Water Temperature Characteristics for Selected Northeastern Nevada Streams

August 2007

Downloading data from thermograph datalogger

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Acknowledgements

This report would not have been possible without the extensive temperature data collected by the Bureau of Land Management, Nevada Department of Wildlife, and Idaho Department of Environmental Quality, and the U.S. Geological Survey. A special thanks go out to Mark Dean (BLM - Elko) and Gary Johnson (NDOW) for their efforts in developing a substantial temperature dataset, and for sharing their insights.

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Introduction

Until recently, limited detailed temperature data existed for streams in Nevada. However with improvements in continuous temperature sensor technology, several resource management agencies such as Nevada Division of Environmental Protection, Nevada Department of Wildlife, BLM, etc., have begun collecting more detailed (hourly or more frequent) temperature data for numerous streams not previously monitored (at least at this level). Such information can be useful to NDEP in carrying out its responsibilities under the Clean Water Act such as: 1) evaluating existing standards; 2) adding new temperature criteria to new waters; and 3) determine impairment status of waters.

For this report, continuous and/or daily min/max temperature data collected by Nevada Department of Wildlife, Bureau of Land Management (Nevada and Idaho), Idaho Department of Environmental Quality, and U.S. Geological Survey were compiled for 78 sites in the Snake and Humboldt basins. The main purpose of this report is to:

- Summarize water temperature characteristics for northeastern Nevada streams for these 78 sites; and
- Describe general relationships between watershed and temperature characteristics

It is hoped that this information will be useful as Nevada moves forward in evaluating temperature criteria and determining the impairment status of its many waters. One result of these monitoring efforts is that more and more waters have been found to be out of compliance with the State's temperature standards. The Federal Clean Water Act requires that these waters be identified on the State's 303(d) List and that TMDL's (Total Maximum Daily Loads) ultimately be developed for these streams. However, NDEP wants to assure that appropriate water quality standards are in place prior to TMDL development.

Water Temperature and Aquatic Life

From an aquatic standpoint, it is well known that temperatures can have a significant impact upon the health of the aquatic ecosystem. According to Lewis et al. (2000), water temperature directly and indirectly influences fish physiology and behavior in several ways:

- Metabolism
- Food requirements, appetite and digestion rates
- Growth rates
- Developmental rates of embryos and alevins
- Timing of life-history events, including adult migrations, fry emergence and smoltification
- Competitor and predator-prey interactions
- Disease-host and parasite-host relationships"

In an attempt to protect the aquatic health, Nevada has incorporated maximum allowable temperature criteria into its water quality standards. NDEP is currently undertaking a review of water quality standards in the Snake and Humboldt River. It is hoped that the information presented in this report will aid NDEP in its review.

Summary of Nevada's Temperature WQ Standards

Many of the current temperature water quality standards for Snake and Humboldt basin streams were set nearly 25 years ago. The numeric criteria were set at levels required to support the fisheries of interest (coldwater or warmwater). However another important factor when assigning standards is considering the achievability of the standards. According to Nevada Revised Statutes (NRS) 445A.520, when setting standards, the standards must be reasonably attainable. It is most likely that there was little to no data which NDEP had at the time to determine the achievability of the temperature standards. One purpose of this study is to examine temperature and watershed relationship in hopes of identified factors useful in determining achievability of standards.

Nevada Administrative Code (NAC) 445A.118 through 445A.225 contains temperature water quality standards for the streams examined in this report. Many of the studied streams are considered cold-water fisheries in the NAC with maximum summer temperature standards of either 20º C or 21º C, depending upon the waterbody. Numerous streams in the study are not explicitly mentioned in the NAC. However under the tributary rule (NAC 445A.145), these streams are considered to have the temperature standards of the waterbody downgradient (either 20º C or 21º C in this study). Only one stream (lower Rock Creek) in the study is identified as a warmwater fishery with a maximum summer standard of 34º C. These coldwater and warmwater fisheries criteria were set in the late 1970s and early 1980s based upon recommendations of fisheries biologists.

While many factors affect the ability of a stream to meet its temperature water quality standard, only flow and its potential impacts are briefly recognized in the NAC. Streamflow in Nevada is highly variable from year to year depending upon the snowpack, other precipitation, and water diversions for any number of uses. This reality was recognized when NAC 445A.121(8) was adopted stating that standards are not considered violated when the natural conditions of the waterbody are outside the standards during times of extreme low flow. Typically, NDEP will rely on the 7Q10[1] statistics for a stream when determining a low flow threshold. However, it becomes problematic applying this approach to smaller streams, many of which do not have stream gage data.

When the temperature standards were set nearly 25 years ago, the criteria were chosen as needed to support the fisheries of interest (coldwater or warmwater). However another important factor when assigning standards is considering the achievability of the standards. According to Nevada Revised Statutes (NRS) 445A.520, when setting standards, the standards must be reasonably attainable. It is most likely that there was little to no data which NDEP had at the time to determine the achievability of the temperature standards.

Once water quality standards are added to the NAC, the criteria can be used in various ways: 1) setting limits on proposed discharges; 2) evaluating beneficial use support status; and 3) used as targets/goals for nonpoint source projects, such as stream restoration activities. If these criteria are not appropriate, it can lead to inappropriate decisions with permits, beneficial use support evaluations, and the need for nonpoint source projects. Such is the concern for some of the temperature criteria assigned to Nevada waters.

Under the Clean Water Act, any water quality actions taken by Nevada cannot impair the state's authority to allocate water. In other words, NDEP has no regulatory authority to seek reductions in diversions, require operational changes, etc. that could lead to increased flow in Nevada's streams. Given our reliance on many streams for irrigation, the assigned standards may not be achievable for some waters.

[1] The 7Q10 statistic is the lowest streamflow for 7consecutive days that occurs on average once every 10 years.

Factors Influencing Stream Temperatures

The temperatures found in streams can be highly variable with time and space depending upon cumulative influence of a myriad of upstream factors related to the heat budget. It is well recognized that components of a stream heat budget are related to physical watershed and stream characteristics.

Heat Budget Components

The following discussion provide a general introduction to the components of a waterbody heat budget. Theurer et al. (1984) describes five basic thermal processes that make up the heat balance for a waterbody: 1) radiation; 2) evaporation; 3) convection; 4) conduction; and 5) conversion of energy from other forms of heat (Figure 1).

Radiation

Solar Radiation: Radiation from the sun is a major component of a water's overall heat budget. Solar radiation levels that reach the water surface (assuming no topographic or vegetative shading) are a function of latitude, time of year, atmospheric conditions, and cloud cover. A portion of the solar radiation can be reflected off the water surface. The actual solar radiation that penetrates the water can be reduced by topographic and/or riparian vegetation shading. (Theurer et al., 1984).

Atmospheric Radiation: The atmosphere emits longwave radiation. Atmospheric radiation levels are a function of atmospheric moisture; air temperature; and cloud cover (Anderson et al., 1984; Theurer et al., 1984). The amount of atmospheric radiation reaching the waterbody can be reduced through interception by vegetative canopy or shading.

Topographic and Riparian Vegetation Radiation: Riparian shading can totally eliminates a portion of the solar radiation reaching the water. Riparian shading also intercepts longwave sources (atmospheric radiation) and replaces it with its own longwave radiation. The land near the waterbody also emits longwave radiation which may reach the waterbody (Theurer, et al., 1984)

Water Back Radiation: Water emits radiation and this is one factor that prevents the water temperature from increasing without limits (Theurer, et al., 1984).

Evaporation

Stream Evaporation: According to Parker and Krenkel (1969), the evaporative heat flux at the air-water interface is typically the most significant fact in dissipating stream heat. Evaporative cooling is a function of the water temperature, air temperature, relative humidity, and wind speed.

Convection

Convection: At the air-water interface, heat is exchanged in response to a heat energy gradient (difference between temperatures of water and air). The higher the difference in temperature, the higher the rate of heat energy transfer (Boyd and Kasper, 2003). The rate of heat exchange is also a function of relative humidity and wind speed.

Conduction

Streambed Conduction: Heat is transferred between the water column and the streambed in response to a heat difference between the water and streambed.

Other

Stream Fiction: Heat is generated by fluid friction as water flows downstream. Typically, fluid friction is the least significant source of heat, but can become noticeable in steep mountain streams (Theurer, 1984).

