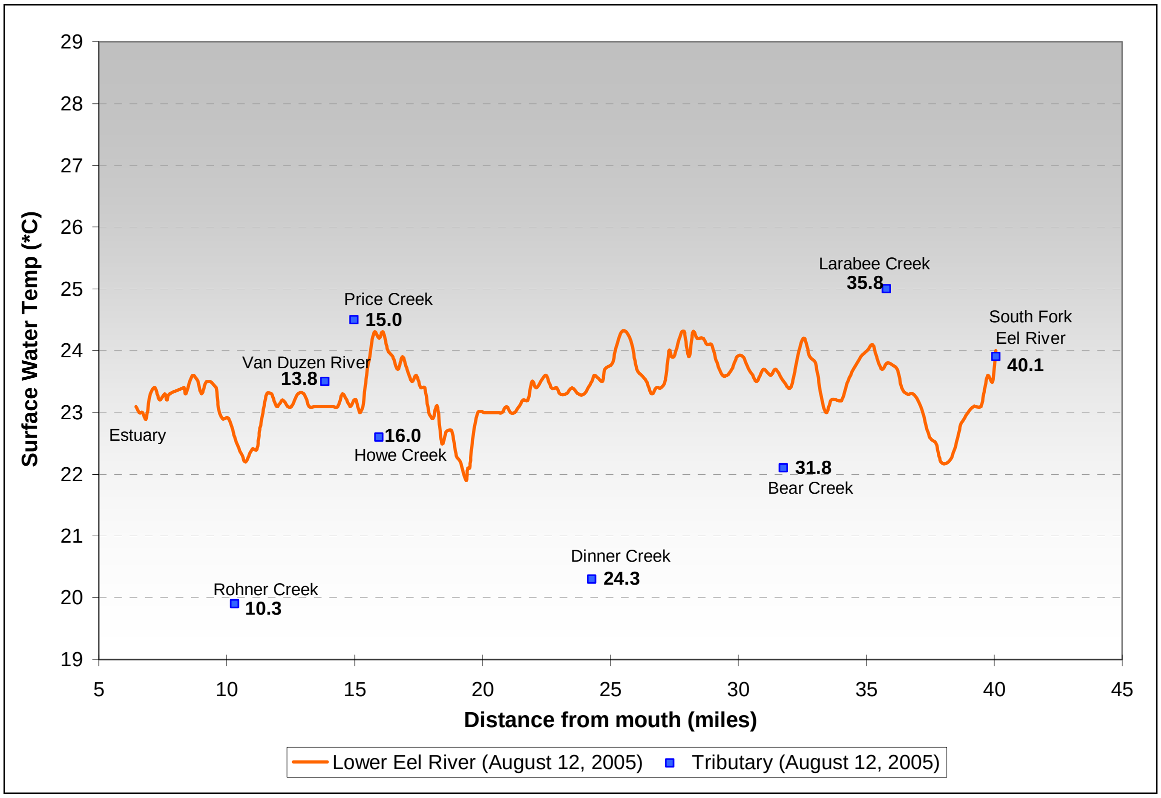

Figure A-20. Median stream temperatures measured by TIR on the main stem LER

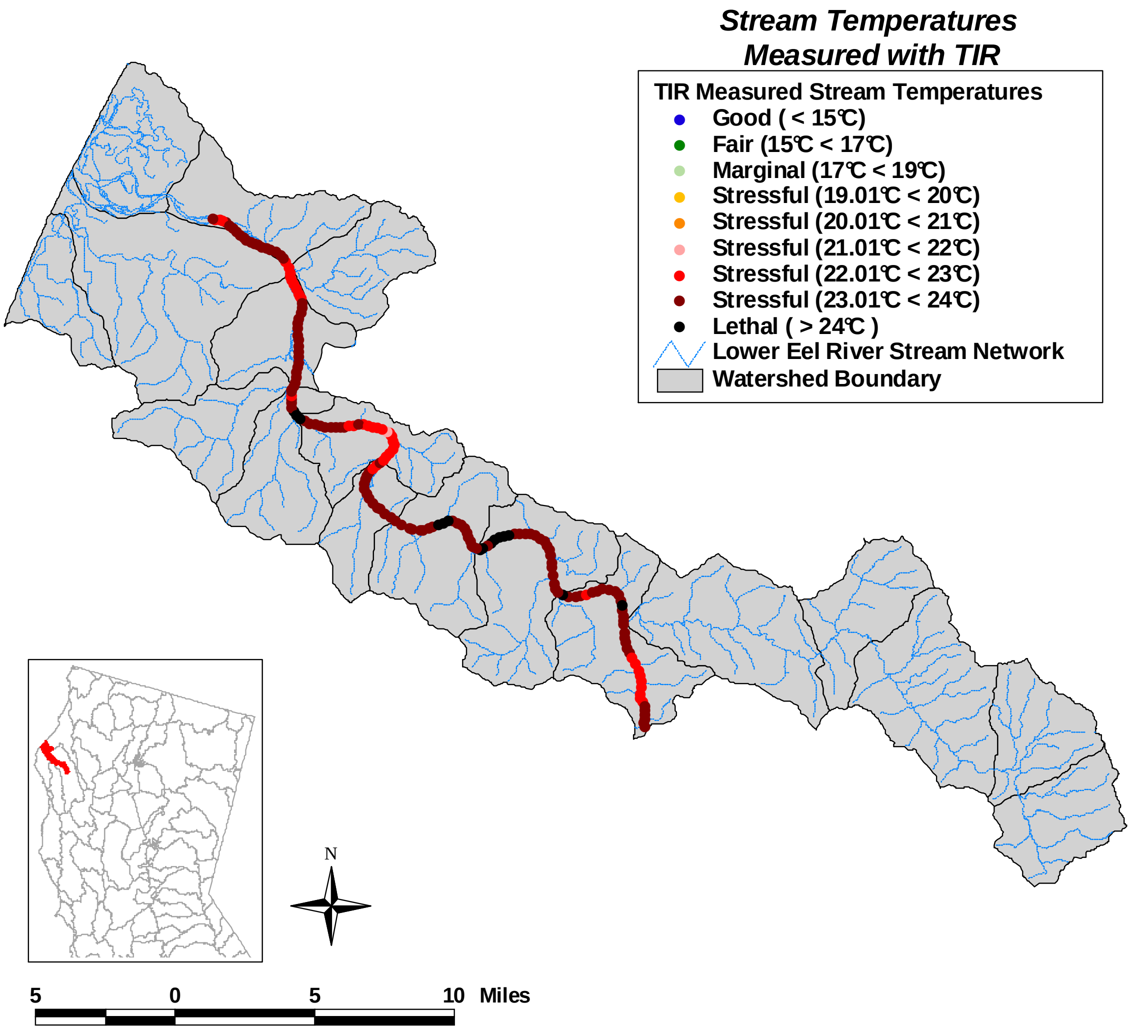

Figure A-21. Stream temperatures measured by TIR on the main stem LER

A.4.2 Q2ESHADE Model of Larabee Creek

As shown in Table A-1, the Q2SHADE model was run for the Larabee Creek stream network. Subsequent to the initial model run using the baseline conditions described in Sections A.2.1.1, A.2.1.2, A.2.2.1, and A.3.2, model calibration was performed. Model calibration included the adjustment of the baseline flow and temperature values, incorporation of springs or seeps, and modification of the channel hydraulic coefficients and exponents to match observed widths and depths. Specifically, overall flow was initially captured by contributions from the various tributaries based primarily on estimates from the SIRs and secondarily on a value of 0.15 cubic feet per second (cfs) or 0.0042 cubic meters per second (cms), which resulted in a general flow balance. During calibration, flows from the headwaters of the tributaries were reduced and small flows from various springs were included based on information provided in the SIRs. Other flow values were adjusted to closely match the observed data in the watershed. Initial temperature values were based on the average temperatures from the SIRs or a constant value of 17.0 degrees Celsius (degC) and were adjusted to closely match the observed temperature data at stations located throughout the watershed (CDFG, 1992a, 1992b, 1992c, 1992d, 2000a, 2000b, 2000c, 2000d). Table A-15 summarizes the initial and final boundary conditions (reach numbers are identified in Figure A-25).

Table A-15. Initial and Calibrated Flow and Temperature Boundary Conditions for the Larabee Creek Watershed

	Initial Conditions		Final Conditions	
Headwater Reach	**Flow (cms)**	**Temperature (degC)**	**Flow (cms)**	**Temperature (degC)**
Larabee Headwaters	0.1469	17.22	0.155	18.0
Reach 2	0.0042	17.0	0.0034	13.3
Reach 4	0.0042	17.0	0.0034	13.3
Reach 6	0.0042	17.0	0.0034	13.3
Bosworth Creek	0.0042	17.0	0.0034	13.3
Reach 10	0.0042	17.0	0.0034	13.3
Martin Creek	0.0045	13.97	0.0035	13.3
Reach 14	0.0042	17.0	0.0034	13.3
Frost Creek	0.0042	17.0	0.0034	13.3
Knack Creek	0.0062	13.97	0.0032	13.3
Mill Creek	0.0042	17.0	0.0034	13.3
Reach 22	0.0042	17.0	0.0034	13.3
Burr Creek 1	0.0042	17.0	0.0014	13.5
Little Burr Creek	0.0042	17.0	0.0014	13.5
Cold Creek	0.0042	17.0	0.0014	13.5
Reach 29	0.0042	17.0	0.0014	13.5
Reach 32	0.0042	17.0	0.0014	13.5
Reach 34	0.0042	17.0	0.0034	13.3
Maxwell Creek	0.0042	17.0	0.0034	13.3
Reach 38	0.0042	17.0	0.0034	13.3
Reach 40	0.0042	17.0	0.0034	13.3
Reach 42	0.0042	17.0	0.0034	13.3
Smith Creek	0.0042	17.0	0.0034	13.3
Arnold Creek	0.0042	14.96	0.0034	13.3
Scott Creek	0.0042	12.89	0.0022	13.75
Dauphiny Creek	0.0042	13.63	0.0022	13.75
Carson Creek	0.0042	14.54	0.0011	14.75
Balcom Creek	0.0042	14.25	0.0014	14.5
Reach 56	0.0042	17.0	0.0022	13.75
Chris Creek	0.0042	15.04	0.0006	15.0

Temperature monitoring data from PALCO were used for comparison with model results during calibration (PALCO, 2005). Nine stations were available in the Larabee Creek model subwatersheds (Figure A-22). Max7daats were calculated for the temperature monitoring data for July 15, 2005 through August 14, 2005 and were compared with the max7daats predicted by the model for the same time period. Model calibration results are presented in Table A-16. The average percent error was –1.24% (percent error ranged from –2.75% to 2.61%).

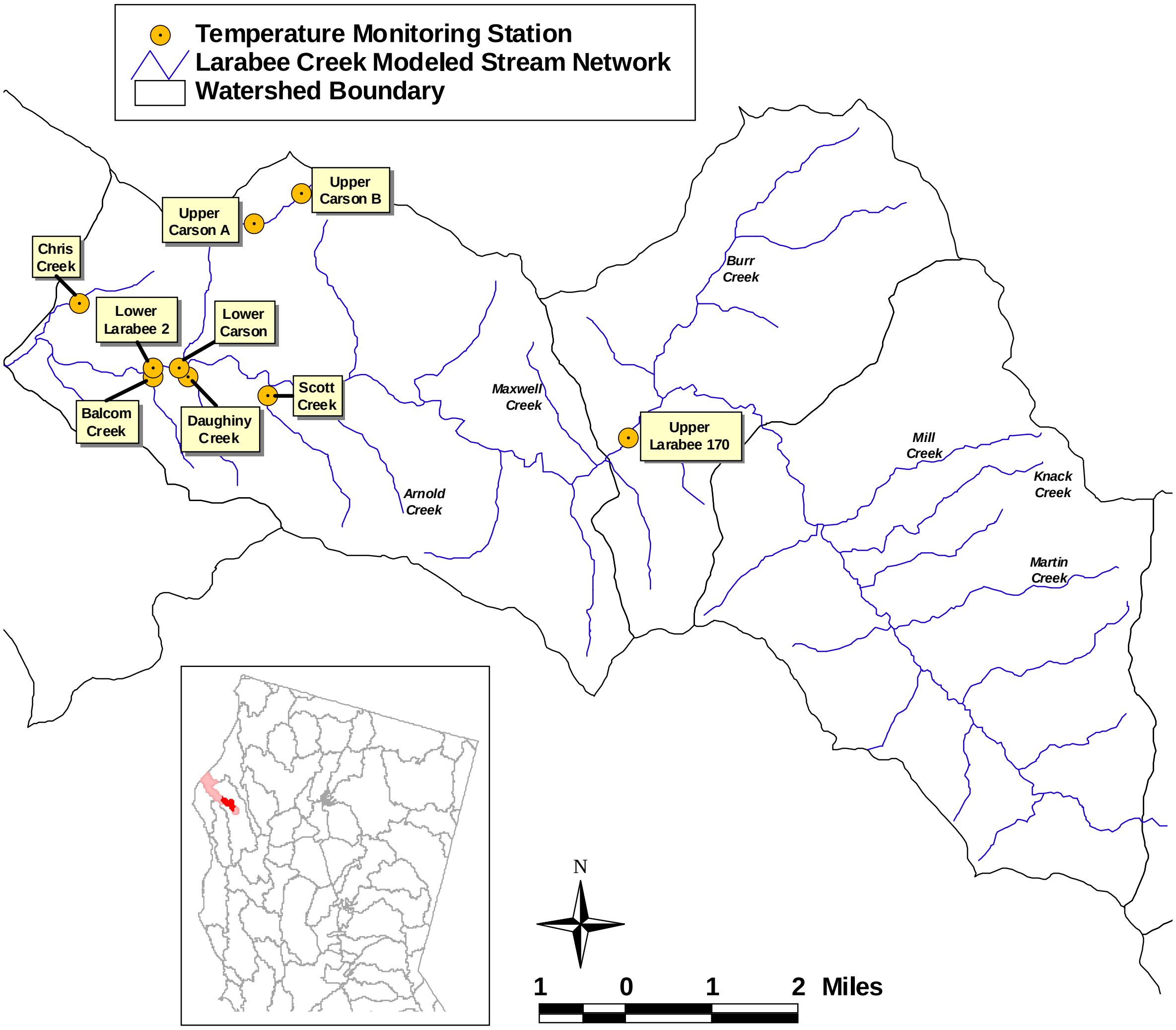

Figure A-22. Monitoring station used for calibration in the Larabee Creek model subwatersheds

Table A-16. Model Calibration Results for Stream Temperatures in Larabee Creek

Location	Observed Temperature max7daat (deg C)	Predicted Temperature max7daat (deg C)	Percent Error
Upper Larabee 170	21.61	21.39	-1.03%
Scott Creek	14.43	14.16	-1.85%
Daughiny Creek	14.14	13.91	-1.65%
Upper Carson B	15.25	15.08	-1.14%
Upper Carson A	14.62	15.00	2.61%
Lower Carson	15.67	15.26	-2.60%
Lower Larabee 2	21.54	21.27	-1.26%
Balcom Creek	14.95	14.73	-1.47%
Chris Creek	15.63	15.20	-2.75%

Table A-17 presents the number of stream miles associated with different max7daat categories, the solar radiation, and the average percent shade for baseline conditions in Larabee Creek. In addition, Figure A-23 and Figure A-24 illustrate the average percent shading and max7daat values for baseline conditions throughout the Larabee Creek subwatersheds. These results indicate that stream temperatures in the Larabee Creek stream network are generally in the good and fair temperature categories; however, 19% of the stream reaches have temperatures in the stressful category.

Table A-17. Baseline Model Results for Larabee Creek

Temperature Category	Larabee Creek	
	Stream Miles	% of Total
Good (max7daat < 15℃)	69.3	38%
Fair (15℃ < max7daat < 17℃)	28.9	16%
Marginal (17℃ < max7daat < 19℃)	15.2	8%
Stressful (19.1℃ < max7daat < 20℃)	5.9	3%
Stressful (20.1℃ < max7daat < 21℃)	15.2	8%
Stressful (21.1℃ < max7daat < 22℃)	14	8%
Stressful (22.1℃ < max7daat < 23℃)	0	0%
Stressful (23.1℃ < max7daat < 24℃)	0	0%
Lethal (max7daat > 24℃)	0	0%
TOTAL	183.6	100%
Solar Radiation (Langley/day)	143.3	
% Shade	79.5%	