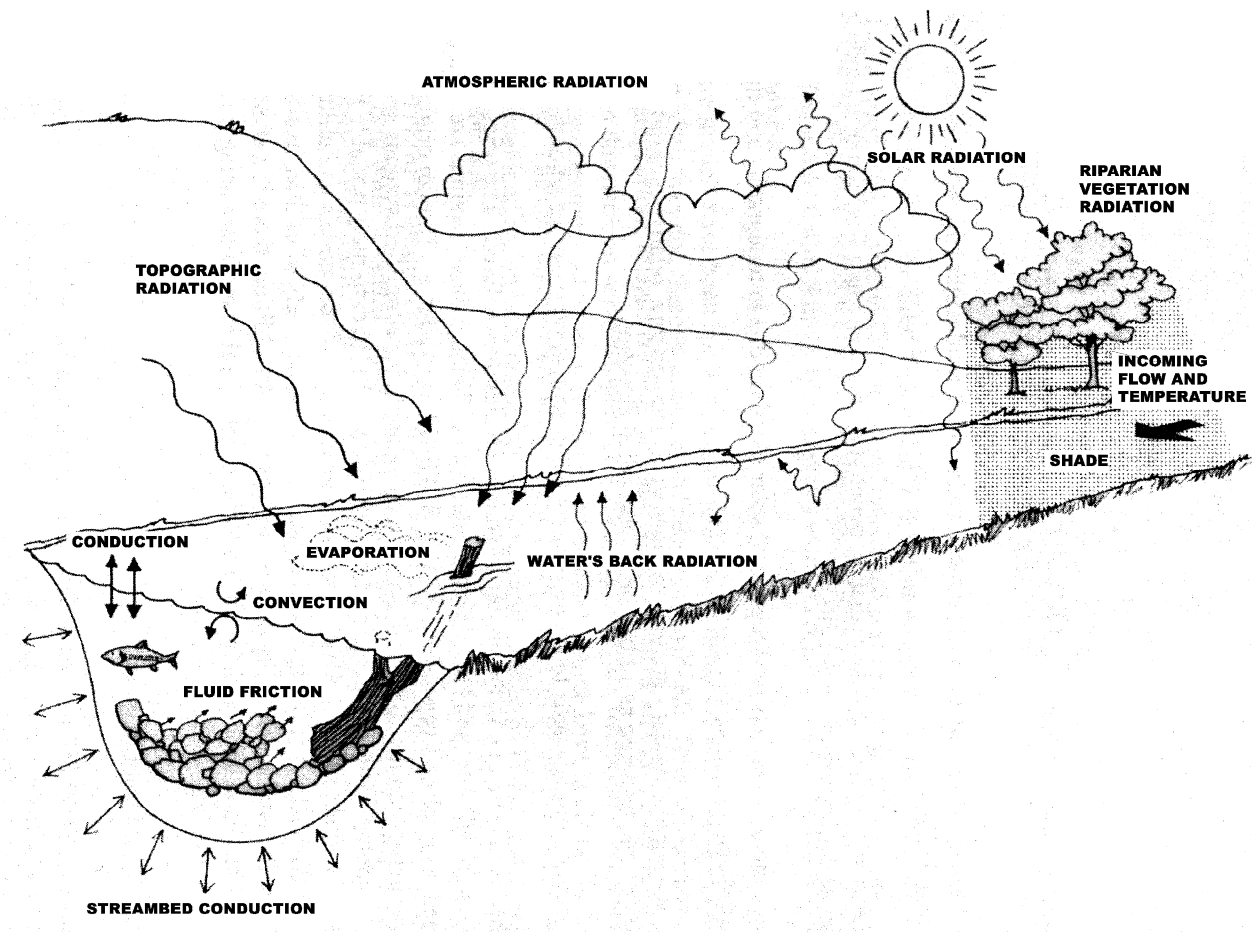

Figure 1. Stream Heat Flux Components (from Bartholow, 2000)

Watershed Characteristics Affecting the Heat Budget

Following is a brief description of some of the key watershed characteristics that affect a stream's heat budget, and thereby determine characteristics of the stream's temperature regime. Many of the discussed characteristics are interrelated.

Latitude: The latitude of a stream affects the angle at which solar radiation strikes the water surface, thereby affecting the solar radiation loading to the water (Theurer, 1984). In general, higher latitude (further north) waters receive less solar radiation than lower latitude waters.

Elevation/Area/Distance from Watershed Divide: Stream temperatures tend to increase with decreasing elevations, increasing watershed area, and increasing distance from the watershed divide (Allan, 1995). In general the farther water has to travel to get to a monitoring point, the longer time there is available for solar radiation, etc. to heat up the water.

Stream Order[2]: In general, stream order increases with increases in watershed area. Both have an influence upon the maximum stream temperatures and also upon the maximum daily temperature fluctuations experienced at a site. As shown by Vannote and Sweeney (1980), variations in daily temperature fluctuations from minimum to maximum tend to follow the relationship shown in Figure 2.

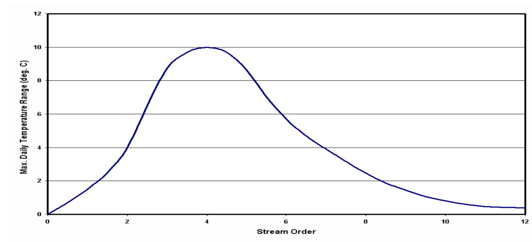

Figure 2. Maximum Daily Temperature Range in Relation to Stream Order (from Vannote and Sweeney (1980)

Shading (topographic and vegetative): Shading from the surrounding topography and riparian vegetation can reduce the amount of solar radiation reaches the water surface, resulting in cooler water.

Stream Orientation: Moore (1967) found that east-west oriented streams in Oregon could have temperatures 2 to 4.5º C warmer than similar north-south oriented streams. He concluded that longer exposure to direct solar radiation (to the east-west streams) is the likely explanation for the difference. Available solar radiation modeling confirms Moore's conclusion of increased solar radiation loading to the east-west stream. However for streams with no shading, the solar radiation loads are essentially the same regardless of stream orientation.

Bartholow (2004) developed the SSTEMP model to serve as a simplified tool to calculate the heat flux components for a stream and the resulting stream temperatures. Using SSTEMP to model fictitious streams with varying orientations, it was found that a north-south oriented stream has more vegetative and topographic shading than the same stream oriented east-west, confirming Moore's (1967) findings.

Flow: Flow plays a significant role in observed stream water temperatures. Higher flows lead to higher velocities resulting in less time for heating to occur. Additionally, higher flows provide more water mass that has to be heated. Flow can be correlated with elevation, watershed area, distance from watershed divide. The type of water year can have a significant influence upon the magnitude and timing of the maximum temperatures. For a given stream in the arid west, significant amounts of flow may be diverted to support agricultural operations, leading to diminished flows with higher water temperatures.

Stream width: Steeper streams generally are narrower, need less vegetation to provide the same level of shading that a wider stream would have. Stream widths can increase with increased flows, increased basin area (Lewis et al., 2000). Wide shallow channels can be more easily heated and cooled than deep narrow channels (Poole et al., 2001).

Stream gradient: Higher gradient streams can be expected to have lower temperatures for a couple reasons. Streams generally become narrower at higher gradients resulting in more effective riparian vegetation shading (Lewis et al., 2000). Also, faster flow velocities in higher gradient streams exposes the water to less heating.

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[2] Strahler's (1952) stream order system is a simple method of classifying stream segments based on the number of tributaries upstream. A stream with no tributaries (headwater stream) is considered a first order stream. A segment downstream of the confluence of two first order streams is a second order stream. Thus, a n^{th} order stream is always located downstream of the confluence of two $(n-1)^{th}$ order streams.

Groundwater: Groundwater inflows can be significantly cooler[3] (or hotter in the case of geothermal springs) than surface water and have a significant influence on stream temperatures. In a recent Thermal Infrared (TIR) survey of the Carson River, a 5º C drop in stream temperature was measured within a 1.5 mile stretch where groundwater contributions are deemed to be a likely cause (Watershed Sciences, Inc., 2006). Another factor affecting stream temperatures is the exchange of water between the stream and the surrounding hyporheic zone (see Figure 3). Significant hyporheic flow can serve as a buffer against water temperature fluctuations (Poole, et al., 2001; Poole and Berman, in press). As a result of groundwater inflows, stream temperatures can vary significant throughout a river reach. Figure 4 shows Carson River temperature varying from about 18 to 26 over a 20-mile reach likely due to groundwater influence.

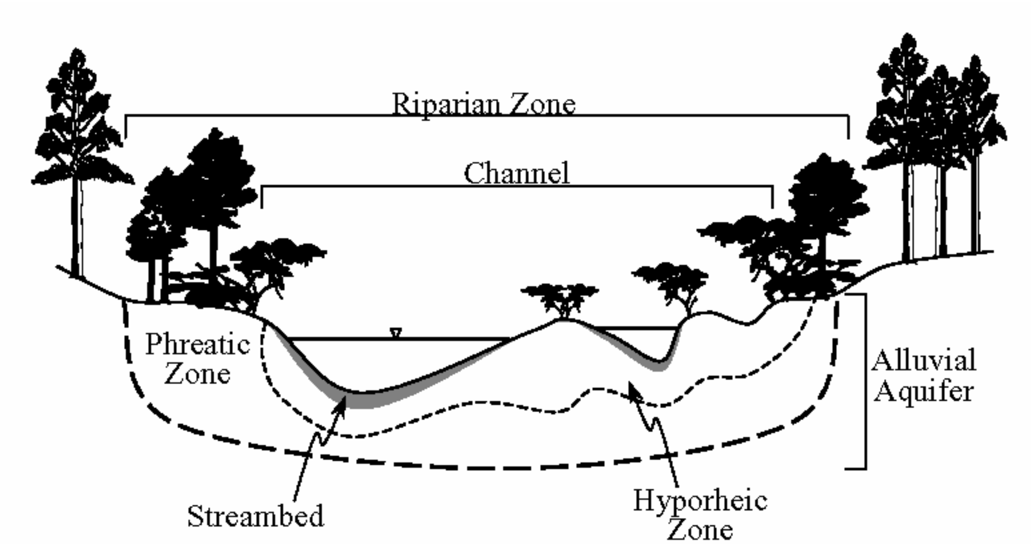

Figure 3. Hyporheic Zone of a Stream System (after Poole and Berman, in press)

Air Temperature: There has been significant debate over the role of air temperature in controlling stream temperatures. While a good correlation can exist between air temperature and water temperature, Johnson and Wondzell (2005) have found that direct solar radiation (not air temperature) was the largest contributor to changes in daily temperature. As Johnson and Wondzell concluded "…*just because air and stream temperatures are correlated does not mean that there is a cause-and-effect relationship*".

One reason air temperature can correlate well with stream temperature is that air temperature is well correlated with elevation, basin area (surrogates for time water is exposed to solar radiation, etc. Though the exchange of heat between the air and the water (convection) represents a small portion of the heat budget, air temperature affects other heat flux components such as atmospheric radiation and evaporation.

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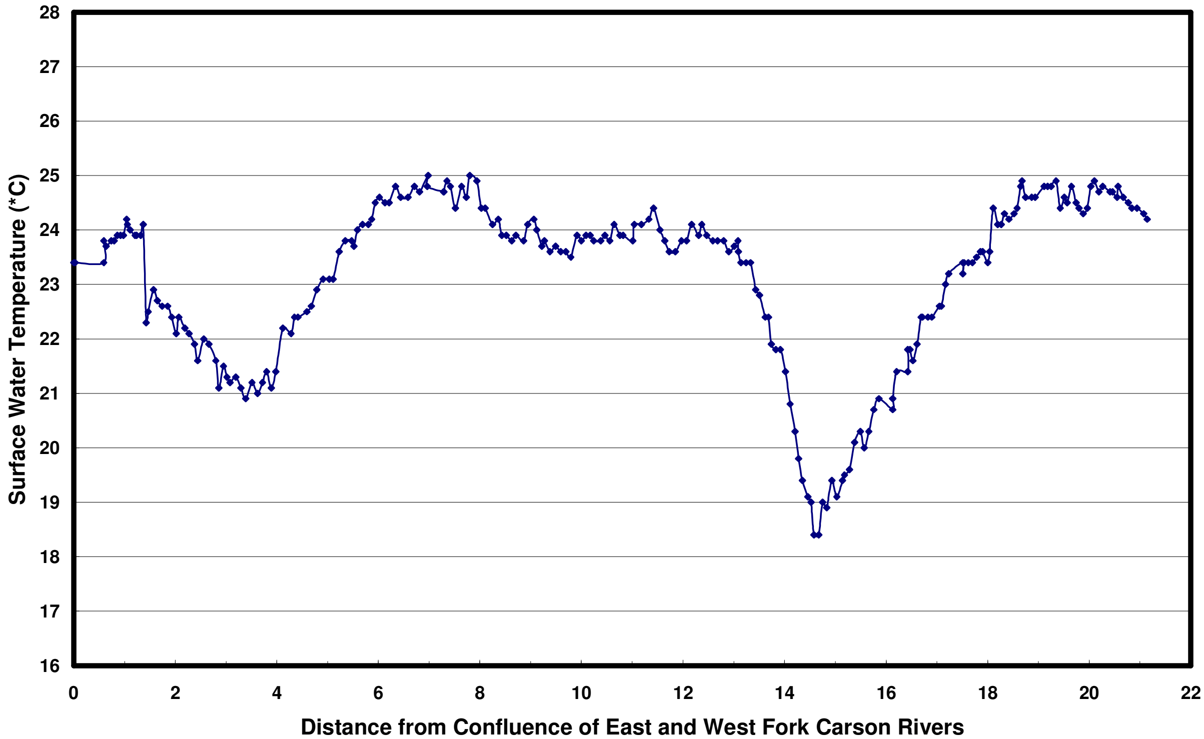
[3] Groundwater temperatures can vary about ± 3° C around the mean annual air temperature for the region (Adams and Sullivan, 1990). The Elko mean annual temperature is about 8° C (46° F).

Figure 4. Water Surface Temperature - Carson River above Deer Run Road (August 8, 2006)



Methodology

Continuous and/or daily min/max temperature data collected by Nevada Department of Wildlife, Bureau of Land Management (Nevada and Idaho), Idaho Department of Environmental Quality, and U.S. Geological Survey were compiled for 71 sites in the Snake and Humboldt basins. Some of these data had been submitted to Nevada as requested during development of the State's 2006 Integrated 303(d)/305(b) Report which generally presents those waters meeting and not meeting water quality standards. Other data were derived from available reports. Table 1 summarizes the 78 sites utilized in this study. Figure 5 presents a location map of the sites and their associated watershed areas.

A majority of the data for the 78 sites were for various years during the period 1998-2006, with a few exceptions (Marys River (MR-2; MR-3) and Bruneau River (B-3). For each site and dataset, the available documentation was reviewed to determine if the data were appropriate for inclusion in this study. Generally, data were included in the analysis if:

- ❑ There was adequate documentation on the site location; and
- ❑ Data were of sufficient quality and frequency for determining daily min/max temperatures for the summer period

Site Location: Many of the datasets had site coordinates (latitude/longitude, UTM). For some sites, only a general description (e.g. 225 feet above Jack Creek) with elevation were given. As needed, approximate site coordinates and site elevations were determined using available GIS layers showing streams, 7.5-minute topographic maps, etc. within ArcMap™ 9.1.