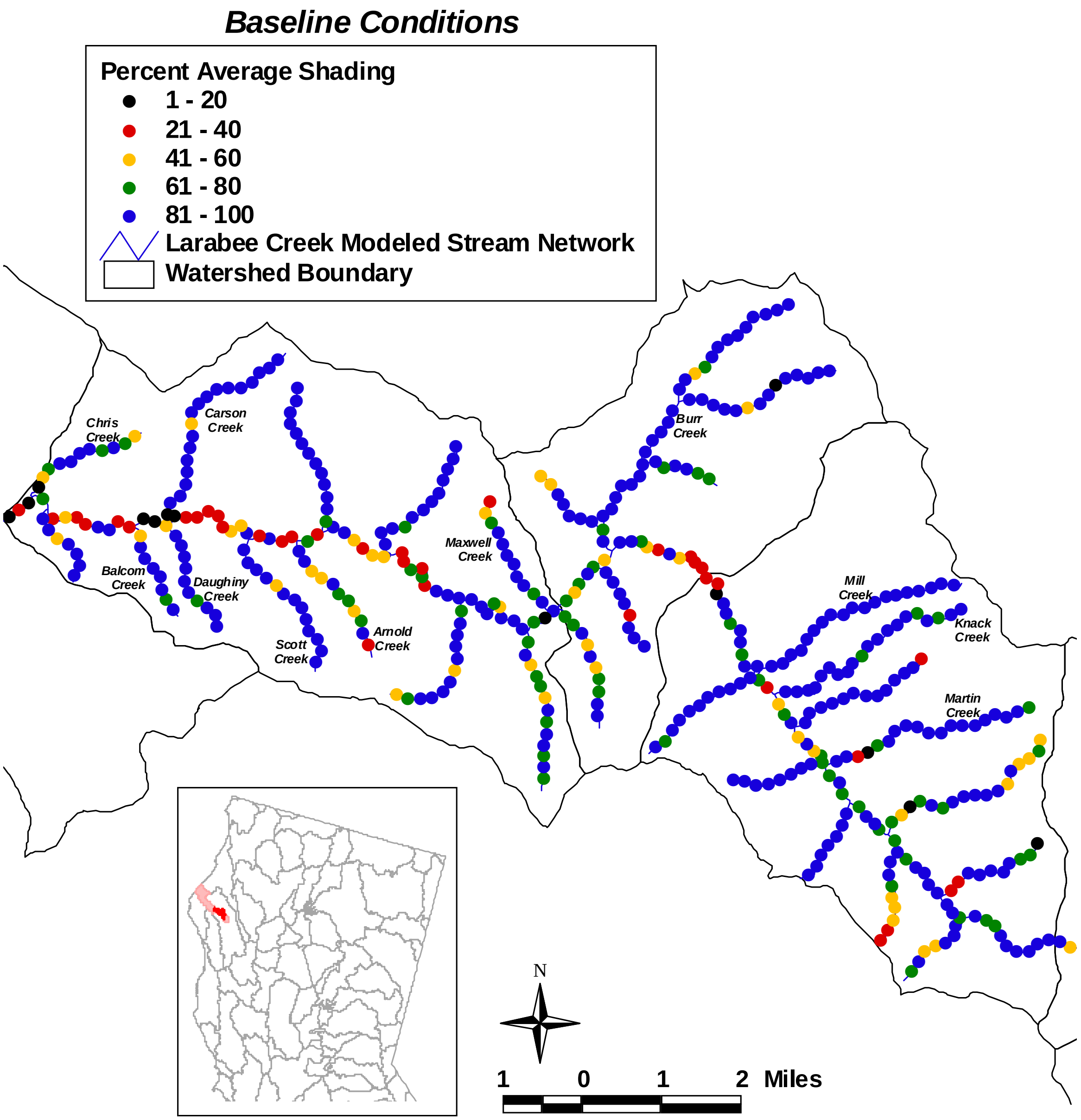

Figure A-23. Percent average shading for baseline conditions at Larabee Creek

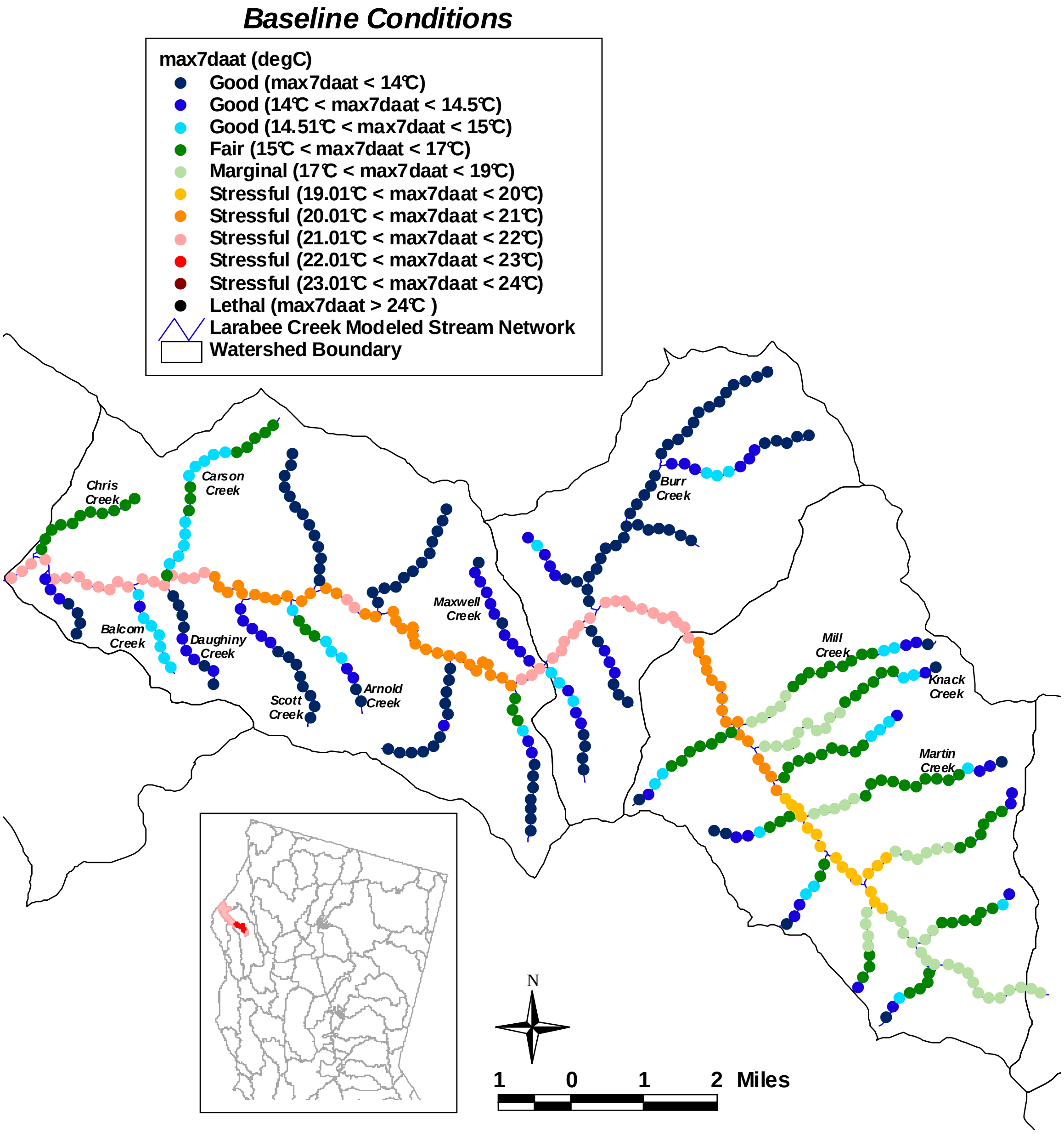

Figure A-24. Max7daat values for baseline conditions at Larabee Creek

Using the calibrated model, the six vegetation scenarios described in Section A.4 were simulated: no vegetation (topographic shading only), 18 inch DBH, 24 inch DBH, 48 inch DBH, 60 inch DBH, and historical riparian vegetation with 60 inch DBH trees (Table A-13). Table A-18and Table A-19 present model results for the vegetation scenarios for Larabee Creek, as compared to the baseline conditions. Table A-18 includes the stream miles associated with different max7daat categories, the solar radiation, and average percent shading, while Table A-19 identifies the specific max7daat value associated with each SSP throughout the Larabee Creek modeled stream network (see Figure A-25 for an illustration of the stream reach identification numbers). Figure A-26 illustrates the stream miles associated with each vegetation scenario and Figure A-27 graphically compares max7daats on the main channel of Larabee Creek for the baseline conditions and vegetation scenarios presented in Table A-19. Figure A-28 through Figure A-33 illustrate the average percent shading at each SSP for the vegetation scenarios described above (Table A-13).

Table A-18. Model Results for Vegetation Scenarios at Larabee Creek

Temperature Category	Baseline Conditions		Topo-graphic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH		60 Inch DBH		Historical Riparian Vegetation
	Stream Miles	% of Total	Stream Miles	Stream Miles	Stream Miles	Stream Miles	% of Total	Stream Miles	% of Total	Stream Miles
Good (max7daat < 15℃)	69.3	47%	10.6	63.4	70.8	71.5	48%	71.8	48%	72.4
Fair (15℃ < max7daat < 17℃)	28.9	19%	26.7	33.2	28.3	28.6	19%	28.3	19%	28.0
Marginal (17℃ < max7daat < 19℃)	15.2	10%	26.7	13.4	13.0	14.9	10%	15.2	10%	14.9
Stressful (19.1℃ < max7daat < 20℃)	5.9	4%	10.6	7.8	6.5	9.6	6%	15.2	10%	15.5
Stressful (20.1℃ < max7daat < 21℃)	15.2	10%	10.9	6.5	9.6	19.9	13%	14.6	10%	14.3
Stressful (21.1℃ < max7daat < 22℃)	14.0	9%	5.0	14.3	18.0	4.0	3%	3.4	2%	3.4
Stressful (22.1℃ < max7daat < 23℃)	0.0	0%	5.6	9.9	2.2	0.0	0%	0.0	0%	0.0
Stressful (23.1℃ < max7daat < 24℃)	0.0	0%	6.2	0.0	0.0	0.0	0%	0.0	0%	0.0
Lethal (max7daat > 24℃)	0.0	0%	46.3	0.0	0.0	0.0	0%	0.0	0%	0.0
TOTAL	148.5	100%	148.6	148.5	148.4	148.5	100%	148.5	100%	148.5
Solar Radiation (Langley/day)	143.3		589.6	166.8	144.7	126.2		124.6		118.3
% Shade	79.5%		17.2%	76.2%	79.3%	81.9%		82.1%		82.9%

Table A-19. Max7daat Values (degC) for Vegetation Scenarios at Each SSP in the Larabee Creek Model Subwatersheds

Q2ESHADE Identification Number	Reach Identification Number	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Historical Riparian Vegetation
1	1	18.24	18.37	18.25	18.25	18.23	18.23	18.23
2	1	18.25	18.73	18.28	18.27	18.24	18.24	18.24
3	1	18.29	19.09	18.38	18.35	18.30	18.30	18.30
4	1	18.36	19.44	18.46	18.43	18.36	18.35	18.35
5	1	18.40	19.77	18.52	18.47	18.39	18.38	18.38
6	1	18.43	20.10	18.56	18.51	18.41	18.40	18.40
7	1	18.49	20.43	18.64	18.57	18.46	18.45	18.45
8	1	18.54	20.75	18.73	18.65	18.53	18.51	18.51
9	1	18.65	21.04	18.89	18.81	18.66	18.64	18.64
10	1	18.76	21.35	19.04	18.95	18.78	18.77	18.77
11	1	18.78	21.65	19.06	18.97	18.80	18.78	18.78
12	2	13.90	14.45	13.90	13.90	13.90	13.90	13.90
13	2	14.16	15.49	14.14	14.15	14.17	14.17	14.17
14	2	14.82	16.51	14.81	14.81	14.91	14.92	14.92
15	2	15.60	17.50	15.61	15.59	15.69	15.69	15.69
16	2	15.74	18.41	15.75	15.73	15.82	15.83	15.83
17	2	16.02	19.31	16.04	16.01	16.09	16.09	16.09
18	2	16.28	20.09	16.33	16.28	16.34	16.34	16.34
19	3	18.80	21.81	19.10	18.99	18.80	18.78	18.78
20	3	18.85	22.08	19.14	19.02	18.83	18.80	18.80
21	3	18.89	22.34	19.19	19.07	18.87	18.84	18.84
22	4	14.43	14.53	14.43	14.43	14.43	14.43	13.97
23	4	15.00	15.60	15.00	15.01	15.02	15.02	14.58
24	4	15.44	16.62	15.43	15.45	15.47	15.47	15.12
25	4	15.56	17.59	15.55	15.56	15.58	15.66	15.36
26	4	15.70	18.48	15.76	15.78	15.79	15.80	15.51
27	4	15.98	19.37	15.98	15.98	16.04	16.04	15.77
28	4	16.17	20.22	16.18	16.17	16.23	16.23	15.97
29	4	16.37	21.05	16.47	16.45	16.41	16.41	16.16
30	4	17.25	21.85	17.35	17.34	17.29	17.29	16.90
31	4	18.02	22.61	18.13	18.11	18.05	18.04	17.67
32	5	18.90	22.48	19.20	19.08	18.87	18.85	18.84
33	5	18.95	22.68	19.24	19.10	18.89	18.86	18.85
34	5	18.98	22.87	19.28	19.14	18.91	18.88	18.87
35	5	19.00	23.06	19.31	19.16	18.93	18.90	18.89
36	5	19.08	23.24	19.40	19.26	19.00	18.97	18.96
37	6	14.38	14.54	14.39	14.39	14.38	14.38	14.06
38	6	15.42	15.69	15.43	15.42	15.41	15.40	14.83
39	6	16.04	16.70	16.12	16.11	16.09	16.09	15.54
40	6	16.65	17.63	16.74	16.71	16.70	16.69	16.17
41	6	17.18	18.61	17.27	17.25	17.23	17.23	16.66
42	6	17.60	19.45	17.67	17.66	17.59	17.59	17.06
43	6	17.64	20.19	17.73	17.71	17.63	17.62	17.12
44	6	17.68	20.90	17.78	17.75	17.66	17.65	17.18
45	7	19.10	23.24	19.41	19.26	19.00	18.97	18.95
46	7	19.22	23.34	19.52	19.36	19.08	19.04	19.02
47	8	14.02	14.52	14.15	14.08	13.97	13.97	13.89
48	8	14.47	15.56	14.71	14.56	14.38	14.38	14.30
49	8	15.07	16.58	15.11	14.91	14.65	14.65	14.58
50	8	15.71	17.61	15.75	15.46	15.04	15.03	14.96
51	8	15.92	18.50	15.95	15.65	15.22	15.21	15.22
52	8	16.46	19.33	16.49	16.15	15.67	15.67	15.67
53	8	16.71	20.13	16.74	16.38	15.89	15.89	15.89
54	8	16.95	20.87	17.05	16.66	16.19	16.18	16.19
55	8	17.03	21.61	17.14	16.77	16.30	16.30	16.30
56	8	17.26	22.35	17.31	16.95	16.57	16.57	16.57
57	8	17.41	23.05	17.48	17.12	16.75	16.74	16.74
58	8	17.67	23.67	17.91	17.49	17.04	17.04	17.04
59	8	17.73	24.27	17.98	17.57	17.13	17.12	17.12
60	8	18.08	24.89	18.46	18.00	17.51	17.51	17.51
61	8	19.03	25.52	19.39	18.96	18.48	18.48	17.72
62	8	19.57	26.13	19.92	19.41	18.76	18.76	18.04
63	8	19.82	26.66	20.15	19.61	18.91	18.91	18.23
64	9	19.31	23.51	19.61	19.44	19.14	19.10	19.07
65	9	19.35	23.66	19.66	19.49	19.18	19.14	19.11
66	9	19.42	23.81	19.73	19.55	19.23	19.19	19.16
67	9	19.51	23.95	19.82	19.64	19.31	19.26	19.24
68	10	13.77	14.46	13.75	13.76	13.77	13.77	13.77

Q2ESHADE Identification Number	Reach Identification Number	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Historical Riparian Vegetation
69	10	14.08	15.54	14.06	14.07	14.08	14.08	14.08
70	10	14.30	16.49	14.29	14.29	14.30	14.30	14.30
71	10	14.60	17.47	14.58	14.58	14.60	14.60	14.60
72	10	14.88	18.37	14.85	14.86	14.90	14.90	14.90
73	10	15.06	19.18	15.04	15.05	15.13	15.14	15.14
74	10	15.33	19.98	15.32	15.31	15.39	15.40	15.40
75	11	19.48	24.02	19.80	19.62	19.29	19.24	19.21
76	11	19.55	24.21	19.88	19.69	19.31	19.26	19.24
77	11	19.61	24.41	19.95	19.75	19.37	19.32	19.29
78	12	13.79	14.11	13.78	13.75	13.78	13.77	13.77
79	12	14.18	15.24	14.16	14.12	14.17	14.17	14.17
80	12	14.47	16.26	14.46	14.42	14.46	14.46	14.46
81	12	14.86	17.29	14.86	14.79	14.85	14.86	14.86
82	12	15.09	18.23	15.13	15.03	15.08	15.08	15.08
83	12	15.33	19.13	15.40	15.28	15.32	15.32	15.32
84	12	15.55	19.98	15.71	15.59	15.61	15.60	15.60
85	12	15.77	20.78	15.95	15.82	15.82	15.82	15.82
86	12	16.00	21.54	16.25	15.99	16.01	16.01	16.01
87	12	16.22	22.27	16.57	16.26	16.23	16.23	16.23
88	12	16.34	22.90	16.68	16.37	16.34	16.35	16.35
89	12	16.53	23.56	16.86	16.56	16.53	16.54	16.54
90	12	16.73	24.19	17.11	16.78	16.73	16.73	16.73
91	12	16.83	24.72	17.32	16.93	16.83	16.83	16.83
92	12	17.10	25.31	17.72	17.30	17.11	17.11	17.11
93	12	18.03	25.90	18.63	18.22	18.02	18.02	17.76
94	12	18.65	26.46	19.23	18.81	18.59	18.59	18.35
95	12	18.67	26.97	19.22	18.81	18.60	18.60	18.36
96	12	18.76	27.46	19.31	18.91	18.68	18.68	18.46
97	13	19.75	24.54	20.07	19.88	19.50	19.46	19.43
98	14	13.56	14.46	13.56	13.56	13.56	13.56	13.56
99	14	13.94	15.54	13.95	13.95	13.94	13.94	13.94
100	14	14.24	16.62	14.25	14.17	14.17	14.17	14.17
101	14	14.50	17.59	14.55	14.47	14.43	14.43	14.43
102	14	14.86	18.52	14.91	14.83	14.79	14.78	14.78
103	14	15.08	19.36	15.15	15.07	15.02	15.01	15.01
104	14	15.34	20.19	15.41	15.33	15.26	15.25	15.25
105	14	15.58	20.98	15.67	15.58	15.51	15.50	15.50
106	15	19.76	24.60	20.06	19.87	19.49	19.45	19.42
107	15	19.90	24.80	20.26	20.04	19.63	19.58	19.55
108	15	19.92	24.98	20.30	20.08	19.65	19.60	19.57
109	15	20.05	25.16	20.43	20.21	19.77	19.72	19.69
110	16	14.23	14.48	14.23	14.23	14.22	14.22	14.22
111	16	14.51	15.55	14.58	14.50	14.51	14.51	14.51
112	16	14.71	16.57	14.79	14.70	14.71	14.71	14.79
113	16	14.99	17.57	15.07	14.98	14.98	14.98	15.05
114	16	15.25	18.48	15.36	15.25	15.24	15.24	15.31
115	16	15.41	19.33	15.56	15.43	15.40	15.40	15.47
116	16	15.57	20.15	15.73	15.60	15.56	15.56	15.62
117	16	15.72	20.93	15.88	15.74	15.71	15.70	15.76
118	16	15.86	21.66	16.05	15.90	15.85	15.84	15.90
119	16	16.05	22.42	16.44	16.23	16.04	16.04	16.09
120	16	16.30	23.11	16.63	16.41	16.23	16.22	16.27
121	16	16.50	23.77	16.85	16.62	16.43	16.43	16.47
122	16	16.70	24.36	17.03	16.76	16.55	16.55	16.59
123	17	20.01	25.19	20.40	20.18	19.74	19.69	19.66
124	17	20.08	25.27	20.45	20.23	19.79	19.73	19.70
125	17	20.22	25.34	20.59	20.37	19.93	19.87	19.84
126	18	13.75	14.50	13.73	13.74	13.76	13.76	13.76
127	18	14.07	15.65	14.07	14.07	14.08	14.08	14.08
128	18	14.53	16.71	14.53	14.55	14.58	14.58	14.58
129	18	14.86	17.72	14.87	14.88	14.90	14.90	14.90
130	18	15.42	18.67	15.41	15.43	15.46	15.46	15.46
131	18	15.70	19.60	15.70	15.71	15.73	15.73	15.73
132	18	15.99	20.44	16.00	16.01	16.01	16.01	16.01
133	18	16.23	21.26	16.26	16.27	16.25	16.25	16.25
134	18	16.53	22.00	16.55	16.56	16.56	16.55	16.55
135	18	16.71	22.71	16.73	16.74	16.74	16.73	16.73
136	18	17.20	23.34	16.93	16.93	16.91	16.90	16.90
137	18	17.27	23.99	17.01	17.01	17.00	16.99	16.99
138	18	17.34	24.52	17.10	17.10	17.08	17.07	17.07
139	18	17.49	25.12	17.27	17.27	17.25	17.24	17.24
140	18	17.64	25.65	17.44	17.43	17.40	17.40	17.40

Q2ESHADE Identification Number	Reach Identification Number	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Historical Riparian Vegetation
141	18	17.76	26.20	17.60	17.58	17.54	17.53	17.53
142	18	17.90	26.69	17.75	17.72	17.69	17.68	17.68
143	18	18.02	27.22	17.90	17.86	17.82	17.81	17.81
144	18	18.07	27.72	17.95	17.92	17.88	17.87	17.87
145	18	18.12	28.18	18.02	17.98	17.94	17.93	17.93
146	19	20.31	25.39	20.66	20.45	20.02	19.96	19.93
147	19	20.35	25.42	20.69	20.48	20.06	19.99	19.97
148	20	13.81	14.52	13.73	13.73	13.73	13.73	13.73
149	20	14.12	15.65	14.06	14.05	14.04	14.04	14.04
150	20	14.40	16.68	14.35	14.34	14.33	14.33	14.33
151	20	14.60	17.60	14.56	14.55	14.54	14.53	14.62
152	20	14.99	18.52	15.04	14.95	14.94	14.94	15.02
153	20	15.39	19.42	15.49	15.34	15.36	15.37	15.44
154	20	15.55	20.26	15.73	15.57	15.52	15.52	15.59
155	20	15.85	21.09	16.05	15.88	15.82	15.83	15.89
156	20	16.06	21.84	16.28	16.09	16.03	16.03	16.09
157	20	16.25	22.56	16.48	16.29	16.22	16.22	16.28
158	20	16.36	23.20	16.61	16.41	16.34	16.34	16.39
159	20	16.48	23.85	16.78	16.57	16.45	16.45	16.50
160	20	16.65	24.45	16.89	16.68	16.63	16.62	16.67
161	20	16.84	25.06	17.20	16.93	16.81	16.81	16.86
162	20	17.04	25.63	17.50	17.19	17.00	16.99	17.04
163	20	17.21	26.16	17.72	17.36	17.17	17.16	17.21
164	20	17.29	26.68	17.78	17.43	17.25	17.25	17.29
165	20	17.37	27.17	17.90	17.54	17.33	17.33	17.37
166	20	17.61	27.66	18.08	17.72	17.57	17.56	17.60
167	21	20.37	25.49	20.67	20.46	20.04	19.98	19.95
168	22	13.71	14.46	13.80	13.72	13.72	13.72	13.72
169	22	14.23	15.56	14.41	14.25	14.24	14.24	14.24
170	22	14.56	16.57	14.81	14.60	14.57	14.56	14.56
171	22	14.92	17.46	15.21	14.95	14.93	14.92	14.92
172	22	15.18	18.42	15.62	15.31	15.25	15.25	15.25
173	22	15.56	19.26	15.90	15.54	15.48	15.47	15.47
174	22	15.71	20.05	16.06	15.70	15.63	15.63	15.63
175	22	15.97	20.85	16.37	15.96	15.91	15.91	15.91
176	22	16.15	21.54	16.53	16.13	16.10	16.10	16.10
177	22	16.35	22.23	16.72	16.33	16.29	16.29	16.29
178	22	16.64	22.90	17.11	16.67	16.54	16.54	16.54
179	23	20.34	25.55	20.65	20.43	20.00	19.94	19.92
180	23	20.40	25.69	20.73	20.50	20.04	19.98	19.96
181	23	20.41	25.83	20.75	20.51	20.04	19.97	19.95
182	23	20.43	25.96	20.79	20.55	20.07	19.99	19.97
183	23	20.52	26.10	20.88	20.64	20.14	20.07	20.05
184	23	20.54	26.23	20.89	20.64	20.15	20.07	20.06
185	23	20.58	26.36	20.94	20.69	20.18	20.11	20.09
186	23	20.79	26.51	21.15	20.91	20.40	20.32	20.25
187	23	20.97	26.65	21.34	21.09	20.58	20.50	20.43
188	23	21.15	26.78	21.53	21.28	20.76	20.68	20.61
189	23	21.33	26.92	21.71	21.46	20.93	20.85	20.78
190	23	21.48	27.05	21.84	21.59	21.06	20.98	20.91
191	23	21.61	27.17	21.97	21.72	21.19	21.11	21.04
192	23	21.73	27.30	22.11	21.85	21.29	21.20	21.13
193	23	21.74	27.43	22.14	21.87	21.30	21.21	21.16
194	23	21.88	27.55	22.29	22.02	21.44	21.35	21.30
195	23	21.95	27.67	22.36	22.09	21.50	21.41	21.36
196	23	21.98	27.78	22.39	22.11	21.52	21.42	21.37
197	23	21.97	27.89	22.38	22.10	21.51	21.41	21.36
198	23	21.97	28.01	22.40	22.11	21.51	21.42	21.37
199	24	13.38	14.74	13.39	13.39	13.38	13.38	13.38
200	24	13.27	15.9	13.29	13.28	13.27	13.27	13.27
201	24	13.07	16.96	13.09	13.08	13.07	13.07	13.07
202	24	12.88	18.01	12.98	12.96	12.88	12.88	12.89
203	24	12.76	18.93	12.82	12.8	12.75	12.76	12.84
204	24	12.75	19.84	12.94	12.84	12.75	12.75	12.85
205	24	12.84	20.71	13.15	12.93	12.84	12.85	13.03
206	24	12.82	21.52	13.14	12.79	12.76	12.78	12.94
207	24	12.85	22.25	13.14	12.85	12.67	12.68	12.84
208	24	13.06	22.95	13.32	13.04	12.91	12.92	13.06
209	24	13.72	23.61	13.96	13.6	13.57	13.58	13.72
210	24	13.68	24.28	14.01	13.55	13.56	13.57	13.7
211	24	13.55	24.84	13.87	13.43	13.42	13.43	13.56
212	25	13.41	14.83	13.46	13.43	13.41	13.4	13.4