Table 1. List of Temperature Monitoring Sites Use d in Study

Site ID	Stream	Site	Hdyro-graphic Region	Watershed	Site Elev. (ft)	Period of Record	UTM Easting	UTM Northing	Datum	Data Source
BG-1	Little Goose Ck.	Little Goose Creek	Snake R.	Big Goose Creek	5540	2006	724922	4636772	NAD 27	Elko BLM
BG-2	Trout Creek	Trout Creek (Big Bend)	Snake R.	Big Goose Creek	5260	2005-06	738084	4646161	NAD 83	Elko BLM
BG-3	Goose Creek	Goose Creek	Snake R.	Big Goose Creek	5117	2000	742396	4647981	NAD 83	IDEQ
B-1	Bruneau River	Upper Bruneau River	Snake R.	Bruneau River	6110	2006	628391	4600390	NAD 27	Elko BLM
B-2	Bruneau River	Lower Bruneau River	Snake R.	Bruneau River	6090	2006	626438	4602404	NAD 27	Elko BLM
B-3	Bruneau River	Bruneau River	Snake R.	Bruneau River	2599	1997, 2000, 2004-06	604683	4736124	NAD 83	USGS
EFJ-1	Dave Creek	Upper Dave Creek	Snake R.	EF Jarbidge River	7600	1998-2003 (Avg. Only)	636586	4638876	NAD 83	NDOW
EFJ-2	Dave Creek	Lower Dave Creek	Snake R.	EF Jarbidge River	6000	2006	635050	4648451	NAD 83	Idaho BLM
EFJ-3	Slide Creek	Slide Creek	Snake R.	EF Jarbidge River	7160	1998-2003 (Avg. Only)	643257	4633234	NAD 83	NDOW
EFJ-4	Robinson Creek	Upper Robinson Creek	Snake R.	EF Jarbidge River	7030	1998-2003 (Avg. Only)	641996	4640373	NAD 83	NDOW
EFJ-5	Cougar Creek	Lower Cougar Creek	Snake R.	EF Jarbidge River	6800	1998-2003 (Avg. Only)	638647	4632713	NAD 83	NDOW
EFJ-6	Gods Pocket Creek	Gods Pocket Creek	Snake R.	EF Jarbidge River	6800	1998-2003 (Avg. Only)	641677	4634214	NAD 83	NDOW
EFJ-7	Fall Creek	Fall Creek	Snake R.	EF Jarbidge River	6560	1998-2003 (Avg. Only)	639071	4634571	NAD 83	NDOW
EFJ-8	EF Jarbidge R.	Upper EF Jarbidge River	Snake R.	EF Jarbidge River	7360	1998-2003 (Avg. Only)	639357	4627883	NAD 83	NDOW
EFJ-9	EF Jarbidge R.	Above Cougar Ck.	Snake R.	EF Jarbidge River	6800	2004	639331	4630803	NAD 83	NDOW
EFJ-10	EF Jarbidge R.	Below Slide Ck.	Snake R.	EF Jarbidge River	6240	2003-04	639872	4637975	NAD 83	NDOW
EFJ-11	EF Jarbidge R.	Above Robinson Ck.	Snake R.	EF Jarbidge River	5860	1997	638606	4644270	NAD 83	NDOW
EFJ-12	EF Jarbidge R.	Below Robinson Ck.	Snake R.	EF Jarbidge River	5838	2003	638715	4644712	NAD 83	NDOW
J-1	Deer Creek	Upper Deer Creek	Snake R.	Jarbidge River	7380	1998-2003 (Avg. Only)	627393	4635965	NAD 83	NDOW
J-2	Pine Creek	Upper Pine Creek	Snake R.	Jarbidge River	7280	1998-2003 (Avg. Only)	629064	4629381	NAD 83	NDOW
J-3	Fox Creek	Fox Creek	Snake R.	Jarbidge River	7040	1998-2003 (Avg. Only)	630997	4630847	NAD 83	NDOW
J-4	Jack Creek	Upper Jack Creek	Snake R.	Jarbidge River	6720	1998-2003 (Avg. Only)	633285	4639315	NAD 83	NDOW
J-5	Jack Creek	Lower Jack Creek	Snake R.	Jarbidge River	6320	1998-2003 (Avg. Only)	631840	4640098	NAD 83	NDOW
J-6	Jack Creek	Near Mouth	Snake R.	Jarbidge River	5880	2006	630663	4641188	NAD 83	Idaho BLM

Table 1. List of Temperature Monitoring Sites Use d in Study (cont'd)

Site ID	Stream	Site	Hdyro-graphic Region	Watershed	Site Elev. (ft)	Period of Record	UTM Easting	UTM Northing	Datum	Data Source
J-7	Bear Creek	Lower Bear Creek	Snake R.	Jarbidge River	6040	1998-2003 (Avg. Only)	630223	4637108	NAD 83	NDOW
J-7a	Buck Creek	Buck Creek	Snake River	Jarbidge River	5300	2006	631320	4652048	NAD 83	Idaho BLM
J-8	Jarbidge River	Upper Jarbidge River	Snake R.	Jarbidge River	7400	1998-2003 (Avg. Only)	632881	4628452	NAD 83	NDOW
J-9	Jarbidge River	Pine Ck. Campgraound	Snake R.	Jarbidge River	6570	1998-2003 (Avg. Only)	630369	4634024	NAD 83	NDOW
J-10	Jarbidge River	Above Jarbidge	Snake R.	Jarbidge River	6240	2001-04	630160	4636380	NAD 83	NDOW
J-11	Jarbidge River	At Cemetery Rd.	Snake R.	Jarbidge River	6040	2002	630329	4638889	NAD 83	NDOW
J-12	Jarbidge River	Above Jack Ck.	Snake R.	Jarbidge River	5885	2001	630632	4641176	NAD 83	NDOW
J-12a	Jarbidge River	Below Jack Creek	Snake R.	Jarbidge River	5880	2006	630565	4641246	NAD 83	Idaho BLM
J-12b	Jarbidge River	Below Deer Creek	Snake River	Jarbidge River	5740	2006	630956	4643614	NAD 83	Idaho BLM
J-13	Jarbidge River	At Freighter's Defeat Draw	Snake R.	Jarbidge River	5560	2001	631412	4646571	NAD 83	NDOW
J-15	Jarbidge River	Below EF Jarbidge R.	Snake R.	Jarbidge River	5117	2000	633156	4656583	NAD 83	IDEQ
J-16	Jarbidge River	Below Poison Creek	Snake River	Jarbidge River	4200	2006	619857	4678409	NAD 83	Idaho BLM
J-17	Jarbidge River	At Bruneau River	Snake River	Jarbidge River	3660	2006	611037	4687209	NAD 83	Idaho BLM
SF-1	WF Deer Ck.	WF Deer Ck. A	Snake R.	Salmon Falls Ck.	6520	2005	657031	4607408	NAD 83	Elko BLM
SF-2	WF Deer Ck.	WF Deer Ck. B	Snake R.	Salmon Falls Ck.	6250	2005	658027	4610189	NAD 83	Elko BLM
SF-3	WF Deer Ck.	WF Deer Ck. C	Snake R.	Salmon Falls Ck.	6200	2005	658204	4610414	NAD 83	Elko BLM
SF-4	Deer Ck.	Deer Creek	Snake R.	Salmon Falls Ck.	5980	2006	659876	4614372	NAD 83	Elko BLM
SF-5	Camp Ck.	Upper Camp Ck.	Snake R.	Salmon Falls Ck.	6460	2006	647932	4619516	NAD 83	Elko BLM
SF-6	Camp Ck.	Lower Camp Ck.	Snake R.	Salmon Falls Ck.	5860	2006	660969	4618832	NAD 83	Elko BLM
SF-7	Shack Ck.	Shack Creek	Snake R.	Salmon Falls Ck.	6320	2003-06	670288	4648095	NAD 27	Elko BLM
SF-8	NF Cottonwood Ck.	NF Cottonwood Ck.	Snake R.	Salmon Falls Ck.	6100	2004-05	654116	4624324	NAD 83	Elko BLM
SF-9	SF Cottonwood Ck.	SF Cottonwood Ck.	Snake R.	Salmon Falls Ck.	6100	2005-06	654183	4623843	NAD 83	Elko BLM
SF-10	Sun Ck. (SF Salmon Falls Ck.)	Sun Ck. (SF Salmon Falls Ck.)	Snake R.	Salmon Falls Ck.	5860	2006	660907	4618700	NAD 83	Elko BLM
SF-11	NF Jakes Ck.	NF Jakes Creek	Snake R.	Salmon Falls Ck.	5840	2003-05	673400	4607179	NAD 27	Elko BLM
SF-12	SF Salmon Falls Ck.	SF Salmon Falls Creek	Snake R.	Salmon Falls Ck.	5780	2003-06	662817	4622444	NAD 83	Elko BLM

Table 1. List of Temperature Monitoring Sites Use d in Study (cont'd)