Q2ESHADE Identification Number	Reach Identification Number	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Historical Riparian Vegetation
213	25	13.42	16.08	13.46	13.44	13.39	13.4	13.4
214	25	13.4	17.24	13.49	13.44	13.34	13.34	13.34
215	25	13.19	18.23	13.27	13.22	13.14	13.15	13.15
216	25	13.17	19.23	13.32	13.18	13.13	13.14	13.14
217	25	14.41	20.21	14.57	14.42	14.37	14.38	13.37
218	25	14.34	20.96	14.53	14.26	14.33	14.34	13.38
219	25	14.24	21.7	14.51	14.14	14.24	14.25	13.34
220	25	14.95	22.46	15.3	14.89	14.91	14.93	14.07
221	25	14.79	23.12	15.22	14.72	14.78	14.8	13.98
222	25	14.58	23.74	15.03	14.48	14.57	14.59	13.82
223	25	14.41	24.4	14.86	14.32	14.4	14.42	13.68
224	25	14.25	25.04	14.74	14.17	14.24	14.26	13.56
225	25	14.02	25.62	14.5	13.94	14	14.02	13.35
226	26	13.68	25.53	14.11	13.63	13.61	13.63	13.36
227	26	13.55	25.88	14	13.51	13.49	13.5	13.31
228	26	13.6	26.23	14.03	13.44	13.43	13.45	13.26
229	26	13.56	26.58	14.07	13.4	13.4	13.42	13.24
230	26	13.55	26.93	14.23	13.47	13.47	13.49	13.32
231	27	13.75	14.75	13.76	13.63	13.77	13.77	13.77
232	27	13.99	15.94	14.01	13.77	14.02	14.03	14.03
233	27	13.76	17.06	13.78	13.55	13.79	13.8	13.8
234	27	13.64	18.11	13.67	13.44	13.66	13.67	13.67
235	27	13.79	19.15	14.03	13.61	13.81	13.81	13.79
236	27	13.68	20.06	13.97	13.51	13.69	13.69	13.67
237	28	13.55	24.87	14.12	13.41	13.46	13.48	13.36
238	28	13.64	25.17	14.19	13.45	13.45	13.47	13.36
239	28	13.69	25.52	14.32	13.54	13.46	13.48	13.37
240	28	13.63	25.87	14.24	13.48	13.39	13.41	13.3
241	28	13.51	26.16	14.1	13.36	13.27	13.28	13.18
242	28	13.45	26.44	14.18	13.39	13.22	13.23	13.13
243	28	13.4	26.74	14.15	13.35	13.16	13.18	13.08
244	29	14.15	14.82	14.17	14.16	14.15	14.13	14.12
245	29	14.71	16.03	14.73	14.73	14.7	14.69	14.68
246	29	14.45	17	14.46	14.46	14.43	14.42	14.41
247	29	14.25	17.9	14.25	14.25	14.25	14.24	14.23
248	29	14.24	18.77	14.24	14.13	14.14	14.12	14.12
249	29	14	19.69	14.02	13.91	13.91	13.89	13.98
250	29	13.87	20.54	13.9	13.78	13.77	13.76	13.84
251	30	13.62	25.4	14.22	13.56	13.39	13.39	13.34
252	30	13.63	25.69	14.34	13.63	13.38	13.39	13.34
253	31	21.73	27.92	22.18	21.89	21.28	21.19	21.14
254	32	13.5	14.78	13.52	13.51	13.49	13.49	13.49
255	32	13.58	16.03	13.61	13.6	13.57	13.56	13.55
256	32	13.44	17	13.43	13.43	13.44	13.44	13.43
257	32	14.37	17.97	14.05	14.05	14.06	14.06	14.05
258	32	14.43	18.8	13.82	13.83	13.82	13.82	13.81
259	32	14.24	19.71	13.73	13.75	13.67	13.66	13.66
260	32	13.99	20.48	13.53	13.53	13.45	13.45	13.44
261	32	13.8	21.32	13.61	13.4	13.29	13.28	13.28
262	33	21.66	27.93	22.14	21.84	21.21	21.11	21.07
263	33	21.48	28.02	22.01	21.7	21.03	20.93	20.89
264	33	21.39	28.1	21.94	21.63	20.93	20.83	20.79
265	33	21.44	28.17	22.03	21.69	20.99	20.88	20.84
266	33	21.39	28.25	21.97	21.6	20.89	20.78	20.78
267	34	13.31	14.07	13.32	13.3	13.32	13.32	13.32
268	34	13.31	14.47	13.34	13.29	13.33	13.34	13.34
269	34	13.54	15.19	13.57	13.45	13.37	13.38	13.44
270	34	13.65	15.85	13.68	13.49	13.31	13.32	13.38
271	34	14.15	16.55	14.3	14.09	13.83	13.84	13.9
272	34	14.2	17.16	14.34	14.06	13.76	13.77	13.82
273	34	14.63	17.75	14.76	14.44	14.09	14.09	14.14
274	34	14.48	18.28	14.74	14.36	13.94	13.95	14
275	34	14.6	18.87	14.97	14.54	14.01	14.02	14.07
276	34	14.76	19.39	15.01	14.55	14.05	14.05	14.1
277	35	21.03	28.3	21.7	21.3	20.53	20.42	20.42
278	36	13.87	14.14	13.91	13.87	13.87	13.87	13.87
279	36	14.2	14.98	14.37	14.23	14.19	14.19	14.18
280	36	14.34	15.67	14.59	14.38	14.34	14.34	14.33
281	36	14.19	16.32	14.53	14.25	14.19	14.19	14.18
282	36	14.2	16.95	14.53	14.17	14.07	14.07	14.09
283	36	14.1	17.54	14.55	14.13	13.98	13.99	14
284	36	13.99	18.12	14.56	14.08	13.86	13.87	13.88

Q2ESHADE Identification Number	Reach Identification Number	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Historical Riparian Vegetation
285	36	14.05	18.66	14.76	14.22	13.92	13.93	13.94
286	36	14.06	19.17	14.85	14.24	13.94	13.95	13.96
287	36	14.29	19.66	15.05	14.38	14.06	14.08	14.08
288	36	14.37	20.18	15.09	14.37	13.93	13.94	13.95
289	37	21.11	28.22	21.78	21.38	20.6	20.49	20.49
290	37	21.11	28.28	21.79	21.39	20.57	20.46	20.46
291	38	13.59	14.06	13.37	13.29	13.2	13.2	13.2
292	38	13.46	14.77	13.35	13.21	13.08	13.08	13.08
293	38	13.62	15.51	13.64	13.43	13.15	13.15	13.15
294	38	13.6	16.18	13.76	13.54	13.17	13.17	13.17
295	38	13.67	16.81	13.82	13.52	13.13	13.13	13.13
296	38	13.79	17.41	13.94	13.56	13.13	13.13	13.13
297	38	13.72	17.97	14	13.56	13.1	13.1	13.1
298	38	14.23	18.55	14.58	14.12	13.64	13.64	13.7
299	38	14.42	19.1	14.74	14.22	13.67	13.67	13.72
300	38	14.56	19.59	14.87	14.29	13.66	13.67	13.72
301	38	15.03	20.07	15.37	14.79	14.16	14.16	14.21
302	38	15.04	20.52	15.37	14.77	14.12	14.12	14.17
303	38	15.09	20.96	15.51	14.87	14.11	14.16	14.2
304	39	20.96	28.27	21.65	21.24	20.4	20.28	20.3
305	39	20.89	28.39	21.59	21.16	20.31	20.2	20.21
306	39	20.79	28.5	21.48	21.04	20.17	20.04	20.06
307	39	20.86	28.61	21.48	21.04	20.18	20.05	20.06
308	39	20.84	28.72	21.47	21.03	20.16	20.02	20.02
309	39	20.76	28.82	21.41	20.97	20.09	19.95	19.94
310	39	20.64	28.93	21.34	20.89	19.98	19.83	19.83
311	39	20.55	29.03	21.28	20.83	19.9	19.74	19.74
312	40	13.85	14.12	13.69	13.69	13.71	13.72	13.72
313	40	13.98	14.92	13.83	13.75	13.79	13.8	13.8
314	40	13.89	15.68	13.79	13.68	13.71	13.71	13.71
315	40	13.82	16.34	13.72	13.62	13.64	13.65	13.65
316	40	13.76	17	13.67	13.55	13.55	13.56	13.56
317	40	13.68	17.61	13.72	13.51	13.48	13.48	13.48
318	40	14.04	18.16	14.17	13.94	13.86	13.86	13.86
319	40	13.89	18.66	14.09	13.81	13.71	13.71	13.71
320	40	13.74	19.13	13.97	13.66	13.56	13.57	13.57
321	40	13.67	19.58	13.95	13.62	13.49	13.49	13.49
322	40	13.72	20.04	14.14	13.75	13.5	13.5	13.5
323	40	13.91	20.52	14.27	13.83	13.53	13.53	13.53
324	41	20.39	28.99	21.13	20.66	19.73	19.58	19.58
325	41	20.28	29.08	21.05	20.57	19.62	19.46	19.46
326	41	20.18	29.18	20.97	20.48	19.52	19.36	19.36
327	41	20.41	29.28	21.18	20.68	19.69	19.53	19.52
328	41	20.44	29.36	21.16	20.67	19.68	19.52	19.51
329	41	20.65	29.45	21.36	20.87	19.85	19.68	19.67
330	41	20.64	29.53	21.33	20.82	19.78	19.6	19.59
331	41	20.79	29.62	21.47	20.95	19.92	19.75	19.74
332	41	20.94	29.69	21.59	21.07	20.06	19.89	19.88
333	42	13.26	14.08	13.27	13.26	13.27	13.27	13.27
334	42	13.27	14.84	13.28	13.27	13.27	13.27	13.27
335	42	13.27	15.56	13.28	13.27	13.27	13.26	13.26
336	42	13.29	16.24	13.29	13.28	13.29	13.29	13.29
337	42	13.25	16.84	13.32	13.27	13.25	13.25	13.25
338	42	13.27	17.46	13.33	13.28	13.26	13.26	13.26
339	42	13.26	18.08	13.33	13.27	13.2	13.2	13.2
340	42	13.35	18.67	13.42	13.3	13.19	13.19	13.19
341	42	13.47	19.19	13.48	13.3	13.15	13.2	13.2
342	42	13.32	19.65	13.36	13.16	13.02	13.06	13.06
343	42	13.28	20.14	13.39	13.11	12.99	13.03	13.03
344	42	13.33	20.58	13.53	13.17	13.06	13.1	13.1
345	43	20.88	29.65	21.54	21.02	20.02	19.85	19.84
346	43	20.92	29.74	21.61	21.08	20.07	19.9	19.89
347	43	21.07	29.82	21.75	21.22	20.23	20.06	20.05
348	43	21.1	29.91	21.81	21.28	20.28	20.1	20.09
349	43	20.96	30	21.72	21.18	20.16	19.98	19.98
350	43	20.82	30.09	21.62	21.08	20.04	19.86	19.85
351	44	13.33	14.17	13.51	13.34	13.32	13.32	13.31
352	44	13.2	14.9	13.41	13.21	13.2	13.19	13.19
353	44	13.09	15.58	13.29	13.1	13.08	13.08	13.07
354	44	12.97	16.2	13.22	12.98	12.97	12.96	12.95
355	44	12.87	16.81	13.14	12.89	12.86	12.86	12.85
356	44	12.77	17.39	13.08	12.8	12.76	12.76	12.75

Q2ESHADE Identification Number	Reach Identification Number	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Historical Riparian Vegetation
357	44	12.67	17.95	13	12.7	12.66	12.66	12.65
358	44	12.64	18.51	13.02	12.69	12.63	12.63	12.62
359	44	12.55	19	12.98	12.62	12.54	12.54	12.53
360	44	12.51	19.48	12.97	12.58	12.5	12.49	12.49
361	44	12.47	19.95	12.94	12.55	12.47	12.46	12.46
362	44	12.46	20.4	13.08	12.64	12.45	12.45	12.44
363	44	12.7	20.87	13.46	12.96	12.74	12.73	12.73
364	45	20.82	29.96	21.61	21.08	20.04	19.86	19.85
365	45	20.75	29.98	21.55	21.01	19.96	19.78	19.78
366	46	13.95	14.15	13.91	13.87	13.87	13.87	13.87
367	46	13.85	14.87	13.81	13.74	13.75	13.75	13.75
368	46	14.08	15.63	14.17	14	13.99	14	14
369	46	14.4	16.34	14.59	14.34	14.31	14.31	14.3
370	46	14.55	17	14.77	14.47	14.47	14.48	14.47
371	46	14.75	17.65	15.09	14.73	14.67	14.68	14.67
372	46	14.77	18.22	15.09	14.67	14.56	14.56	14.55
373	46	15.03	18.77	15.34	14.86	14.75	14.76	14.75
374	46	15.36	19.32	15.66	15.15	15.02	15.04	15.03
375	46	15.19	19.8	15.55	15.01	14.86	14.87	14.87
376	46	15	20.08	15.39	14.85	14.69	14.7	14.69
377	47	20.79	29.93	21.6	21.05	20.02	19.84	19.84
378	47	20.95	30.03	21.78	21.24	20.19	20.01	20
379	47	20.85	30.11	21.79	21.22	20.11	19.93	19.92
380	47	20.98	30.19	21.9	21.31	20.22	20.03	20.02
381	48	13.83	14.63	13.83	13.82	13.82	13.82	13.82
382	48	13.92	15.14	13.92	13.84	13.85	13.85	13.85
383	48	13.9	15.51	13.97	13.88	13.89	13.89	13.89
384	48	13.91	15.81	13.99	13.9	13.9	13.9	13.9
385	48	13.95	16.06	14.04	13.95	13.94	13.94	13.94
386	48	13.92	16.24	14.02	13.91	13.91	13.92	13.92
387	48	13.91	16.41	14.03	13.89	13.93	13.93	13.93
388	48	13.9	16.59	14.01	13.89	13.92	13.92	13.92
389	48	14.16	16.76	14.33	14.18	14.21	14.21	14.21
390	48	14.12	16.91	14.3	14.16	14.17	14.17	14.17
391	48	14.12	17.04	14.38	14.2	14.15	14.15	14.15
392	48	14.16	17.16	14.44	14.24	14.14	14.17	14.17
393	48	14.16	17.31	14.42	14.24	14.14	14.16	14.16
394	49	20.56	29.59	21.47	20.9	19.84	19.67	19.66
395	49	20.61	29.67	21.52	20.95	19.9	19.73	19.72
396	49	20.71	29.76	21.62	21.05	20.01	19.84	19.83
397	49	20.83	29.84	21.73	21.17	20.14	19.96	19.96
398	49	20.95	29.92	21.89	21.32	20.27	20.09	20.08
399	49	21.09	30.01	22.07	21.49	20.42	20.23	20.22
400	49	21.23	30.1	22.23	21.65	20.56	20.36	20.35
401	49	21.37	30.19	22.4	21.82	20.7	20.5	20.49
402	49	21.58	30.28	22.61	22.03	20.93	20.73	20.6
403	50	13.99	14.7	14.07	14	13.99	13.98	13.94
404	50	14.02	15.17	14.1	14.02	14.02	14.02	14.02
405	50	14	15.57	14.07	13.99	14	14	14
406	50	14.18	15.89	14.25	14.16	14.18	14.18	14.18
407	50	14.11	16.14	14.17	14.09	14.11	14.11	14.11
408	50	14.05	16.32	14.1	14.03	14.04	14.05	14.05
409	50	13.99	16.48	14.07	13.98	13.99	13.99	13.99
410	50	13.95	16.62	14.02	13.94	13.95	13.95	13.95
411	50	13.91	16.76	14.03	13.92	13.91	13.92	13.92
412	50	13.91	16.94	14.05	13.92	13.91	13.91	13.91
413	51	21.35	29.76	22.3	21.77	20.73	20.54	20.42
414	52	15.01	15.94	15.06	15.03	15.01	15.01	15.01
415	52	15.08	16.48	15.15	15.11	15.08	15.07	15.07
416	52	15.12	16.83	15.28	15.19	15.13	15.13	15.13
417	52	15.06	17.04	15.22	15.12	15.07	15.07	15.07
418	52	15.01	17.26	15.16	15.07	15.02	15.02	15.02
419	52	15	17.47	15.13	15.05	15	14.97	14.97
420	52	14.95	17.63	15.08	14.99	14.95	14.92	14.92
421	52	14.9	17.78	15.02	14.94	14.91	14.88	14.88
422	52	14.9	17.93	15	14.93	14.9	14.88	14.88
423	52	14.89	18.04	14.98	14.92	14.89	14.87	14.87
424	52	15.14	18.16	15.22	15.14	15.11	15.1	15.1
425	52	15.08	18.25	15.19	15.08	15.06	15.04	15.04
426	52	15.04	18.34	15.17	15.03	15.02	15.01	15.01
427	52	15	18.43	15.18	15.01	14.98	14.96	14.96
428	52	14.97	18.51	15.18	14.99	14.95	14.94	14.94

Q2ESHADE Identification Number	Reach Identification Number	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Historical Riparian Vegetation
429	52	14.93	18.6	15.14	14.94	14.91	14.9	14.9
430	52	14.88	18.68	15.1	14.92	14.89	14.88	14.88
431	52	14.84	18.78	15.06	14.88	14.85	14.84	14.84
432	52	15.26	18.97	15.47	15.3	15.26	15.25	14.9
433	53	21.05	29.02	21.94	21.43	20.48	20.3	20.16
434	53	21.27	29.12	22.15	21.65	20.71	20.53	20.4
435	54	14.52	15.1	14.53	14.53	14.52	14.52	14.52
436	54	14.74	15.45	14.75	14.75	14.74	14.74	14.74
437	54	14.67	15.67	14.68	14.68	14.67	14.67	14.67
438	54	14.59	15.83	14.6	14.6	14.59	14.59	14.59
439	54	14.53	15.99	14.54	14.54	14.53	14.53	14.53
440	54	14.53	16.13	14.52	14.52	14.53	14.53	14.53
441	54	14.48	16.25	14.47	14.48	14.48	14.48	14.48
442	54	14.73	16.43	14.73	14.73	14.73	14.74	14.73
443	55	21.21	28.85	22.07	21.59	20.67	20.5	20.36
444	55	21.34	28.94	22.24	21.75	20.81	20.64	20.5
445	55	21.24	29.01	22.19	21.69	20.73	20.55	20.42
446	55	21.18	29.08	22.18	21.65	20.64	20.46	20.33
447	55	21.28	29.15	22.28	21.76	20.74	20.55	20.43
448	55	21.37	29.22	22.36	21.84	20.83	20.64	20.52
449	55	21.44	29.29	22.42	21.9	20.86	20.66	20.54
450	55	21.53	29.37	22.54	22.01	20.96	20.76	20.63
451	56	13.81	14.56	13.81	13.81	13.81	13.81	13.81
452	56	13.83	14.99	13.84	13.82	13.83	13.84	13.84
453	56	13.82	15.28	13.83	13.81	13.82	13.82	13.82
454	56	13.8	15.53	13.83	13.79	13.81	13.81	13.81
455	56	14.11	15.74	14.13	14.07	14.08	14.09	14.09
456	56	14.13	15.91	14.21	14.11	14.11	14.11	14.11
457	56	14.09	16.11	14.19	14.08	14.07	14.08	14.07
458	57	21.26	29.06	22.26	21.74	20.72	20.53	20.41
459	58	15.68	16.19	15.69	15.68	15.68	15.68	15.68
460	58	15.79	16.63	15.5	15.48	15.49	15.49	15.49
461	58	15.54	16.93	15.34	15.32	15.32	15.33	15.33
462	58	15.56	17.18	15.24	15.22	15.22	15.22	15.22
463	58	15.41	17.4	15.15	15.13	15.13	15.13	15.13
464	58	15.29	17.59	15.1	15.06	15.06	15.06	15.06
465	58	15.2	17.75	15.08	15.01	15.01	15.01	15.01
466	58	15.12	17.91	15.03	14.96	14.95	14.96	14.96
467	58	15.22	18.06	15.19	15.08	15.07	15.07	15.07
468	58	15.42	18.19	15.44	15.32	15.29	15.3	15.3
469	58	15.9	18.39	15.92	15.81	15.79	15.79	15.57
470	59	21.24	28.81	22.2	21.69	20.71	20.53	20.38
471	59	21.31	28.85	22.26	21.76	20.79	20.61	20.46
472	59	21.49	28.9	22.42	21.93	20.98	20.8	20.59

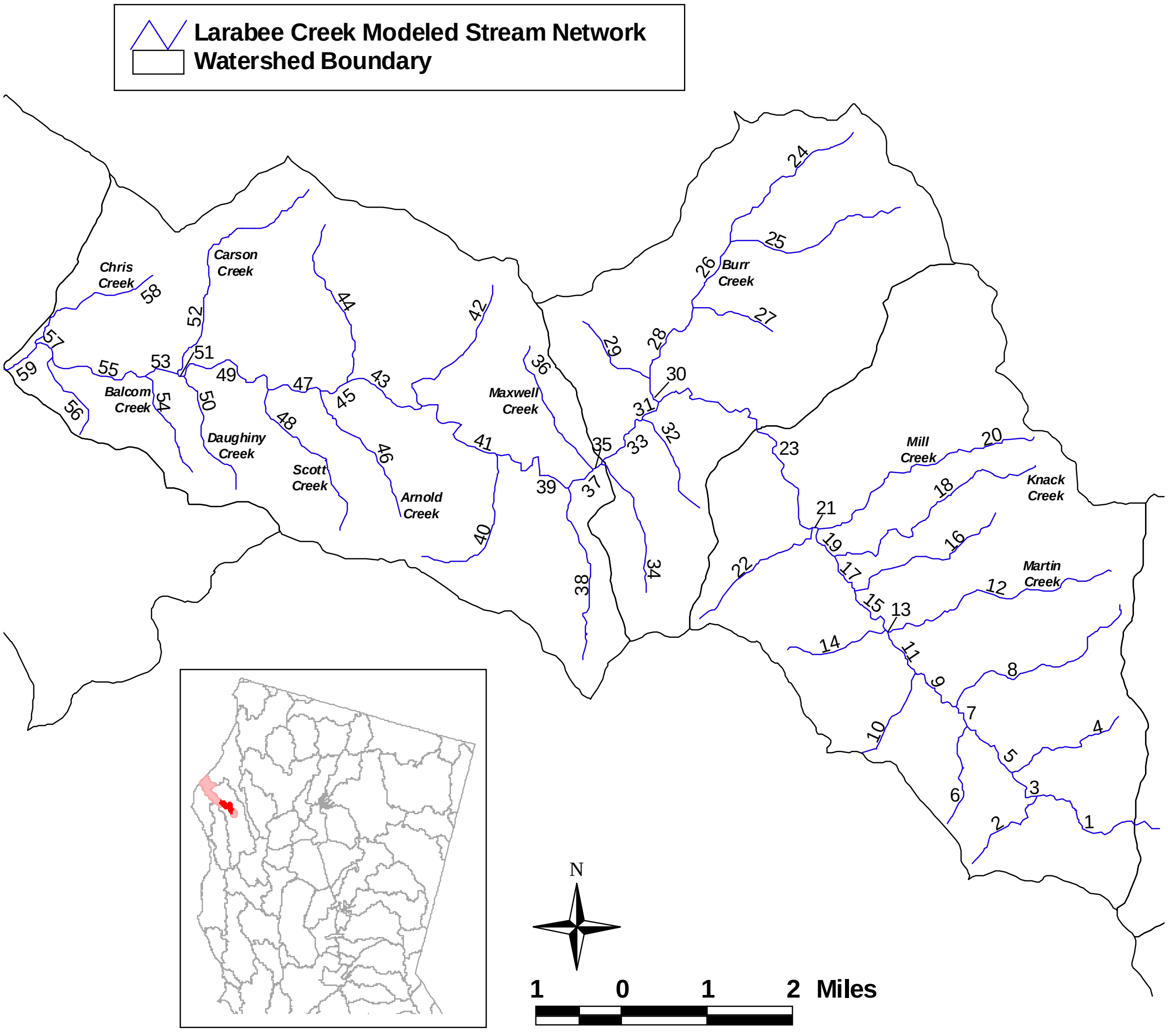

Figure A-25. Stream reach identification numbers in Larabee Creek

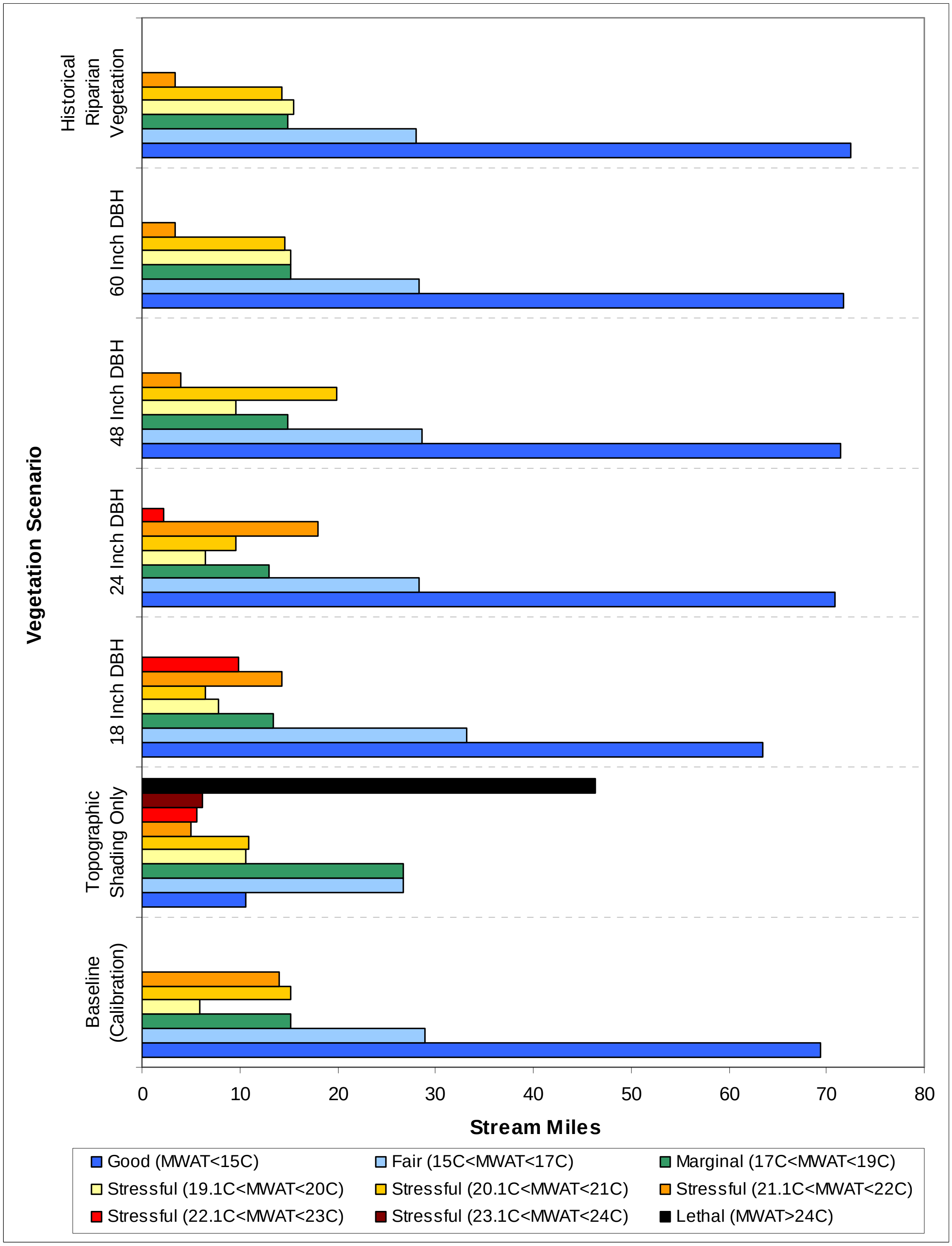

Figure A-26. Stream miles associated with each vegetation scenario in Larabee Creek

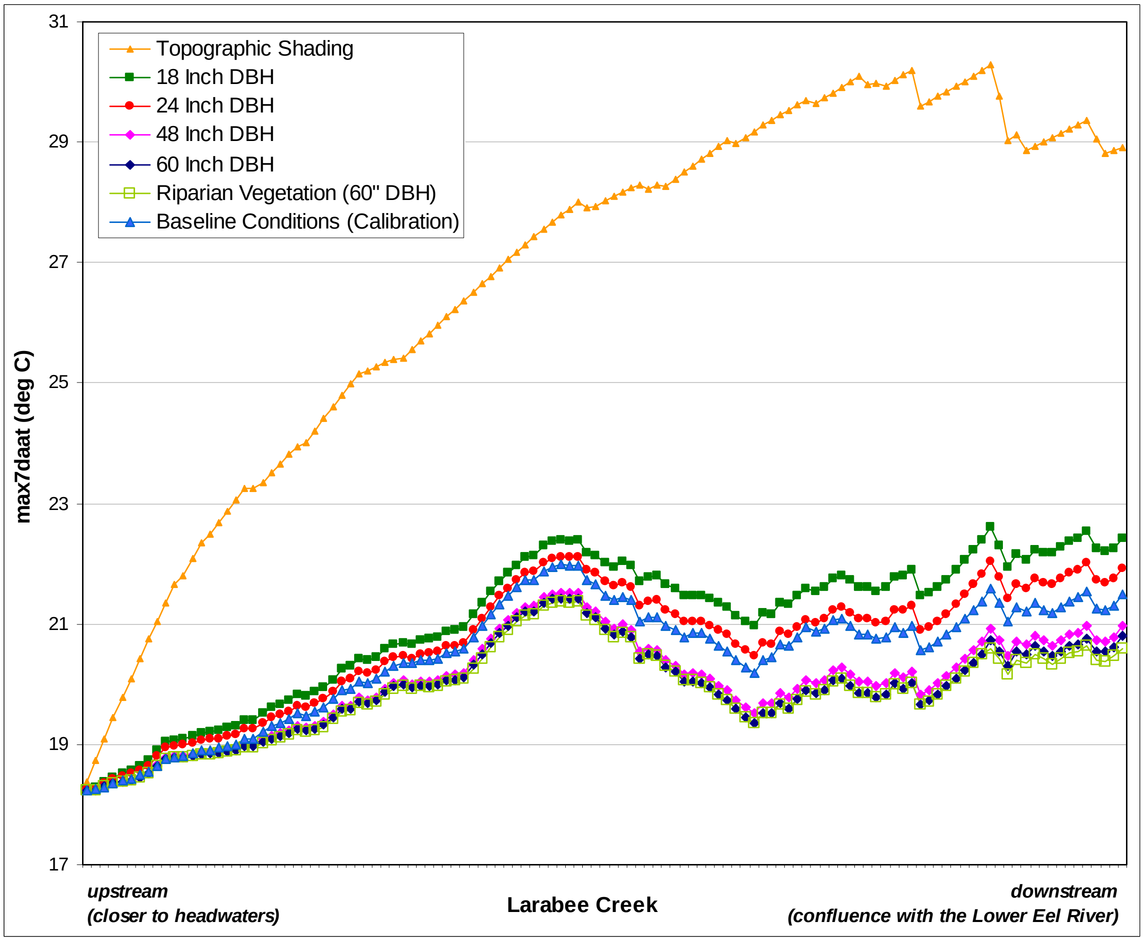

Figure A-27. Max7daat values for vegetation scenarios at each SSP along the main channel of Larabee Creek

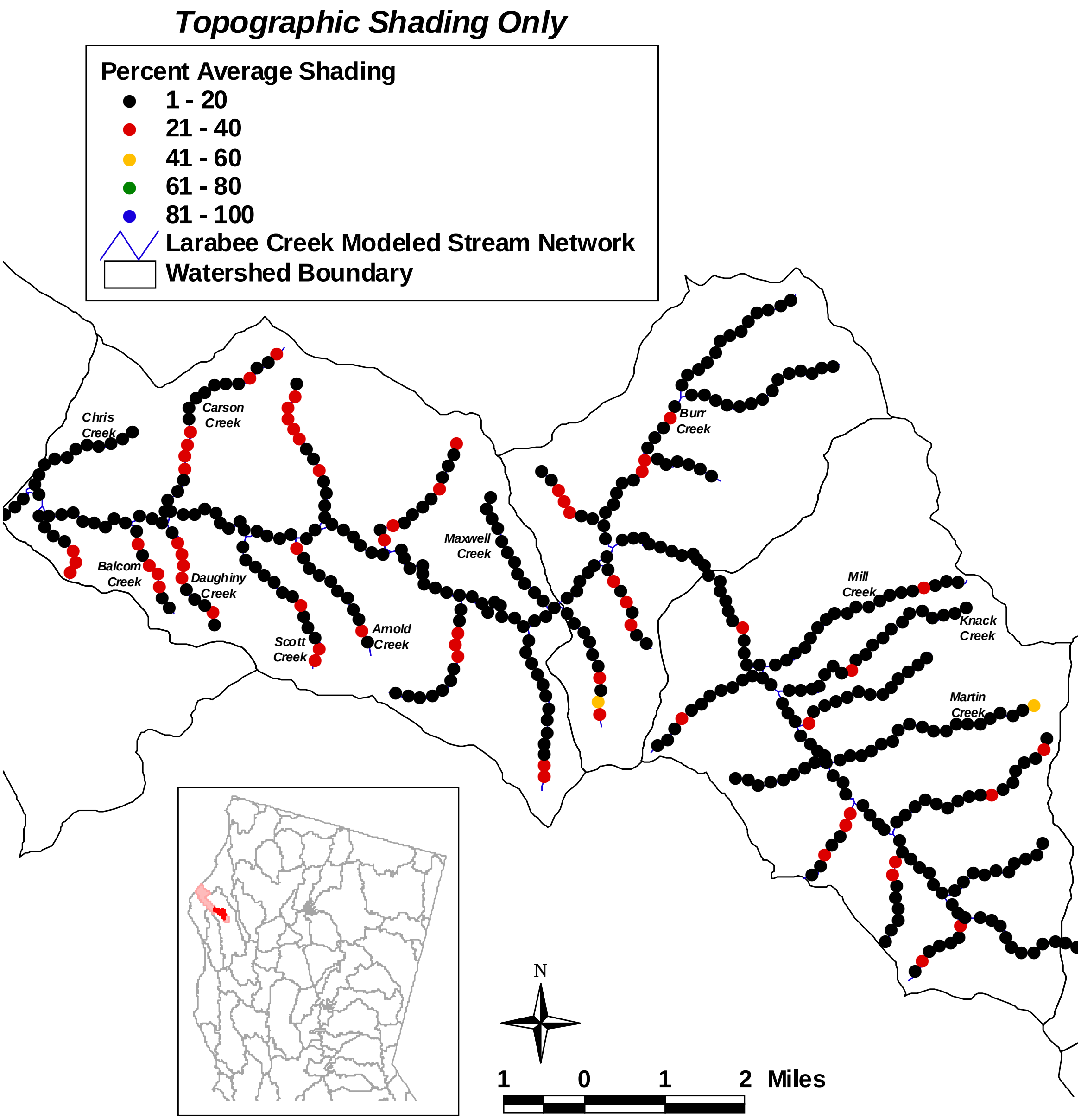

Figure A-28. Percent average shading for the topographic shading scenario at Larabee Creek

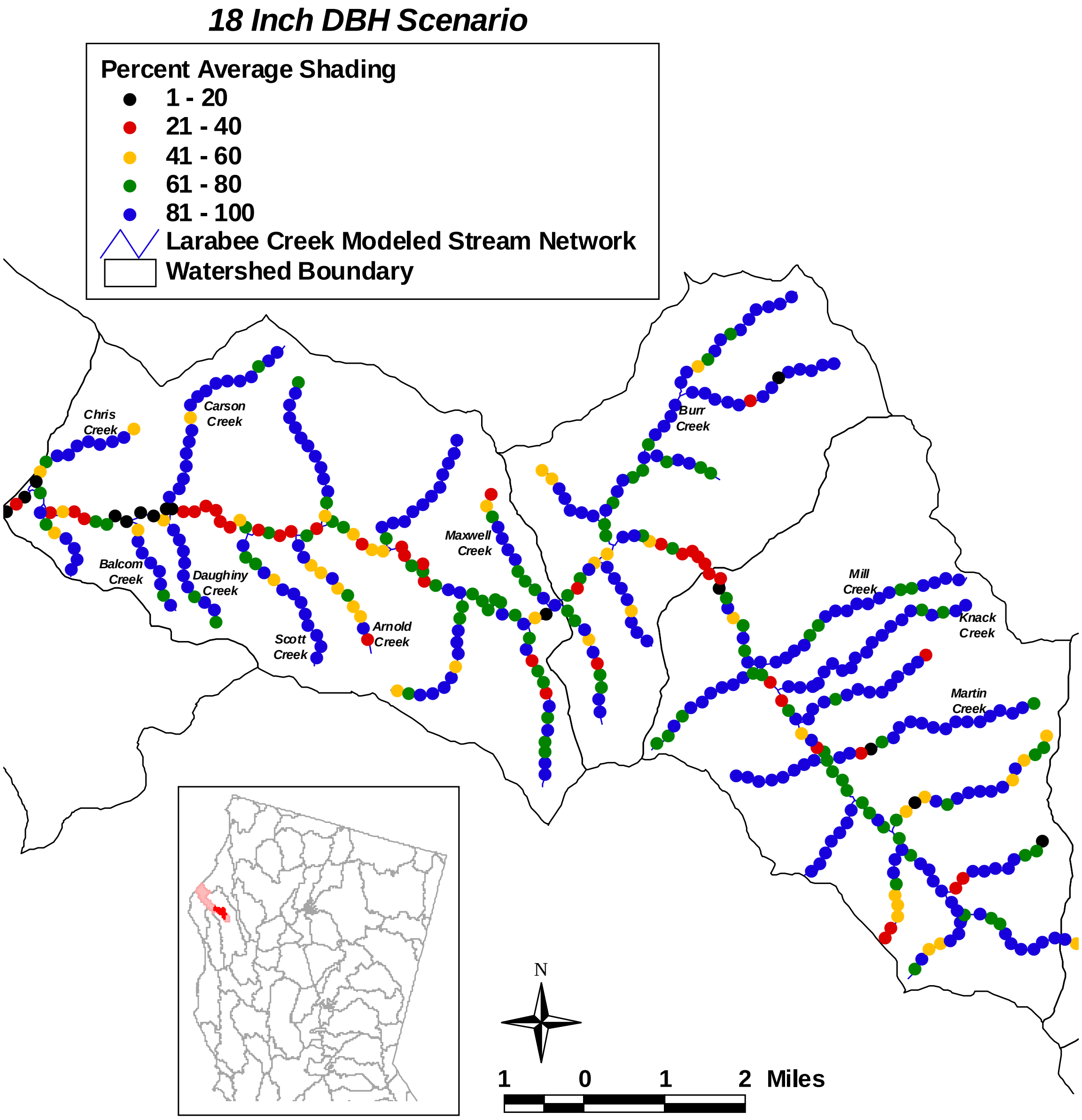

Figure A-29. Percent average shading for the 18 inch DBH vegetation scenario at Larabee Creek