Site ID	Stream	Site	Hdyro-graphic Region	Watershed	Site Elev. (ft)	Period of Record	UTM Easting	UTM Northing	Datum	Data Source
SF-13	Hot Creek	Above Shoshone Ck.	Snake R.	Salmon Falls Ck.	5620	2000, 2002-03	711697	4654686	NAD 83	IDEQ
SF-14	Shoshone Ck.	Above Hot Creek	Snake R.	Salmon Falls Ck.	5620	2000, 2002-03	711597	4654786	NAD 83	IDEQ
SF-15	Shoshone Ck.	Below Magic Springs	Snake R.	Salmon Falls Ck.	5458	2000, 2003	705657	4655486	NAD 83	IDEQ
SF-16	Shoshone Ck.	At NV/ID Stateline	Snake R.	Salmon Falls Ck.	5389	2003	703997	465086	NAD 83	IDEQ
SFO-1	SF Owyhee R.	At USGS Gage	Snake R.	SF Owyhee River	4880	1999-2003, 2006	543662	4628006	NAD 83	Elko BLM
SFO-2	SF Owyhee R.	At Pipeline	Snake R.	SF Owyhee River	4670	1999-2001, 2003	527151	4643890	NAD 83	Elko BLM
MC-1	Toro Canyon	Toro Canyon	Humboldt R.	Maggie Ck.	6440	2006	562629	4550894	NAD 27	Elko BLM
MC-2	Beaver Creek	Beaver Creek	Humboldt R.	Maggie Ck.	5800	2003-04, 2006	569099	4547526	NAD 27	Elko BLM
MR-1	Hanks Creek	Hanks Creek	Humboldt R.	Marys R.	5860	2002-06	643079	4593218	NAD 83	Elko BLM
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt R.	Marys R.	5940	1993, 1997, 1999, 2002, 2004-06	641195	4601217	NAD 83	USGS
MR-3	Marys River	Marys River below Twin Butte (10315600)	Humboldt R.	Marys R.	5410	1993, 1995-98, 2006	645427	4556449	NAD 83	USGS
PC-1	Trout Creek	Upper Trout Creek	Humboldt R.	Pine Ck.	5680	2004-06	580018	4479621	NAD 83	Elko BLM
PC-2	Trout Creek	Middle Trout Creek	Humboldt R.	Pine Ck.	5440	2006	579024	4477952	NAD 27	Elko BLM
PC-3	Trout Creek	Lower Trout Creek	Humboldt R.	Pine Ck.	5360	2004	577885	4477777	NAD 83	Elko BLM
RC-1	Rock Creek	Upper Rock Creek 1	Humboldt R.	Rock Ck.	6900	2001, 2006	553066	4577530	NAD 27	Elko BLM
RC-2	Rock Creek	Upper Rock Creek 2	Humboldt R.	Rock Ck.	4840	2005	525296	4530339	NAD 27	Elko BLM
RC-3	Rock Creek	Lower Rock Creek	Humboldt R.	Rock Ck.	4670	2005	534897	4519385	NAD 27	Elko BLM
RC-4	Lewis Creek	Lewis Creek	Humboldt R.	Rock Ck.	6300	2004-06	549906	4571735	NAD 27	Elko BLM
RC-5	Nelson Creek	Upper Nelson Creek	Humboldt R.	Rock Ck.	5920	2006	548178	4569163	NAD 27	Elko BLM
RC-6	Nelson Creek	Lower Nelson Creek	Humboldt R.	Rock Ck.	5700	2003-05	545762	4568738	NAD 27	Elko BLM
RC-7	Willow Creek	Willow Creek	Humboldt R.	Rock Ck.	5450	2003, 2005-06	544744	4562915	NAD 27	Elko BLM
SFH-1	Pearl Creek	Upper Pearl Creek	Humboldt R.	SF Humboldt R.	6300	2006	617645	4460698	NAD 27	Elko BLM
SFH-2	Pearl Creek	Middle Pearl Creek	Humboldt R.	SF Humboldt R.	6140	2006	616363	4460887	NAD 27	Elko BLM
SFH-3	Pearl Creek	Lower Pearl Creek	Humboldt R.	SF Humboldt R.	6130	2006	616172	4460929	NAD 27	Elko BLM

Table 1. List of Temperature Monitoring Sites Use d in Study (cont'd)

Site ID	Stream	Site	Hdyro-graphic Region	Watershed	Site Elev. (ft)	Period of Record	UTM Easting	UTM Northing	Datum	Data Source
SFLH-1	Secret Creek	Secret Creek	Humboldt R.	SF Little Humboldt R.	6400	2003, 2005-06	511194	4568576	NAD 27	Elko BLM
SFLH-2	Sheep Creek	Sheep Creek	Humboldt R.	SF Little Humboldt R.	6200	2002-06	511140	4570834	NAD 27	Elko BLM
SFLH-3	SF Little Humbolt River	Below Oregon Flat	Humboldt R.	SF Little Humboldt R.	6100	2002-06	512220	4572149	NAD 27	Elko BLM
SFLH-4	SF Little Humboldt River	Above Pole Creek	Humboldt R.	SF Little Humboldt R.	5960	2002, 2005-06	511521	4574129	NAD 83	Elko BLM
SC-1	Sherman Creek	Sherman Creek	Humboldt R.	SF Little Humboldt R.	5650	2005-06	606238	4534092	NAD 27	Elko BLM

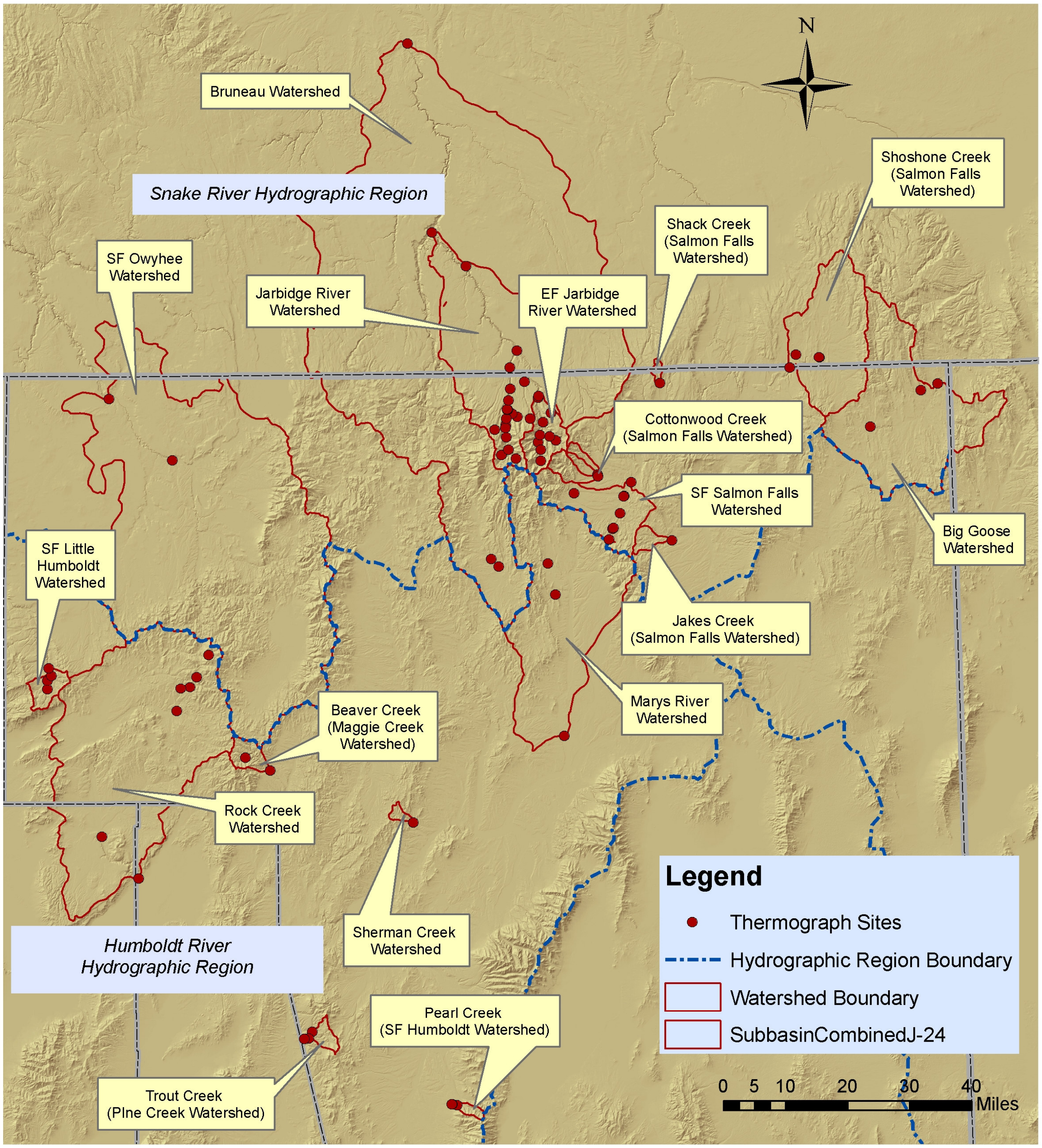


Figure 5. Study Area with Thermograph and Watershed Locations

It must be recognized that the placement of the thermograph whether in a pool, riffle, area with groundwater influence can have significant influence of the measured temperatures. No documentation was available on these types of specifics regarding the monitoring sites.