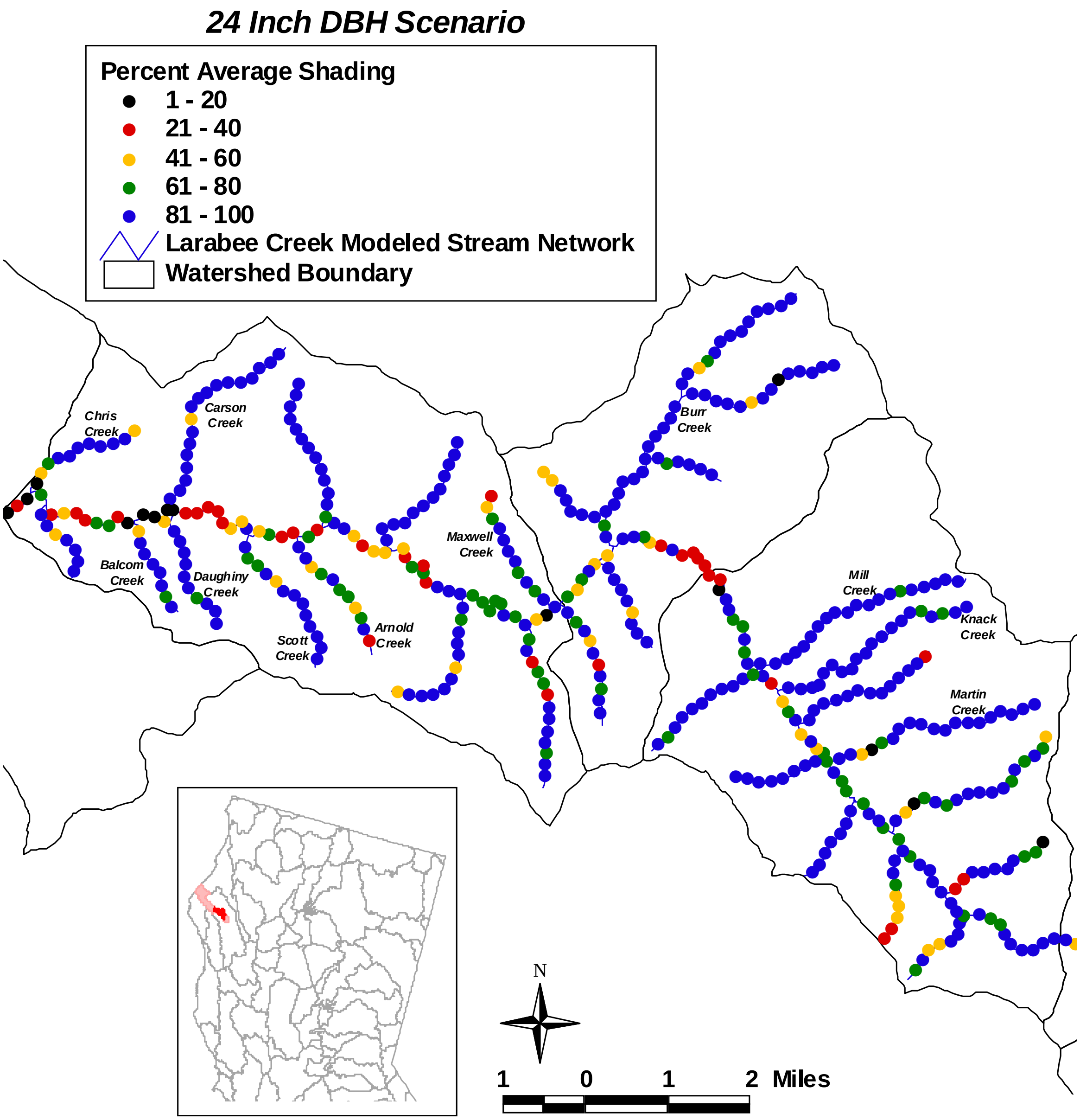

Figure A-30. Percent average shading for the 24 inch DBH vegetation scenario at Larabee Creek

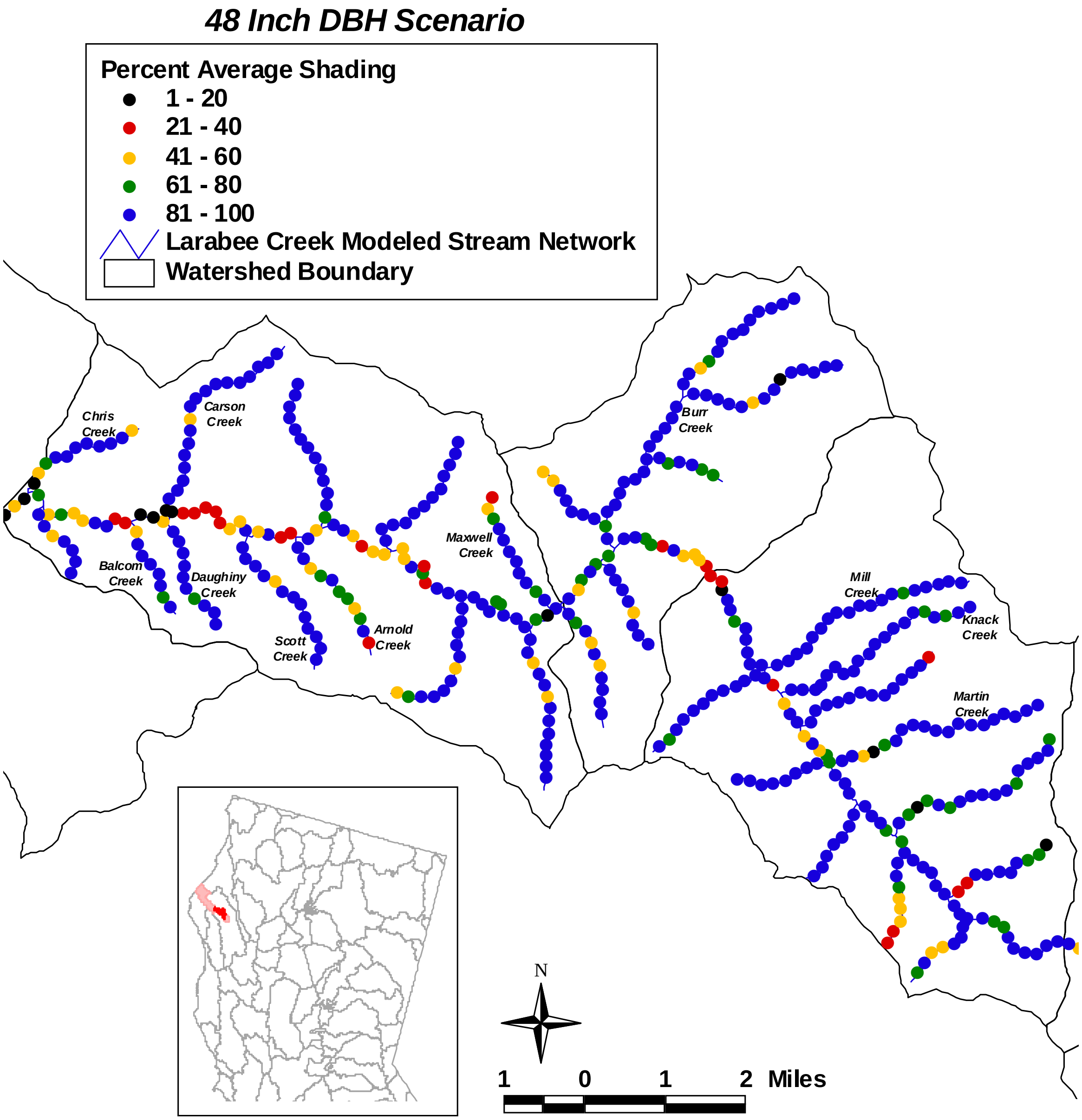

Figure A-31. Percent average shading for the 48 inch DBH vegetation scenario at Larabee Creek

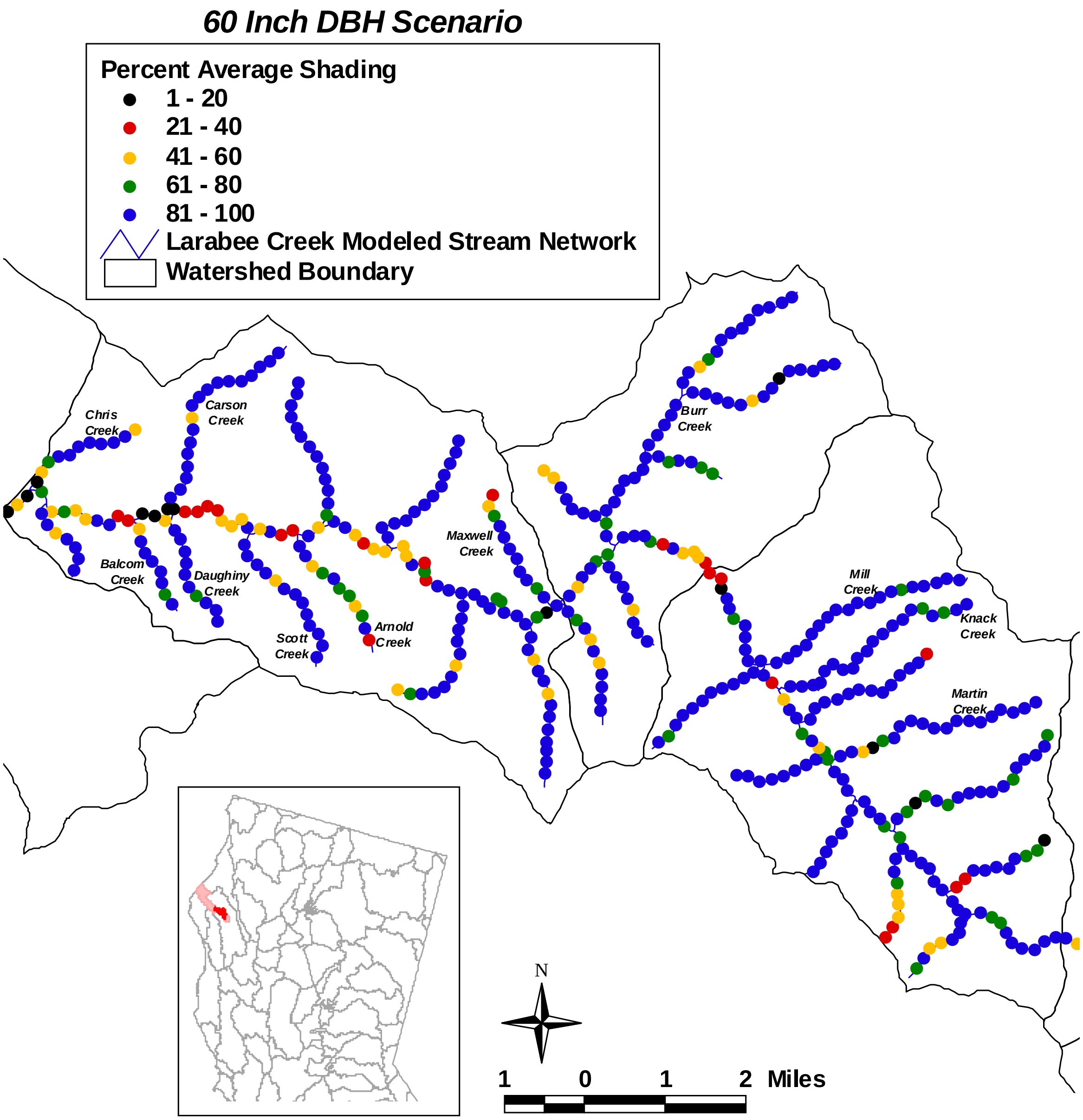

Figure A-32. Percent average shading for the 60 inch DBH vegetation scenario at Larabee Creek

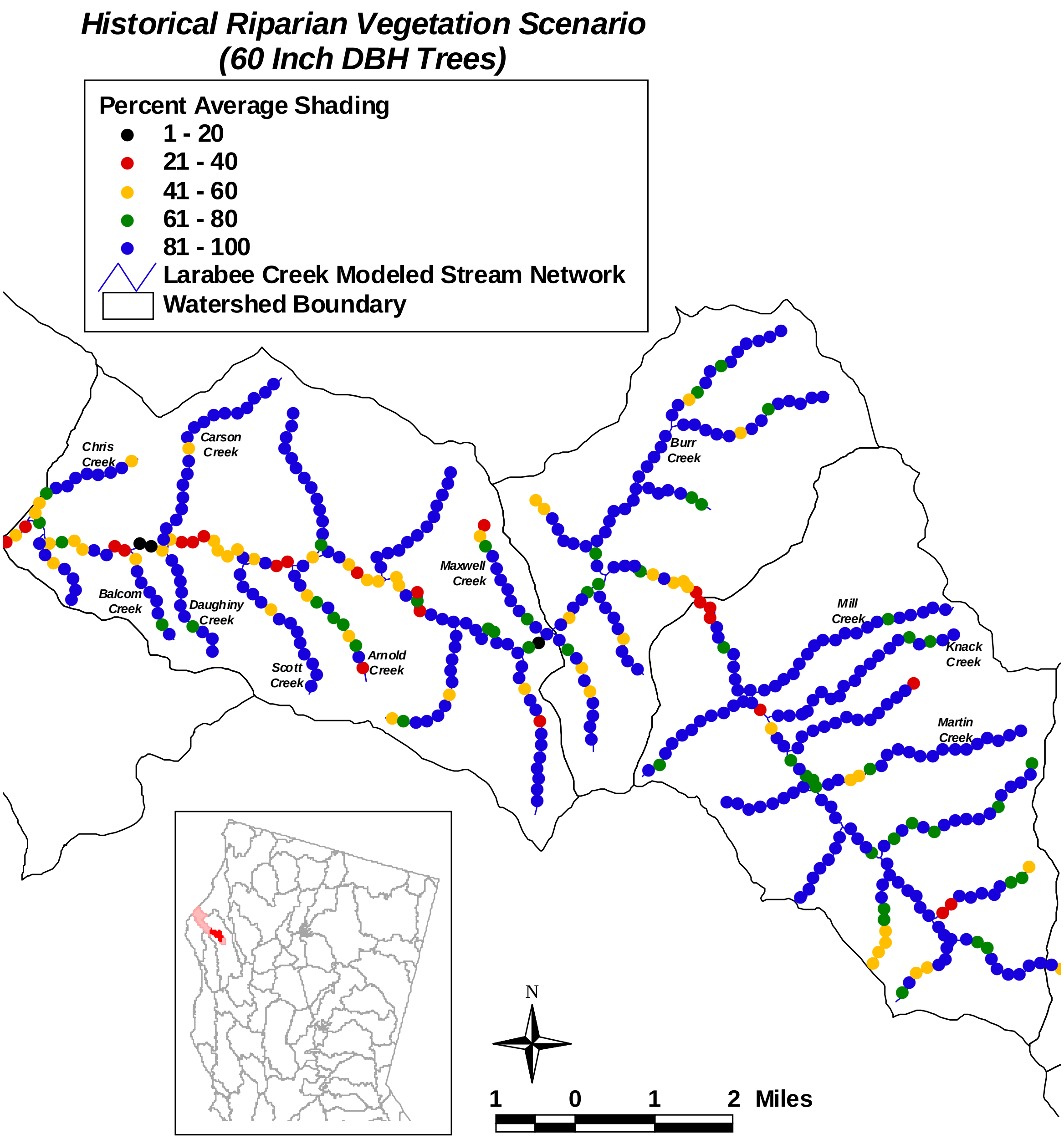

Figure A-33. Percent average shading for the historical riparian vegetation scenario at Larabee Creek

A.4.3 Q2ESHADE Model of the Creeks Draining to Salt River

As shown in Table A-1, the Q2SHADE model was run for the stream network associated with several creeks draining to Salt River. Subsequent to the initial model run using the baseline conditions described in Sections A.2.1.1, A.2.1.2, A.2.2.1, and A.3.2, model calibration was performed. Model calibration included the adjustment of the baseline flow and temperature values, incorporation of springs or seeps, and modification of the channel hydraulic coefficients and exponents to match observed widths and depths. Specifically, overall flow was initially captured by contributions from the various tributaries based primarily on estimates from the SIRs and secondarily on a value of 0.15 cfs or 0.0042 cms, which resulted in a general flow balance. During calibration, flows from the headwaters of the tributaries were reduced and small flows from various springs were included based on information provided in the SIRs. Other flow values were adjusted to closely match the observed data in the watershed. Initial temperature values were based on the average temperatures from the SIRs or a constant value of 15.0 degC and were adjusted to closely match the observed temperature data at stations located throughout the watershed (CDFG, 2003a, 2003b, 2003c). Table A-20 summarizes the initial and final boundary conditions (reach numbers are identified in Figure A-37).

Table A-20. Initial and Calibrated Flow and Temperature Boundary Conditions for the Salt River Watershed

	Initial Conditions		Final Conditions	
Headwater Reach	**Flow (cms)**	**Temperature (degC)**	**Flow (cms)**	**Temperature (degC)**
Francis Creek	0.0312	15.0	0.0052	14.75
Unnamed Tributary to Francis	0.0113	12.54	0.0043	14.75
Reach 5	0.0042	15.0	0.0084	15.0
Reach 6	0.0042	15.0	0.0084	15.0
Reach 7	0.0042	15.0	0.0084	15.0
Perry Slough	0.0042	15.0	0.0113	15.0
Williams Creek	0.07	17.67	0.013	18.0
Reach 13	0.0042	20.0	0.0066	18.0
Reach 15	0.0042	20.0	0.0066	18.0
Reas Creek	0.0042	16.0	0.0125	16.0

The 2005 temperature monitoring data from the Humboldt County RCD were used for calibration (Humboldt County RCD, 2005). Three stations were available in the Salt River watershed (Figure A-34). No data in 2005 were available along the main channel of the Salt River for calibration; therefore, the only calibrated reaches are several tributaries to the Salt River (Figure A-2). Max7daats were calculated for the temperature monitoring data for July 15, 2005 through August 14, 2005 and were compared with the max7daats predicted by the model for the same time period. Model calibration results are presented in Table A-21. The average percent error was –1.98% (percent error ranged from –2.95% to –1.32%).

Table A-21. Model Calibration Results for Stream Temperature in the Creeks Draining to Salt River

Location	Observed Temperature max7daat (deg C)	Predicted Temperature max7daat (deg C)	Percent Error
Francis Creek	14.53	14.34	-1.32%
Reas Creek	15.63	15.37	-1.66%
Williams Creek	17.99	17.46	-2.95%

Table A-22 presents the number of stream miles associated with different max7daat categories and the solar radiation for baseline conditions (see Sections A.2.1.1, A.2.1.2, A.2.2.1, and A.3.2) in the entire Salt River watershed (note that these values include uncalibrated portions of the Salt River main channel). Average percent shading for each of the calibrated stream networks are also included (Table A-22). In addition, Figure A-35and Figure A-36 illustrate the average percent shading and max7daat values for baseline conditions in the creeks draining to the Salt River.

Table A-22. Baseline Model Results for the Entire Salt River Watershed

Temperature Category	**Salt River**	
	Stream Miles	**% of Total**
Good (max7daat < 15℃)	4.3	13%
Fair (15℃ < max7daat < 17℃)	10.9	33%
Marginal (17℃ < max7daat < 19℃)	17.1	51%
Stressful (19.1℃ < max7daat < 20℃)	1.2	4%
Stressful (20.1℃ < max7daat < 21℃)	0.0	0%
Stressful (21.1℃ < max7daat < 22℃)	0.0	0%
Stressful (22.1℃ < max7daat < 23℃)	0.0	0%
Stressful (23.1℃ < max7daat < 24℃)	0.0	0%
Lethal (max7daat > 24℃)	0.0	0%
TOTAL	33.5	100%
Watershed-wide Solar Radiation (Langley/day)	405.9	
% Shade - Francis Creek	50.7%	
% Shade - Reas Creek	37.5%	
% Shade - Williams Creek	52.4%	

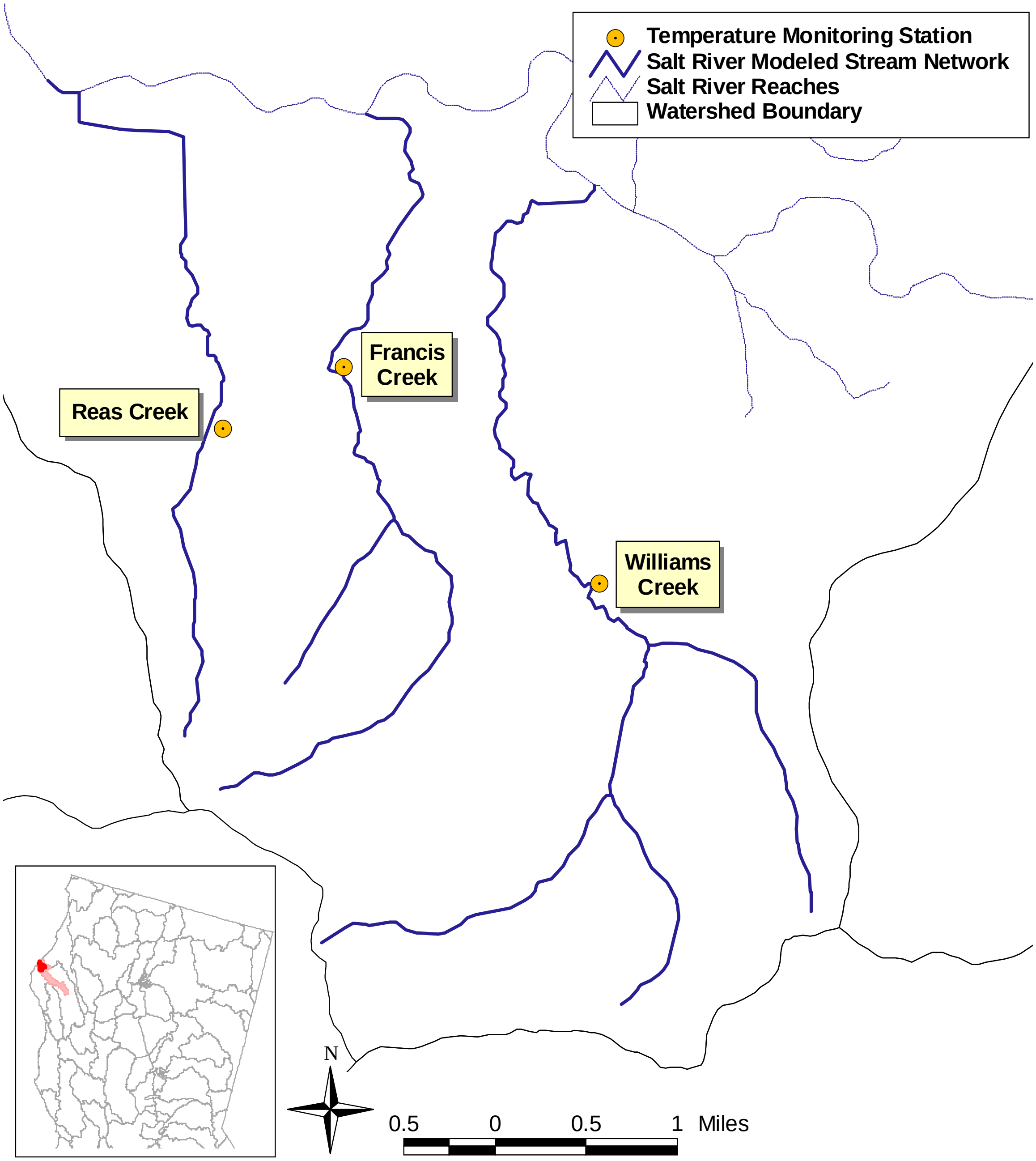

Figure A-34. Monitoring stations used for calibration in the Salt River watershed

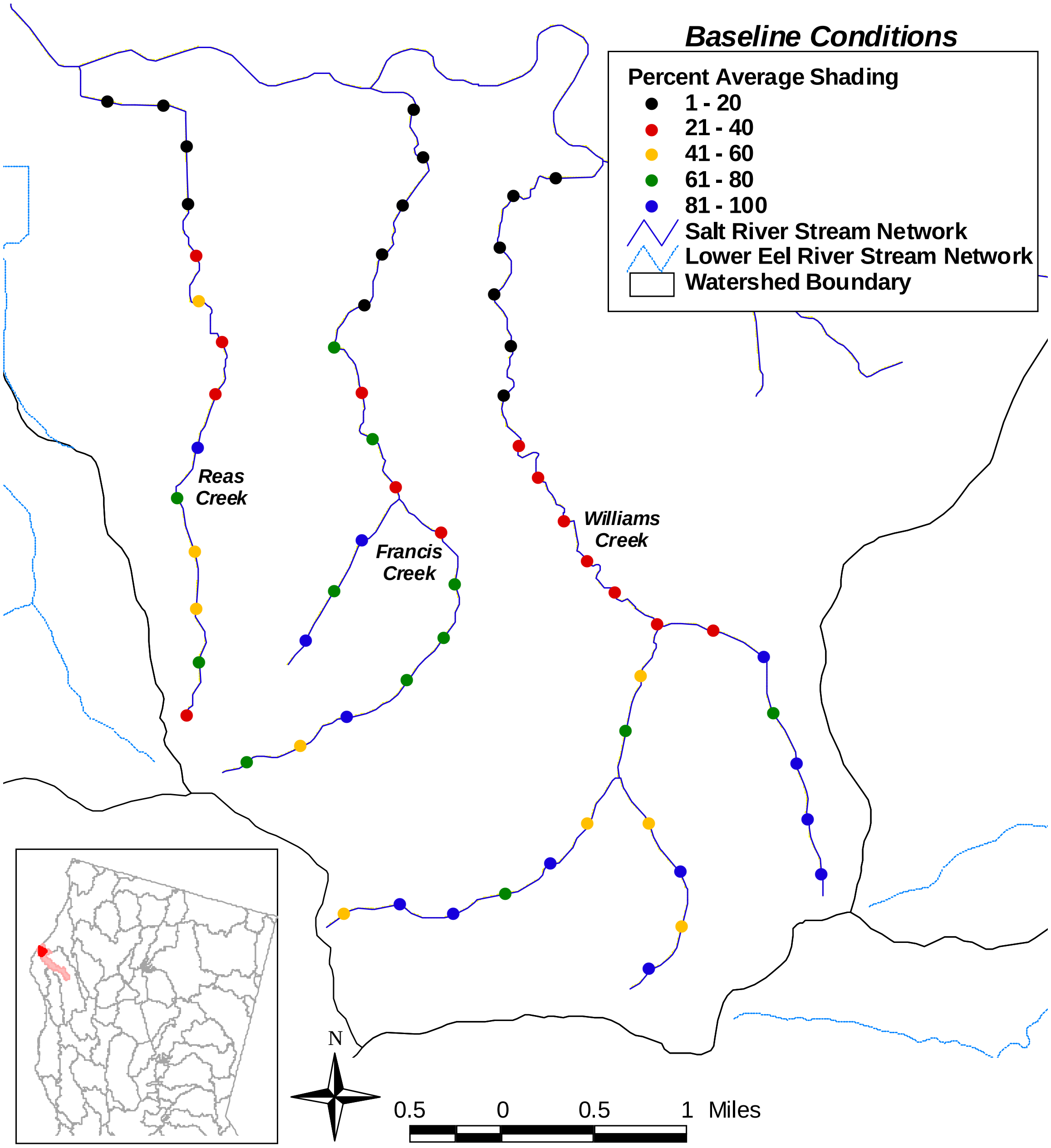

Figure A-35. Percent average shading for baseline conditions for the creeks draining to Salt River

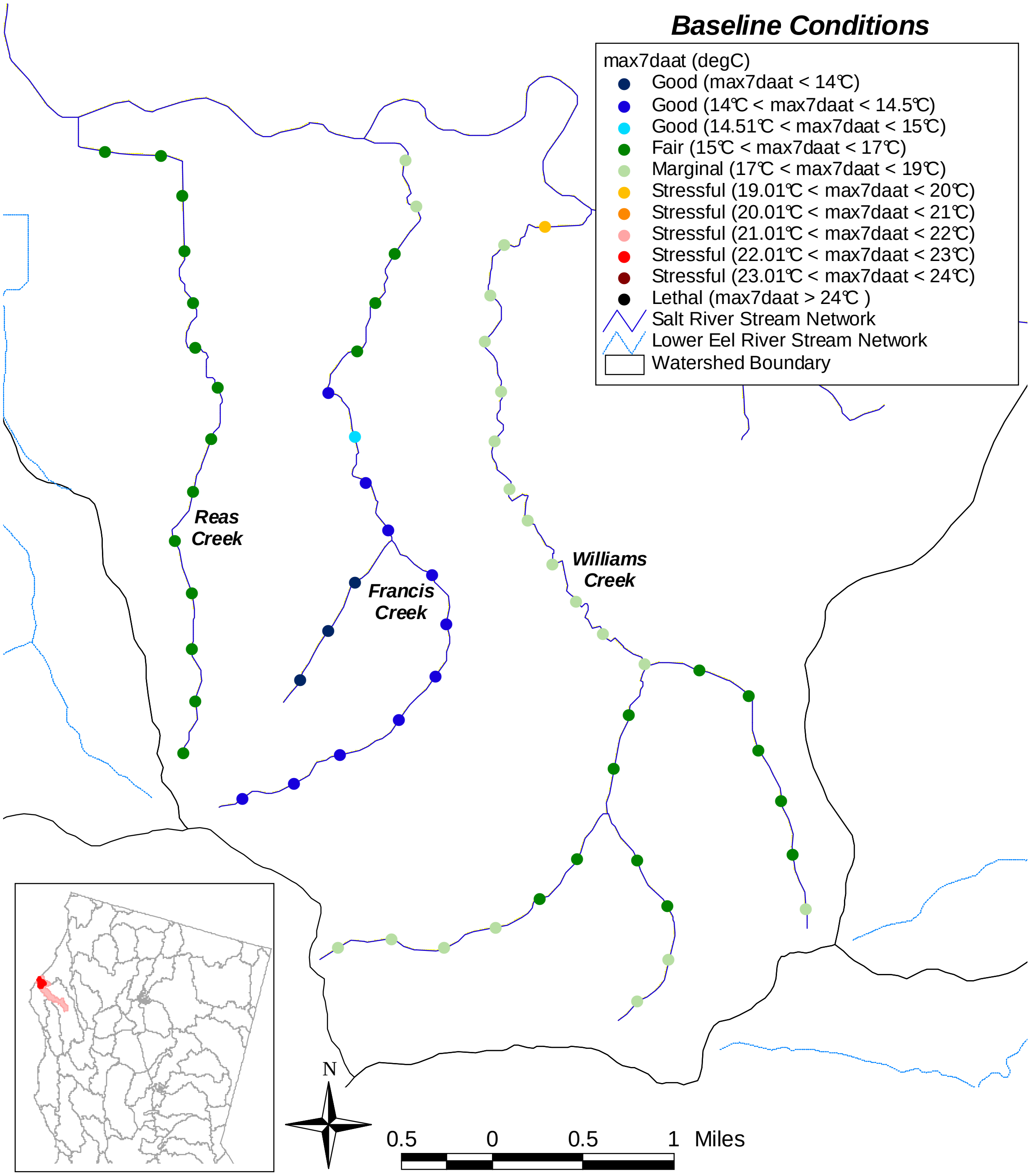

Figure A-36. Max7daat values for baseline conditions for the creeks draining to Salt River

Using the calibrated model, the six vegetation scenarios described in Section A.4 were simulated: no vegetation (topographic shading only), 18 inch DBH, 24 inch DBH, 48 inch DBH, 60 inch DBH, and historical riparian vegetation with 60 inch DBH trees (Table A-13). Table A-23 and Table A-24 present model results for the vegetation scenarios in the Salt River watershed, as compared to the baseline conditions (see Sections A.2.1.1, A.2.1.2, A.2.2.1, and A.3.2). Table A-23 includes the stream miles associated with different max7daat categories and the solar radiation for the entire Salt River watershed along with the average percent shading for the calibrated stream networks. Table A-24 identifies the specific max7daat value associated with each SSP along the calibrated reaches (see Figure A-37 for an illustration of the stream reach identification numbers). Figure A-38 illustrates the stream miles in the entire Salt River watershed associated with each vegetation scenario.   Figure A-39 through Figure A-41 graphically compare max7daats for the baseline conditions and the vegetation scenarios (Table A-24) for Francis Creek, Reas Creek, and Williams Creek, respectively. Figure A-42 through Figure A-47 illustrate the average percent shading at each SSP for vegetation scenarios described above (Table A-13).

Table A-23. Model Results for Vegetation Scenarios in the Salt River Watershed

Temperature Category	Baseline Conditions		Topo-graphic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH		60 Inch DBH		Historical Riparian Vegetation
	Stream Miles	% of Total	Stream Miles	Stream Miles	Stream Miles	Stream Miles	% of Total	Stream Miles	% of Total	Stream Miles
Good (max7daat < 15℃)	4.3	13%	0.0	4.3	4.3	4.3	13%	4.3	13%	5.9
Fair (15℃ < max7daat < 17℃)	10.9	33%	9.0	9.9	10.6	11.2	33%	11.2	33%	10.3
Marginal (17℃ < max7daat < 19℃)	17.1	51%	14.3	17.1	17.1	16.8	50%	16.8	50%	16.5
Stressful (19.1℃ < max7daat < 20℃)	1.2	4%	9.0	2.2	1.6	1.2	4%	1.2	4%	0.9
Stressful (20.1℃ < max7daat < 21℃)	0.0	0%	1.2	0.0	0.0	0.0	0%	0.0	0%	0.0
Stressful (21.1℃ < max7daat < 22℃)	0.0	0%	0.0	0.0	0.0	0.0	0%	0.0	0%	0.0
Stressful (22.1℃ < max7daat < 23℃)	0.0	0%	0.0	0.0	0.0	0.0	0%	0.0	0%	0.0
Stressful (23.1℃ < max7daat < 24℃)	0.0	0%	0.0	0.0	0.0	0.0	0%	0.0	0%	0.0
Lethal (max7daat > 24℃)	0.0	0%	0.0	0.0	0.0	0.0	0%	0.0	0%	0.0
TOTAL	33.5	100%	33.5	33.5	33.6	33.5	100%	33.5	100%	33.6
Watershed-wide Solar Radiation (Langley/day)	405.9		530.4	412.8	406.4	400.7		400.5		362.3
% Shade - Francis Creek	50.7%		17.8%	50.2%	51.5%	52.7%		52.7%		66.2%
% Shade - Reas Creek	37.5%		15.2%	35.7%	37.0%	38.4%		38.5%		50.2%
% Shade - Williams Creek	52.4%		17.5%	49.6%	51.5%	53.4%		53.5%		61.5%

Table A-24. Max7daat Values (degC) for Vegetation Scenarios at Each SSP Along the Creeks Draining to Salt River

Q2ESHADE Identification Number	Reach Identification Number	Stream Network	Baseline Conditions (Calibration)	Topographic Shading	18 Inch DBH	24 Inch DBH	48 Inch DBH	60 Inch DBH	Riparian Vegetation (60" DBH)
1	1	Francis	14.42	15.11	14.43	14.43	14.43	14.43	14.43
2	1	Francis	14.49	15.38	14.52	14.50	14.50	14.50	14.53
3	1	Francis	14.22	15.53	14.27	14.23	14.23	14.23	14.26
4	2	Francis	14.15	15.68	14.13	14.08	14.08	14.08	14.10
5	2	Francis	14.16	15.77	14.09	14.03	14.03	14.03	14.04
6	2	Francis	14.12	15.89	14.06	13.99	13.80	13.80	13.92
7	2	Francis	14.33	16.00	14.29	14.22	14.07	14.06	14.16
8	3	Francis	13.97	15.66	14.03	13.98	13.95	13.95	13.95
9	3	Francis	13.80	16.10	13.92	13.81	13.79	13.79	13.79
10	3	Francis	13.37	16.25	13.48	13.37	13.35	13.35	13.35
11	4	Francis	14.40	16.48	14.45	14.36	14.30	14.29	13.96
12	4	Francis	14.10	16.85	14.17	14.07	14.00	14.00	13.76
13	4	Francis	14.65	17.32	14.73	14.60	14.53	14.52	14.32
14	4	Francis	14.34	17.49	14.41	14.28	14.22	14.22	14.06
15	4	Francis	15.38	17.79	15.43	15.34	15.29	15.29	14.07
16	4	Francis	16.15	18.02	16.18	16.11	16.08	16.07	14.07
17	4	Francis	16.71	18.19	16.74	16.69	16.66	16.66	14.08
18	4	Francis	17.13	18.31	17.15	17.11	17.09	17.09	14.28
19	4	Francis	17.45	18.42	17.47	17.44	17.42	17.42	14.25
43	12	Williams	17.95	18.17	17.95	17.94	17.94	17.94	17.94
44	12	Williams	17.58	18.23	17.58	17.58	17.58	17.58	17.58
45	12	Williams	17.31	18.31	17.32	17.31	17.31	17.31	17.31
46	12	Williams	17.15	18.36	17.19	17.16	17.15	17.15	17.15
47	12	Williams	16.92	18.39	16.98	16.93	16.92	16.92	16.92
48	12	Williams	16.93	18.44	16.98	16.94	16.92	16.92	16.92
49	13	Williams	17.25	18.25	17.28	17.26	17.25	17.25	17.25
50	13	Williams	17.18	18.44	17.23	17.19	17.16	17.16	17.16
51	13	Williams	16.78	18.48	16.88	16.79	16.77	16.77	16.77
52	13	Williams	16.92	18.56	17.04	16.95	16.92	16.91	16.91
53	14	Williams	16.91	18.51	17.03	16.95	16.86	16.86	16.86
54	14	Williams	16.99	18.68	17.23	17.10	16.86	16.86	16.85
55	15	Williams	17.21	18.23	17.30	17.23	17.21	17.22	17.22
56	15	Williams	16.77	18.39	16.95	16.84	16.74	16.75	16.75
57	15	Williams	16.28	18.45	16.51	16.37	16.22	16.22	16.22
58	15	Williams	16.3	18.61	16.51	16.38	16.24	16.24	16.24
59	15	Williams	16.02	18.62	16.21	16.08	15.96	15.96	15.96
60	15	Williams	16.4	18.67	16.58	16.46	16.36	16.35	16.03
61	16	Williams	17.02	18.82	17.24	17.11	16.91	16.91	16.82
62	16	Williams	17.25	19.02	17.46	17.33	17.15	17.14	17.05
63	16	Williams	17.46	19.22	17.66	17.53	17.36	17.35	17.25
64	16	Williams	17.61	19.39	17.8	17.67	17.5	17.49	17.39
65	16	Williams	17.65	19.5	17.85	17.72	17.55	17.54	17.45
66	16	Williams	17.78	19.66	17.97	17.84	17.69	17.68	17.59
67	16	Williams	18	19.8	18.18	18.04	17.9	17.89	17.63
68	16	Williams	18.27	19.93	18.44	18.31	18.18	18.16	17.59
69	16	Williams	18.53	20.05	18.69	18.57	18.43	18.42	17.57
70	16	Williams	18.76	20.17	18.91	18.8	18.67	18.66	17.55
71	16	Williams	18.97	20.26	19.11	19.01	18.89	18.88	17.52
72	16	Williams	19.16	20.35	19.29	19.19	19.09	19.08	17.49
85	19	Reas	16.01	16.2	16.02	16.01	16.01	16.01	16.01
86	19	Reas	15.81	16.33	15.83	15.81	15.8	15.8	15.8
87	19	Reas	15.7	16.41	15.73	15.71	15.7	15.69	15.69
88	19	Reas	15.6	16.5	15.64	15.6	15.59	15.59	15.59
89	19	Reas	15.43	16.6	15.53	15.47	15.38	15.37	15.37
90	19	Reas	15.16	16.65	15.31	15.22	15.09	15.09	15.09
91	19	Reas	15.37	16.76	15.51	15.42	15.31	15.31	15.3
92	19	Reas	15.57	16.87	15.69	15.61	15.51	15.51	15.5
93	19	Reas	15.6	16.89	15.71	15.63	15.54	15.54	15.52
94	19	Reas	15.77	16.99	15.87	15.8	15.71	15.71	15.56
95	19	Reas	16	17.09	16.09	16.02	15.95	15.95	15.62
96	19	Reas	16.19	17.17	16.28	16.22	16.15	16.15	15.59
97	19	Reas	16.36	17.24	16.44	16.39	16.33	16.32	15.57
98	19	Reas	16.52	17.32	16.59	16.54	16.49	16.49	15.55