Data Adequacy: Data were included if: 1) thermograph readings were collected at least every 2 hours OR if daily minimum/maximum data were available (a vast majority of the data were collected at 0.5 to 1 hour frequency); and 2) data were available for at least July and August or the data appear to have captured the peak temperature period. Data were not included if there were wide daily fluctuations suggesting the thermograph was dry[4]. The first step in evaluating the appropriateness of a dataset was to generate x-y plots of the data to look for any anomalies. In some instances, thermographs were logging data prior to deployment in the stream and following removal from the stream. These values were removed prior to any calculations.

Temperature metrics

For each year of data at each site, the following metrics were calculated:

- MDMT - Maximum daily maximum temperature
- MWMT – Maximum weekly maximum temperature (Maximum average of maximum daily temperatures over any seven-day period)
- MDAT - Maximum daily average temperature
- MWAT – Maximum weekly average temperature (Maximum average of average daily temperatures over any seven-day period)

In addition, the date at which the MDMT and MDAT occurred were also determined. For several sites in the upper Jarbidge and EF Jarbidge drainage, detailed continuous temperature data were not available. Average (1998-2003) MDMT, MWMT and MDAT values for these sites were taken from the *Draft Bull Trout Species Management Plan for the Nevada Portion of the Jarbidge River Drainage Basin* (Johnson et al., 2005), with no ranges available.

Watershed Characteristics

A number of watershed characteristics were developed for each temperature site in the study watersheds. The first step was to digitize the watershed boundaries from 1:100,000 topographic maps within ArcMap™ 9.1. Next using XTools, the watershed areas were calculated. Based upon 30-meter DEM (Digital Elevation Model) raster files, Spatial Analyst™ was used to determine the maximum and mean elevations within the watershed, along with the mean slope.

[4] Near-dry to dry conditions were not uncommon at a number of sites leading to high temperatures.

Findings

Table 2 provides a summary of the temperature metric ranges for MDMT, MWMT, MDAT and MWAT for each of the 78 sites. The metrics for each year of data are summarized in Appendix A. The reader needs to be cautioned that data collected at any one of these site may only be representative of temperature conditions within the immediate area of the site. As already discussed, stream temperatures can be highly variable over time and space. Flow conditions for a given year can have a significant impact upon the maximum temperatures experienced in a waterbody.

Table 3 provides flow conditions for selected USGS gaging stations within the study area. For most of the selected gages, 2001 was the driest year during the period 1998-2005, with the highest flows in 1998 and 2005 (see Figure 6). Therefore, one might expect that in general streams in the area experienced higher water temperatures in 2001 than in the other years. However without detailed flow data for a given stream, limited conclusions can be made regarding the temperature data and any relationships with flows.

Compliance with Standards

All of the 15 NDOW sites in the upper Jarbidge and EF Jarbidge watershed had average MDMT values less than the water quality standards. Of the 52 sites with applicable Nevada standards for coldwater species (excluding the 15 NDOW sites), only 10 sites had no exceedances of the temperature water quality standards. All of these sites were located above elevation 5700 feet. The two sites (RC-2, RC-3) with warmwater temperature standards (34° C) had no exceedances of the standard. The four sites in Nevada with no temperature standards (PC-1, PC-2, PC-3, SC-1) all experienced MDMT values greater than 23° C.

As expected, the number of days of exceedances for a given site varied from year depending upon flow, climate, etc. conditions. The number of days with exceedances in a year ranged from 0 to over 100 days depending upon the site and year (see Appendix A). In general, a waterbody is considered impaired for the 303(d) List if more than 10% of the days sampled have temperature levels greater than the standard. However, more detailed investigations (including biological data, etc.) are typically needed to truly determine impairment.

As discussed above, NAC 445A.121(8) states that standards are not considered violated during extreme low flows. Since most of the sites had none to limited gaging data, it was not possible to determine how many of the exceedances actually occurred during these "extreme" periods. It must be noted that a number of sites in this study appeared to experience dry conditions at times. However, the standards do not adequately define what conditions are needed to qualify for the "extreme" exemption.

Relationships between Temperature Metrics

The available data indicates that the MWMT (maximum average of daily maximum temperatures over 7-day period) is generally about 95% of the MDMT (maximum daily maximum temperature) (Figure 7). Figure 7 shows little scatter in the data, thus a high R^2 is calculated for the linear regression. However, a plot (Figure 8) between MDAT (maximum daily average temperature) and MDMT shows more variability in the data. A linear regression indicates that MDAT values are approximately 82% of MDMT values, with the MDAT data ranging from about 75% to 95% of the MDMT data. Figure 9 shows that MWAT (maximum average temperature over 7-day period) vales are approximately 98% of MDAT.

Table 2. Summary of Temperature Metrics for Temperature Monitoring Sites (ºC)

Site ID	Site	Hdyro-graphic Region	Watershed	Period of Record	MDMT	MWMT	MDAT	MWAT	Max. Daily Change	Max. WQS
BG-1	L. Goose Ck.	Snake R.	Big Goose Creek	2006	30.4	28.8	22.6	21.5	18.4	21 (trib)
BG-2	Trout Ck.	Snake R.	Big Goose Creek	2005-06	27.1 – 28.2	26.3 – 27.2	21.9 – 23.1	21.5 – 21.7	12.5 – 14.9	21 (trib)
BG-3	Goose Creek	Snake R.	Big Goose Creek	2000	25.8	24.7	20.1	19.2	14.1	21
B-1	Upper Bruneau	Snake R.	Bruneau River	2006	27.8	26.66	22.4	21.9	11.7	21
B-2	Lower Bruneau	Snake R.	Bruneau River	2006	32.4	30.2	25.0	23.9	16.1	21
B-3	Bruneau (Idaho)	Snake R.	Bruneau River	1997, 2000, 2004-2006	27.8 – 31.6	27.2 – 30.9	25.3 – 28.8	24.6 – 28.0	6.7 – 8.8	NA
EFJ-1	Upper Dave Ck.	Snake R.	EF Jarbidge River	1998-2003 (Avg. Only)	6.8	6.3	5.4	NA	NA	21 (trib)
EFJ-2	Lower Dave Ck.	Snake R.	EF Jarbdidge	2006	18.0	17.3	16.1	15.6	NA	21 (trib)
EFJ-3	Slide Ck.	Snake R.	EF Jarbidge River	1998-2003 (Avg. Only)	13.7	13.0	11.0	NA	NA	21 (trib)
EFJ-4	Upper Robinson	Snake R.	EF Jarbidge River	1998-2003 (Avg. Only)	15.2	14.6	12.1	NA	NA	21 (trib)
EFJ-5	Lower Cougar	Snake R.	EF Jarbidge River	1998-2003 (Avg. Only)	16.6	16.0	14.1	NA	NA	21 (trib)
EFJ-6	Gods Pocket	Snake R.	EF Jarbidge River	1998-2003 (Avg. Only)	13.1	12.6	11.6	NA	NA	21 (trib)
EFJ-7	Fall Creek	Snake R.	EF Jarbidge River	1998-2003 (Avg. Only)	14.0	13.2	11.8	NA	NA	21 (trib)
EFJ-8	Upper EF Jarbidge	Snake R.	EF Jarbidge River	1998-2003 (Avg. Only)	12.5	12.1	9.9	NA	NA	21
EFJ-9	EF Jarbidge ab. Cougar	Snake R.	EF Jarbidge River	2004	17.7	17.0	13.9	13.3	8.2	21
EFJ-10	EF Jarbidge bel. Slide Ck.	Snake R.	EF Jarbidge River	2003-04	20.4 – 22.3	19.7 – 21.0	15.5 – 17.9	14.7 – 17.1	10.2 – 11.3	21
EFJ-11	EF Jarbidge ab. Robinson	Snake R.	EF Jarbidge River	1997	20.5	19.5	16.3	15.9	8.5	21
EFJ-12	EF Jarbidge bel. Robinson	Snake R.	EF Jarbidge River	2003	25.3	23.4	20.4	19.3	10.9	21
J-1	Upper Deer Creek	Snake R.	Jarbidge River	1998-2003 (Avg. Only)	16.8	15.8	12.7	NA	NA	21 (trib)
J-2	Upper Pine Creek	Snake R.	Jarbidge River	1998-2003 (Avg. Only)	15.7	14.9	11.9	NA	NA	21 (trib)
J-3	Fox Creek	Snake R.	Jarbidge River	1998-2003 (Avg. Only)	15.5	14.8	13.7	NA	NA	21 (trib)
J-4	Upper Jack Creek	Snake R.	Jarbidge River	1998-2003 (Avg. Only)	14.2	13.9	12.6	NA	NA	21 (trib)