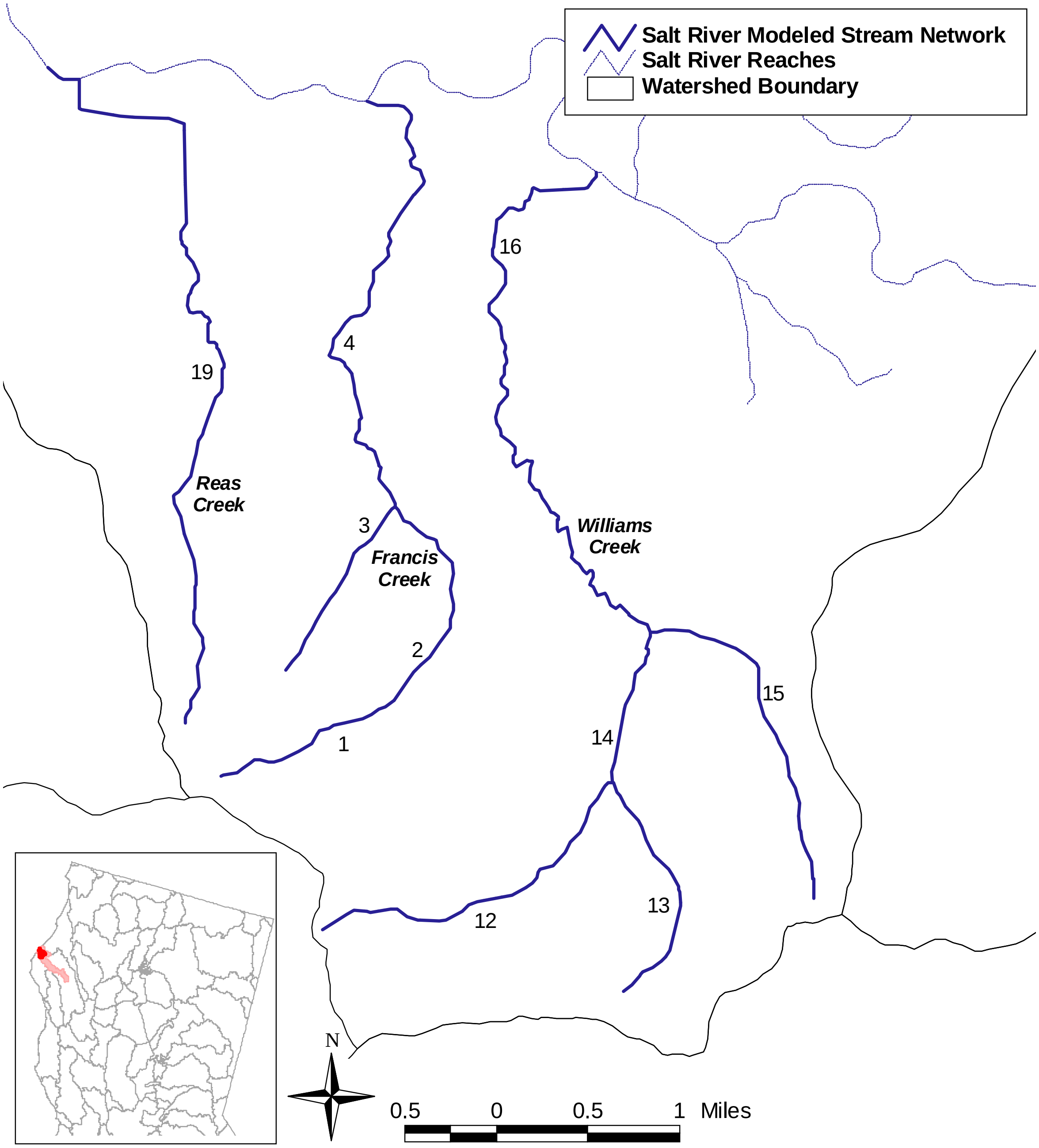

Figure A-37. Stream reach identification numbers for the creeks draining to Salt River

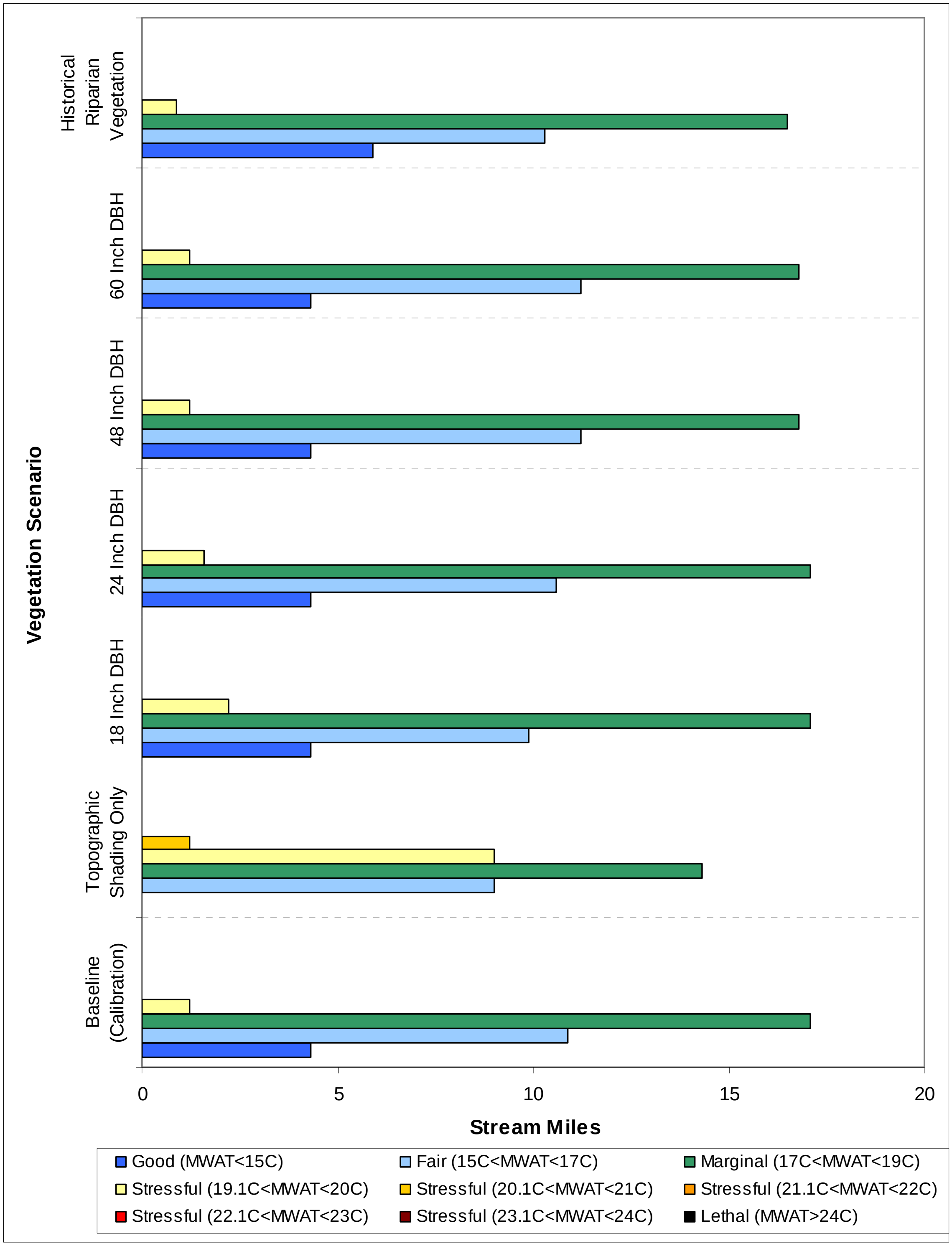

Figure A-38. Stream miles associated with each vegetation scenario in the Salt River watershed

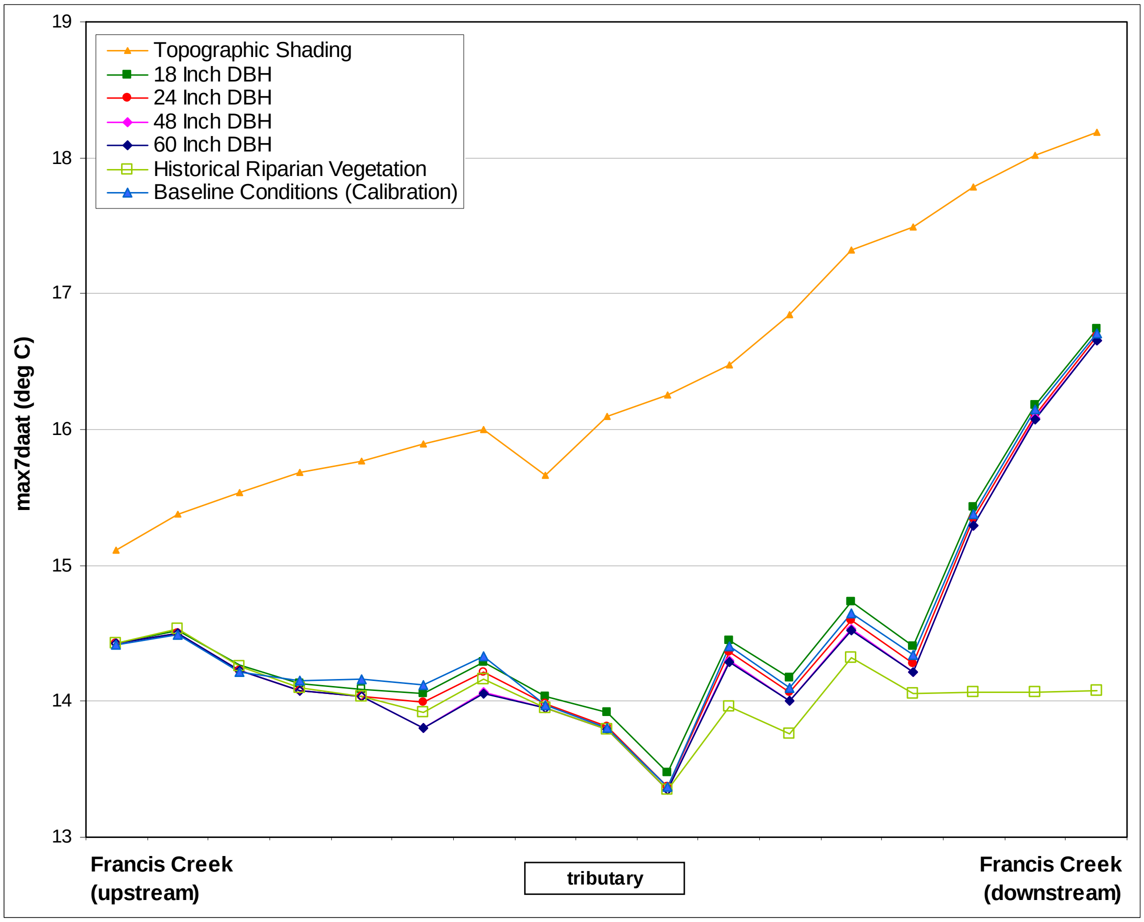

Figure A-39. Max7daat values for vegetation scenarios at Francis Creek

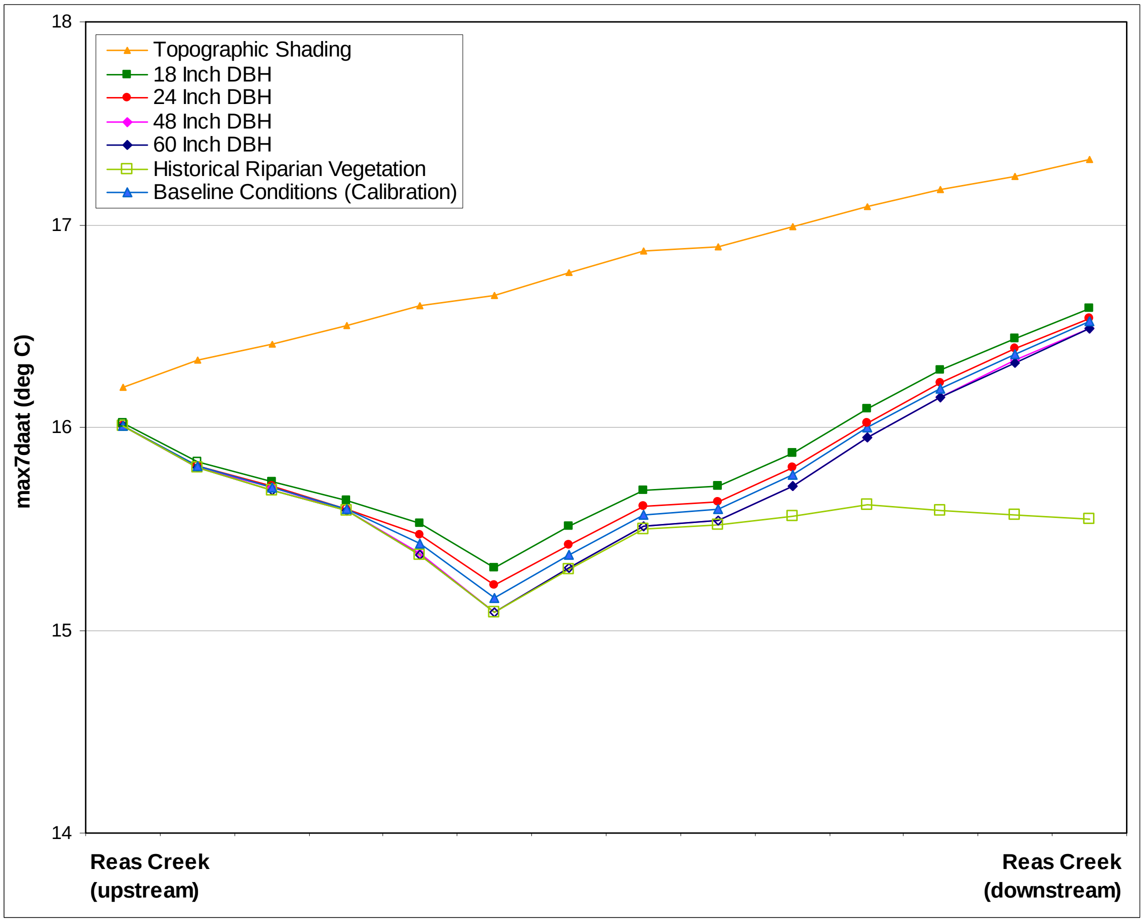

Figure A-40. Max7daat values for vegetation scenarios at Reas Creek

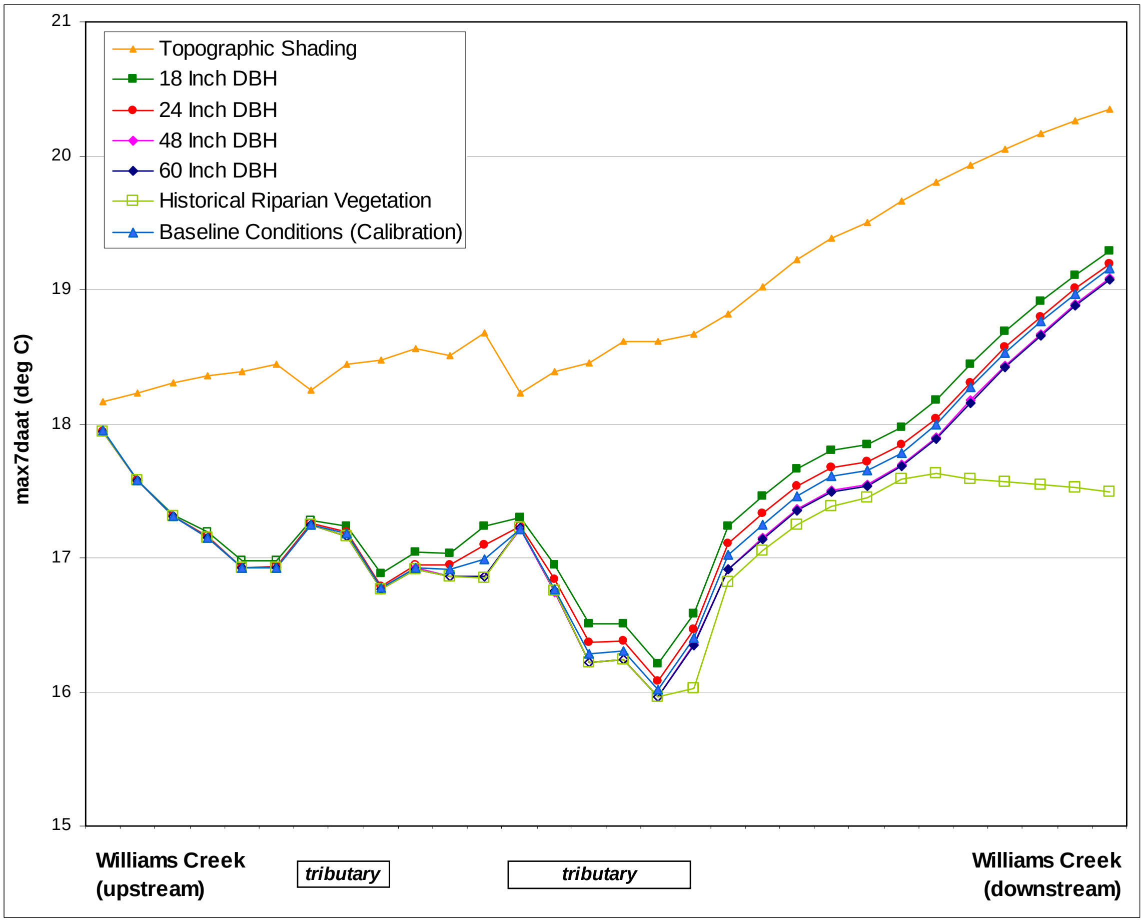

Figure A-41. Max7daat values for vegetation scenarios at Williams Creek

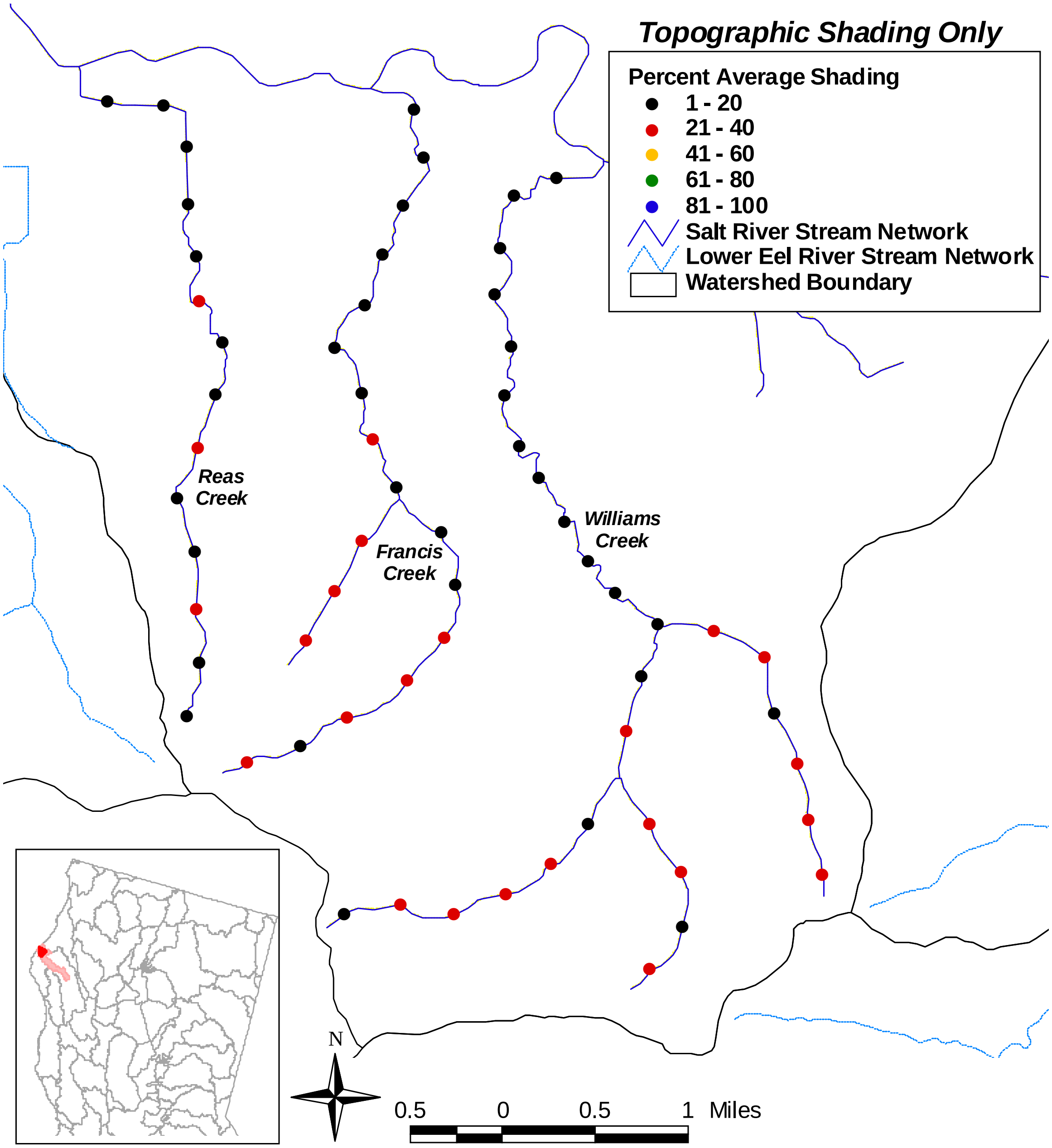

Figure A-42. Percent average shading for the topographic shading scenario for the creeks draining to Salt River

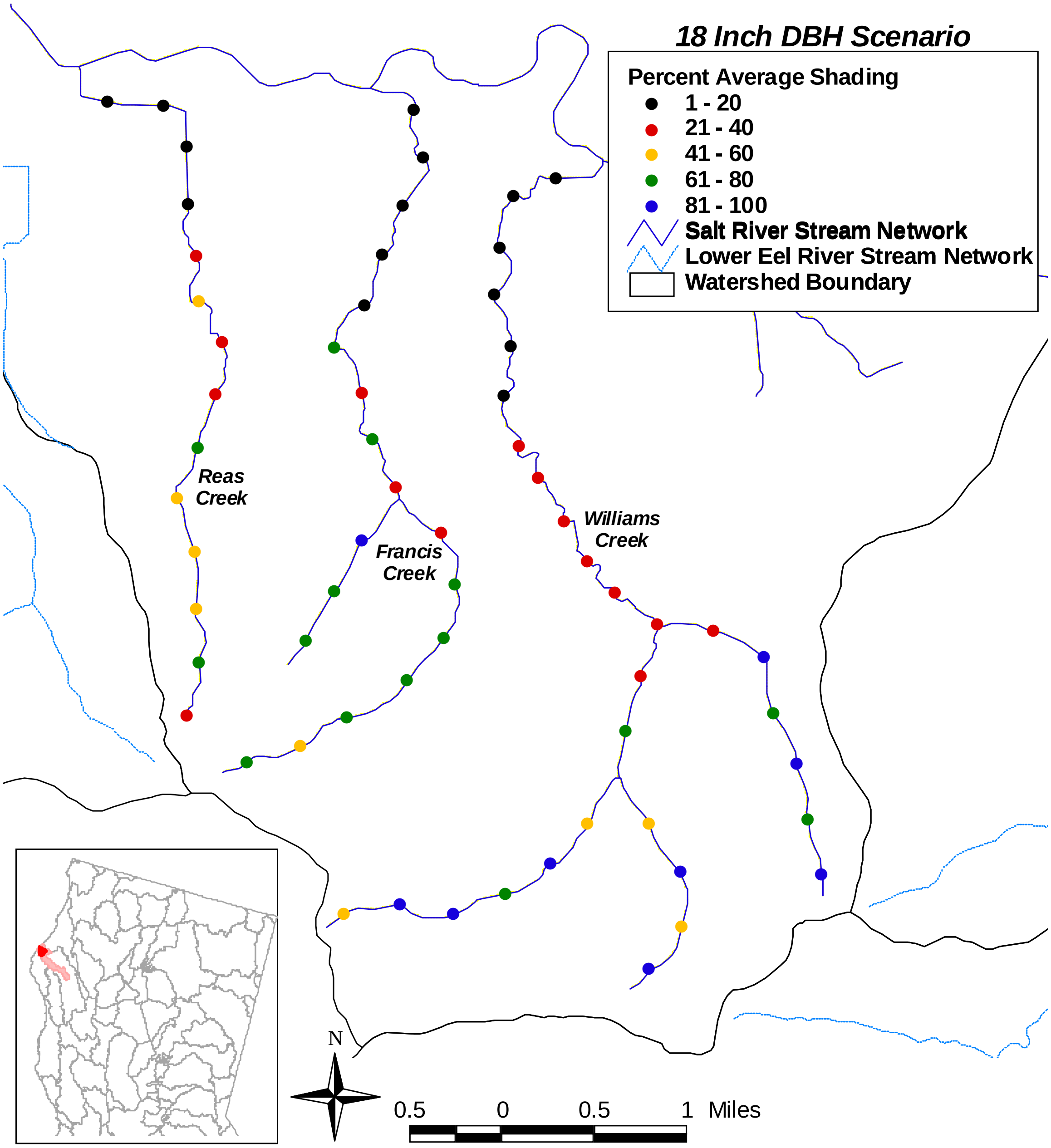

Figure A-43. Percent average shading for the 18 inch DBH vegetation scenario for the creeks draining to Salt River

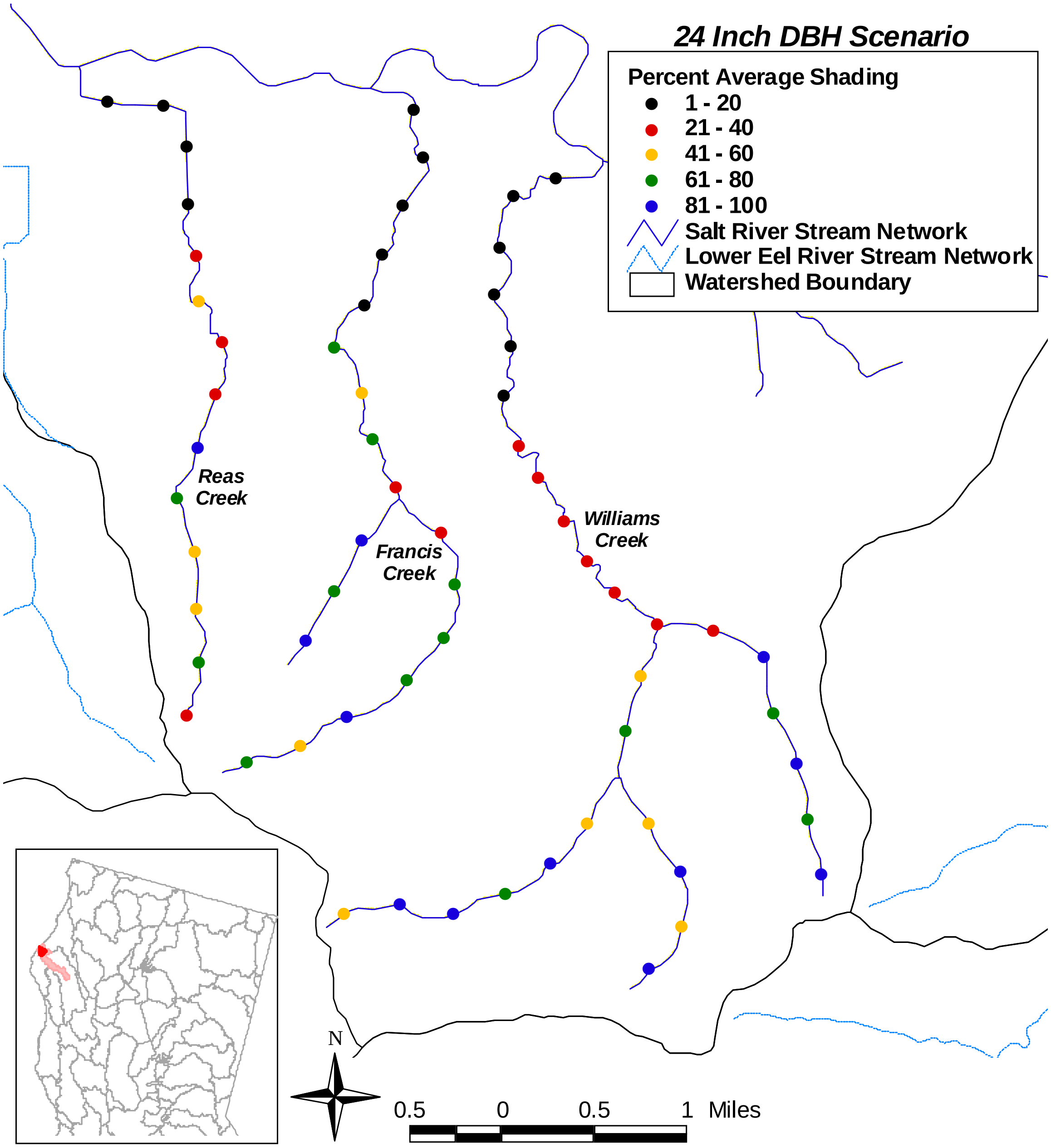

Figure A-44. Percent average shading for the 24 inch DBH vegetation scenario for the creeks draining to Salt River

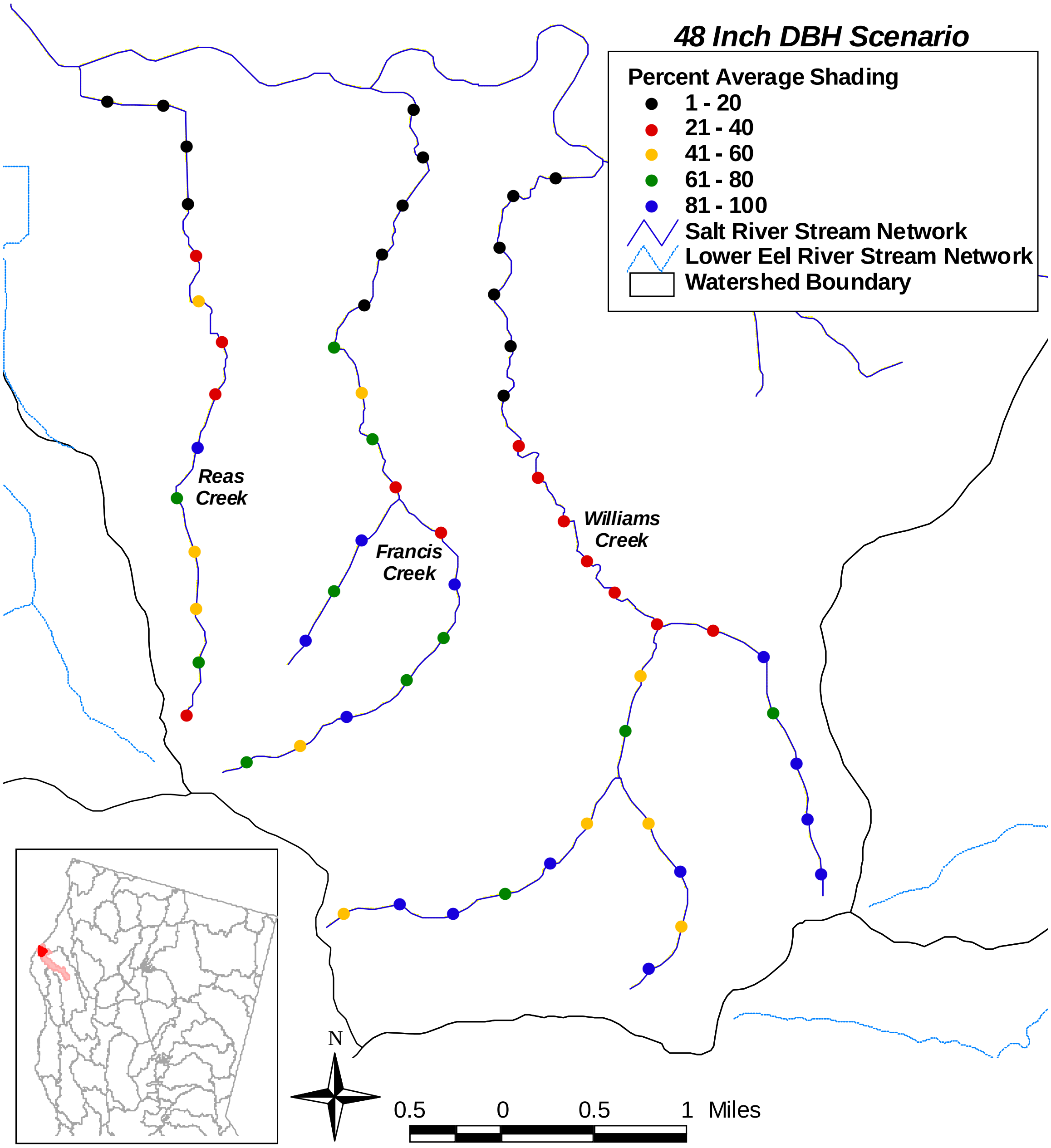

Figure A-45. Percent average shading for the 48 inch DBH vegetation scenario for the creeks draining to Salt River

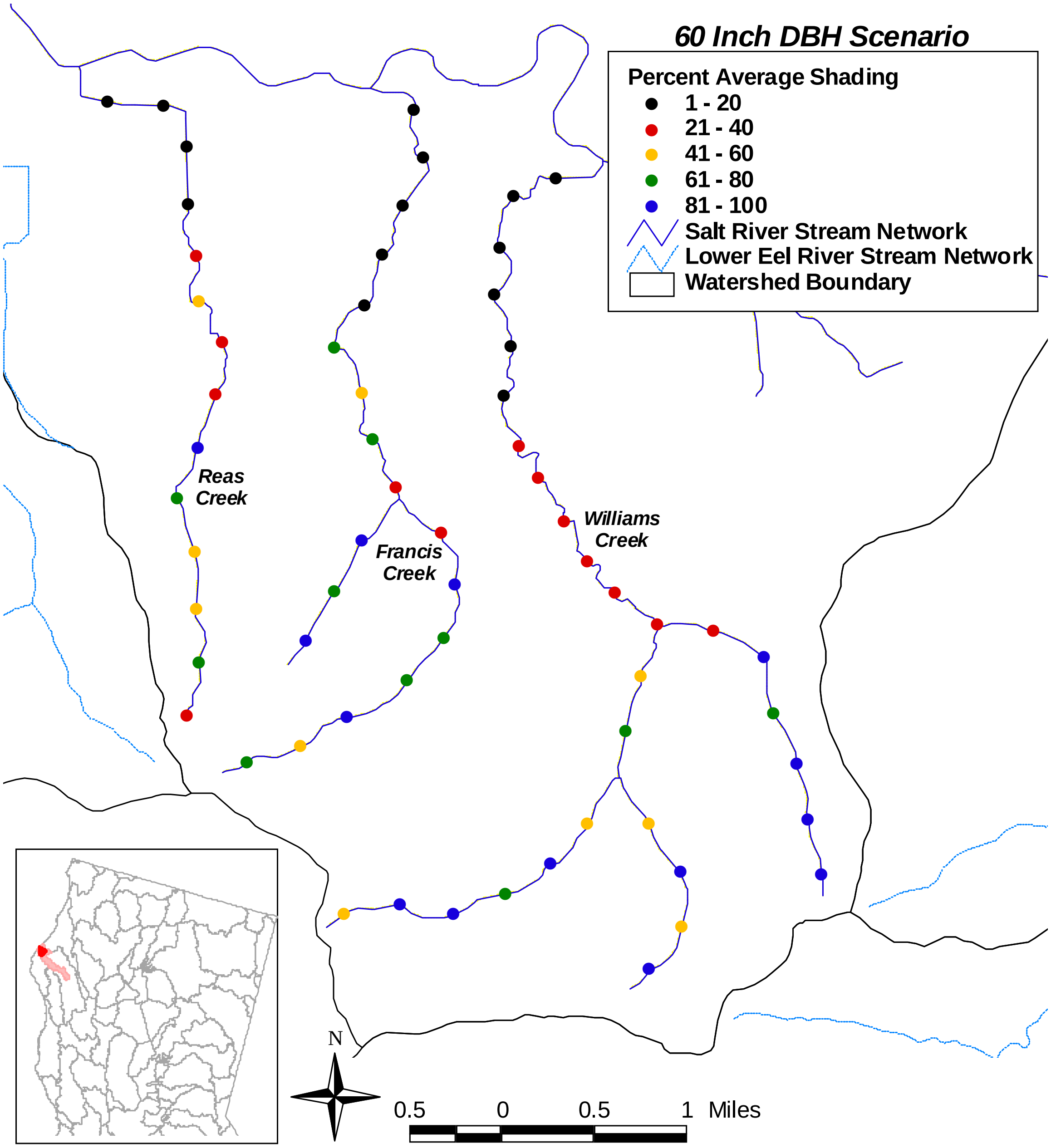

Figure A-46. Percent average shading for the 60 inch DBH vegetation scenario for the creeks draining to Salt River

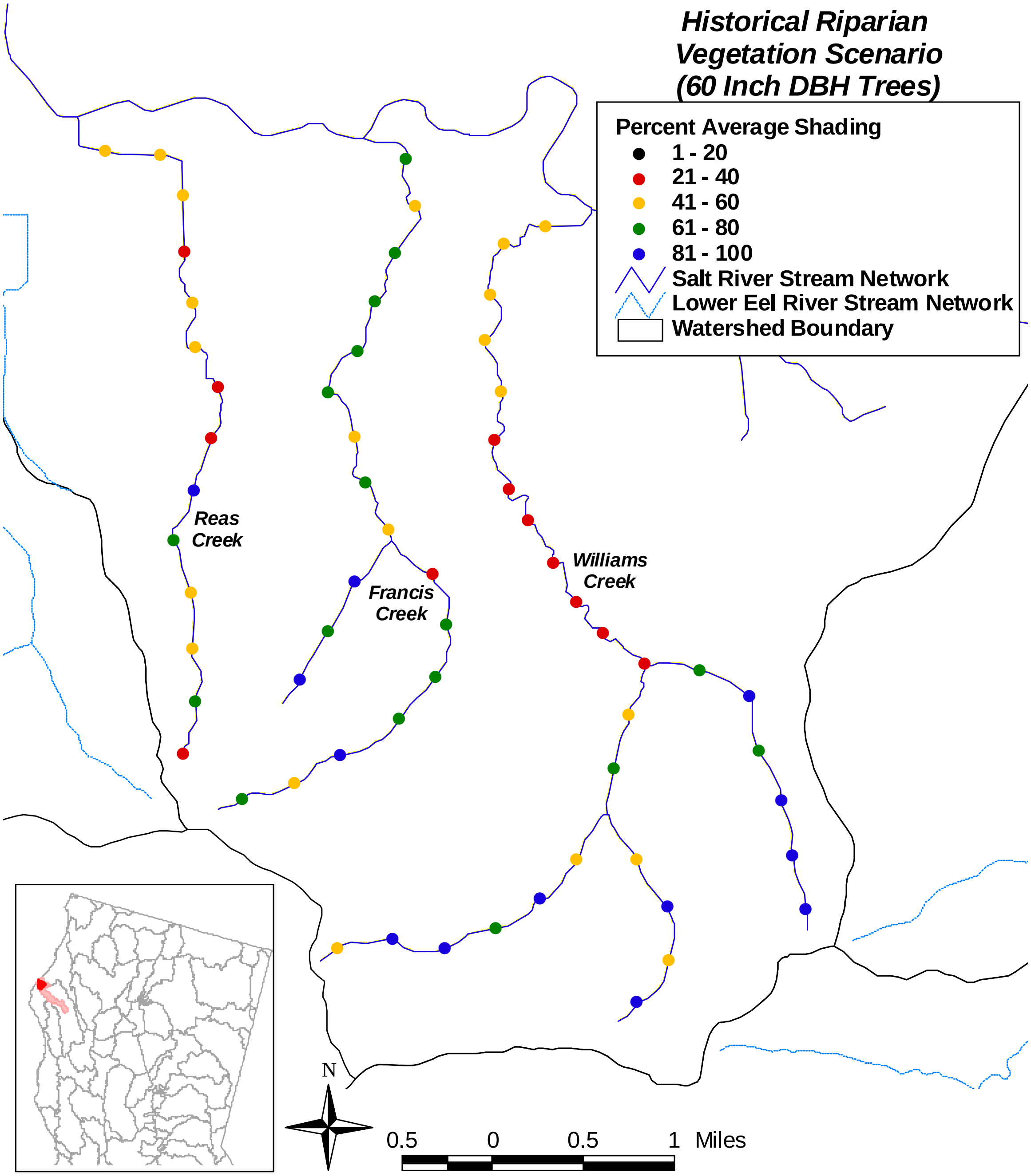

Figure A-47. Percent average shading for the historical riparian vegetation scenario for the creeks draining to Salt River

A.5 Model Application

The SHADE and Q2ESHADE model results can be used to determine temperature total maximum daily loads (TMDL) for solar radiation. Specifically, the various vegetation scenarios can be evaluated to determine which scenario most closely corresponds to natural stream temperatures. The model results for this scenario can then be summarized to calculate the average amount of radiation in Langleys per day that reach the stream network. This value is the TMDL. Model results can also be used to determine allocations, which are generally expressed in terms of percent shade.

A.6 References

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