Table 2. Summary of Temperature Metrics for Temperature Monitoring Sites (ºC) (cont'd)

Site ID	Site	Hdyro-graphic Region	Watershed	Period of Record	MDMT	MWMT	MDAT	MWAT	Max. Daily Change	Max. WQS
J-5	Lower Jack Creek	Snake R.	Jarbidge R.	1998-2003 (Avg. Only)	14.8	14.1	13.4	NA	NA	21 (trib)
J-6	Jack Creek near Mouth	Snake R.	Jarbidge R.	2006	17.0	16.2	14.7	14.2	NA	21 (trib)
J-7	Lower Bear Creek	Snake R.	Jarbidge R.	1998-2003 (Avg. Only)	18.4	17.4	15.6	NA	NA	20
J-7a	Buck Creek	Snake R.	Jarbidge R.	2006	19.9	19.3	17.6	17.4	NA	NA
J-8	Upper Jarbidge River	Snake R.	Jarbidge R.	1998-2003 (Avg. Only)	11.7	11.3	10.4	NA	NA	21
J-9	Jarbidge R. @ Pine Ck. Campgraound	Snake R.	Jarbidge R.	1998-2003 (Avg. Only)	18.4	17.5	14.7	NA	NA	21
J-10	Jarbidge R. ab. Jarbidge	Snake R.	Jarbidge R.	2001-04	20.1 – 22.2	19.5 – 21.1	16.3 – 18.1	15.3 – 17.5	9.2 – 10.7	21
J-11	Jarbidge R. at Cemetery Rd.	Snake R.	Jarbidge R.	2002	22.9	22.2	18.4	17.5	11.6	21
J-12	Jarbidge R. ab. Jack Ck.	Snake R.	Jarbidge R.	2001	23.3	22.3	18.3	17.8	11.1	21
J-12a	Jarbidge R. bel. Jack Ck.	Snake R.	Jarbige R.	2006	20.9	20.0	17.5	17.0	NA	21
J-12b	Jarbidge R. bel. Deer Ck.	Snake R.	Jarbidge R.	2006	20.9	20.0	17.0	16.5	NA	21
J-13	Jarbidge R. at Freighter's Defeat Draw	Snake R.	Jarbidge R.	2001	23.1	22.0	18.4	17.8	10.1	21
J-15	Jarbidge R. bel. EF Jarbidge R.	Snake R.	Jarbidge R.	2000	25.8	24.9	21.9	20.6	11.0	21
J-16	Jarbidge R. bel. Poison Ck.	Snake R.	Jarbidge R.	2006	25.8	25.2	22.9	22.5	NA	NA
J-17	Jarbidge R. at Bruneau R.	Snake R.	Jarbidge R.	2006	27.4	26.6	23.9	23.1	NA	NA
SF-1	WF Deer Ck. A	Snake R.	Salmon Falls	2005	23.2	22.4	16.9	16.3	13.9	20 (trib)
SF-2	WF Deer Ck. B	Snake R.	Salmon Falls	2005	19.0	18.5	16.6	15.1	8.7	20 (trib)
SF-3	WF Deer Ck. C	Snake R.	Salmon Falls	2005	22.1	21.0	18.5	16.3	11.1	20 (trib)
SF-4	Deer Creek	Snake R.	Salmon Falls	2006	31.9	30.0	22.8	22.2	22.9	20 (trib)
SF-5	Upper Camp Ck.	Snake R.	Salmon Falls	2006	21.4	20.2	17.7	17.3	7.6	20
SF-6	Lower Camp Ck.	Snake R.	Salmon Falls	2006	24.0	23.2	19.7	19.3	11.0	20
SF-7	Shack Creek	Snake R.	Salmon Falls	2003-06	21.6 -27.5	20.6 – 26.0	17.1 – 20.6	16.4 – 19.6	11.4 – 13.1	20 (trib)
SF-8	NF Cottonwood Ck.	Snake R.	Salmon Falls	2004-05	23.0 – 27.2	22.6 – 25.5	17.7 – 19.9	17.1 – 18.6	13.1 – 17.0	20 (trib)
SF-9	SF Cottonwood Ck.	Snake R.	Salmon Falls	2005-06	23.5 – 24.3	22.7 – 23.1	19.0 – 19.9	18.6 – 19.5	11.6 – 12.1	20

Table 2. Summary of Temperature Metrics for Temperature Monitoring Sites (ºC) (cont'd)

Site ID	Site	Hdyro-graphic Region	Watershed	Period of Record	MDMT	MWMT	MDAT	MWAT	Max. Daily Change	Max. WQS
SF-10	Sun Ck. (SF Salmon Falls Ck.)	Snake R.	Salmon Falls	2006	26.1	24.3	20.7	20.1	14.0	20 (trib)
SF-11	NF Jakes Creek	Snake R.	Salmon Falls	2003-05	24.7 – 26.8	24.1 – 26.1	21.7 – 22.7	21.0 – 22.1	9.8 – 10.8	21 (trib)
SF-12	SF Salmon Falls Creek	Snake R.	Salmon Falls	2003-06	24.2 – 26.6	23.4 – 25.1	20.4 – 21.6	20.0 – 20.6	9.0 – 11.9	20
SF-13	Hot Ck. Ab. Shoshone Ck.	Snake R.	Salmon Falls	2000, 2002-03	25.4 – 27.3	23.7 – 26.2	19.8 – 21.4	18.7 – 21.0	14.9 – 15.7	NA
SF-14	Shoshone Ck. Ab. Hot Ck.	Snake R.	Salmon Falls	2000, 2002-03	25.4 – 27.4	24.8 – 26.1	20.4 – 21.9	19.7 – 21.3	10.7 – 11.8	NA
SF-15	Shoshone Ck. Bel.. Magic Springs	Snake R.	Salmon Falls	2000, 2003	27.0 – 29.2	26.5 – 28.2	23.6 – 24.6	22.3 – 24.3	10.3 10.7	NA
SF-16	Shoshone Ck. At NV/ID Stateline	Snake R.	Salmon Falls	2003	29.0	28.0	24.3	23.5	13.3	21
SFO-1	SF Owyhee R. at Gage	Snake R.	SF Owyhee R.	1999-2003, 2006	27.2 – 30.9	26.0 – 29.2	23.2 – 25.7	22.0 – 25.2	10.4 – 14.3	21
SFO-2	SF Owyhee at Pipeline	Snake R.	SF Owyhee R.	1999-2001, 2003	27.5 – 30.4	25.8 – 29.2	23.6 – 25.3	22.0 – 24.5	10.8 – 16.9	21
MC-1	Toro Canyon	Humboldt R.	Maggie Ck.	2006	19.8	19.3	16.7	16.4	8.4	20 (trib)
MC-2	Beaver Creek	Humboldt R.	Maggie Ck.	2003-04, 2006	20.4 – 24.2	19.6 – 23.1	17.4 – 20.0	17.0 – 19.4	7.1 – 12.8	20 (trib)
MR-1	Hanks Creek	Humboldt R.	Marys R.	2002-06	21.9 – 25.7	21.9 – 24.5	19.1 – 23.6	18.4 – 22.3	6.1 – 9.8	20 (trib)
MR-2	Marys River below Orange Bridge (10313400)	Humboldt R.	Marys R.	1993, 1997, 1999, 2002, 2004-06	25.0 – 27.5	24.1 – 26.8	20.0 – 22.0	18.9 – 21.4	10.5 – 13.0	20
MR-3	Marys River below Twin Buttes (10315600)	Humboldt R.	Marys R.	1993, 1995-98, 2006	25.0 – 28.0	24.4 – 26.6	21.8 – 24.5	21.0 – 23.9	8.0 – 9.5	20
PC-1	Upper Trout Creek	Humboldt R.	Pine Ck.	2004-06	23.3 – 25.9	21.7 – 24.8	17.4 – 19.5	17.0 – 18.9	10.7 – 14.0	NA
PC-2	Middle Trout Creek	Humboldt R.	Pine Ck.	2006	27.7	27.0	21.4	20.7	16.6	NA
PC-3	Lower Trout Creek	Humboldt R.	Pine Ck.	2004	28.7	27.5	21.8	21.1	18.8	NA
RC-1	Upper Rock Creek 1	Humboldt R.	Rock Ck.	2001, 2006	17.5 – 19.5	16.9 – 18.8	15.1 – 16.2	14.9 -15.2	6.5 – 8.8	20
RC-2	Upper Rock Creek 2	Humboldt R.	Rock Ck.	2005	31.1	29.9	25.5	24.5	13.1	34
RC-3	Lower Rock Creek	Humboldt R.	Rock Ck.	2005	28.7	28.1	25.3	24.9	7.6	34
RC-4	Lewis Creek	Humboldt R.	Rock Ck.	2004-06	21.1 – 26.3	20.7 – 24.0	17.5 – 19.4	16.6 – 18.0	10.1 – 16.4	20 (trib)
RC-5	Upper Nelson Creek	Humboldt R.	Rock Ck.	2006	20.4	19.4	17.5	17.1	7.2	20 (trib)

Table 2. Summary of Temperature Metrics for Temperature Monitoring Sites (ºC) (cont'd)

Site ID	Site	Hdyro-graphic Region	Watershed	Period of Record	MDMT	MWMT	MDAT	MWAT	Max. Daily Change	Max. WQS
RC-6	Lower Nelson Creek	Humboldt R.	Rock Ck.	2003-05	28.2 – 30.6	26.6 – 30.0	22.2 – 25.6	21.1 – 24.9	11.1 – 15.1	20 (trib)
RC-7	Willow Creek	Humboldt R.	Rock Ck.	2003, 2005-06	22.5 – 26.5	21.8 – 25.8	19.7 – 24.1	19.3 – 23.4	5.8 -12.1	20
SFH-1	Upper Pearl Creek	Humboldt R.	SF Humboldt	2006	25.8	24.5	19.1	18.5	15.2	20 (trib)
SFH-2	Middle Pearl Creek	Humboldt R.	SF Humboldt	2006	22.8	22.0	17.4	17.1	11.6	20 (trib)
SFH-3	Lower Pearl Creek	Humboldt R.	SF Humboldt	2006	22.3	21.2	17.4	16.8	10.9	20 (trib)
SFLH-1	Secret Creek	Humboldt R.	SF Little Humboldt R.	2003, 2005-06	17.9 – 25.9	17.3 – 23.9	14.4 – 20.5	13.9 – 19.4	9.6 – 14.4	20 (trib)
SFLH-2	Sheep Creek	Humboldt R.	SF Little Humboldt R.	2002-06	18.8 – 27.0	18.4 – 25.7	15.1 – 19.4	14.1 – 19.2	9.3 – 16.7	20 (trib)
SFLH-3	SFLHR bel. Oregon Flat	Humboldt R.	SF Little Humboldt R.	2002-06	22.5 – 24.9	21.3 – 23.2	17.9 – 19.6	17.4 – 18.8	10.8 – 14.2	20
SFLH-4	SFLHR ab. Pole Creek	Humboldt R.	SF Little Humboldt R.	2002, 2005-06	21.7 – 23.4	21.0 – 22.9	17.3 – 19.1	16.4 – 18.5	11.2 – 11.8	20
SC-1	Sherman Creek	Humboldt R.	SF Little Humboldt R.	2005-06	23.5 – 24.0	22.5 – 23.4	18.9 – 19.4	18.3 – 18.9	11.4 – 11.6	NA

Table 3. Flow Statistics for Selected Gaging Stations in the Humboldt and Snake Drainage

USGS Gaging Station	Period of Record	Drainage Area, sq. mi^2	Avg. Annual Flow, AF	Annual Flow, AF (% of Average Annual Flow)								
				1998	1999	2000	2001	2002	2003	2004	2005	2006
13082500 – Goose Creek above Trapper Creek near Oakley, ID	1919-Present	633	34,000	46,000 (135%)	41,000 (121%)	21,000 (62%)	17,000 (50%)	25,000 (74%)	12,000 (35%)	23,000 (68%)	42,000 (124%)	57,000 (168%)
10313400 - Marys River below Orange Bridge nr. Charleston, NV	1992-Present	72	31,610	43,400 (137%)	33,300 (105%)	24,100 (76%)	13,400 (42%)	30,800 (97%)	21,200 (67%)	27,900 (88%)	45,000 (142%)	70,000 (222%)
10321925 - Simon Creek at Hwy 766 nr. Carlin, NV	1997-Present	46.0	588	1332 (227%)	626 (106%)	469 (80%)	351 (60%)	513 (87%)	234 (40%)	---	---	---
10321950 - Maggie Creek at Maggie Creek Canyon nr. Carlin, NV	1990-Present	334	12,700	30,500 (240%)	13,100 (103%)	6,700 (53%)	1,200 (9%)	4,500 (35%)	2,100 (17%)	7,500 (59%)	36,100 (284%)	Not Available
1310500 - Salmon Falls Creek nr. San Jacinto, NV	1918-Present	1,450	101,900	132,100 (130%)	112,400 (110%)	66,400 (65%)	45,500 (45%)	76,300 (75%)	51,800 (51%)	75,800 (74%)	114,600 (112%)	166,000 (163%)
13161500 - Bruneau River at Rowland, NV	1967-Present	382	79,000	105,000 (133%)	76,200 (96%)	45,700 (58%)	26,000 (33%)	61,100 (77%)	40,400 (51%)	57,000 (72%)	99,400 (126%)	133,000 (168%)
13162225 - Jarbidge River below Jarbidge, NV	1998-Present	30.6	20,200	---	28,300 (140%)	15,000 (74%)	14,000 (69%)	23,200 (115%)	20,200 (100%)	23,500 (116%)	33,700 (167%)	32,800 (163%)
13168500 - Bruneau River nr. Hot Spring, ID	1909-Present	2630	276,000	344,000 (125%)	280,000 (101%)	147,000 (53%	112,000 (41%)	168,000 (61%)	147,000 (53%)	173,000 (63%)	317,000 (115%)	372,000 (135%)

Figure 6. Percent of Annual Average Flow for Selected Gages in Humboldt and Snake Basin - 1998-2006

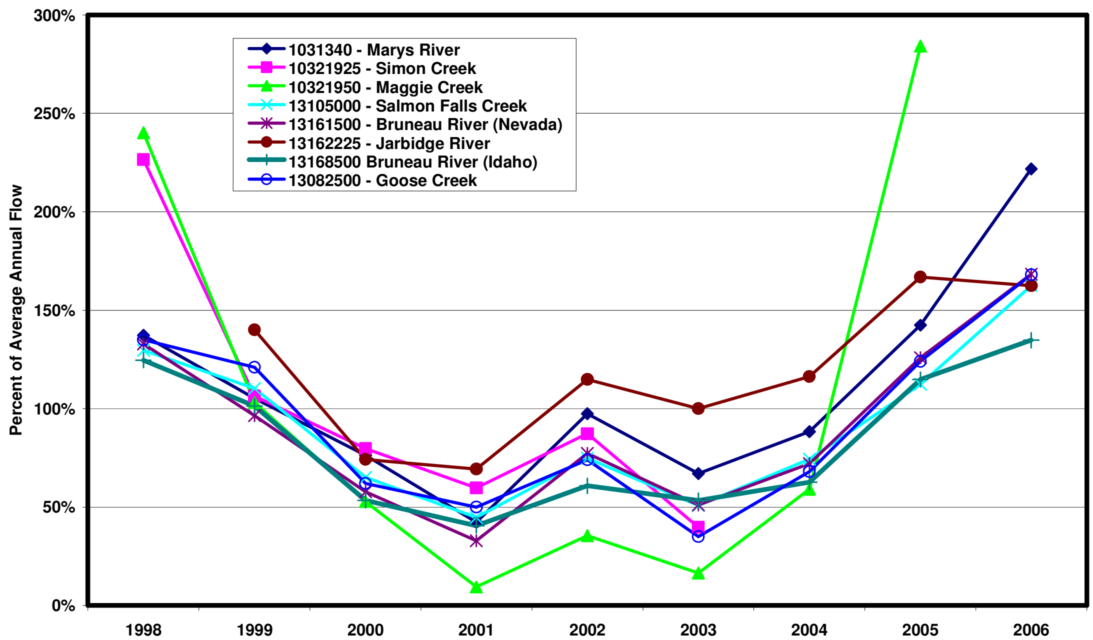


Figure 7. Comparison of MDMT and MWMT

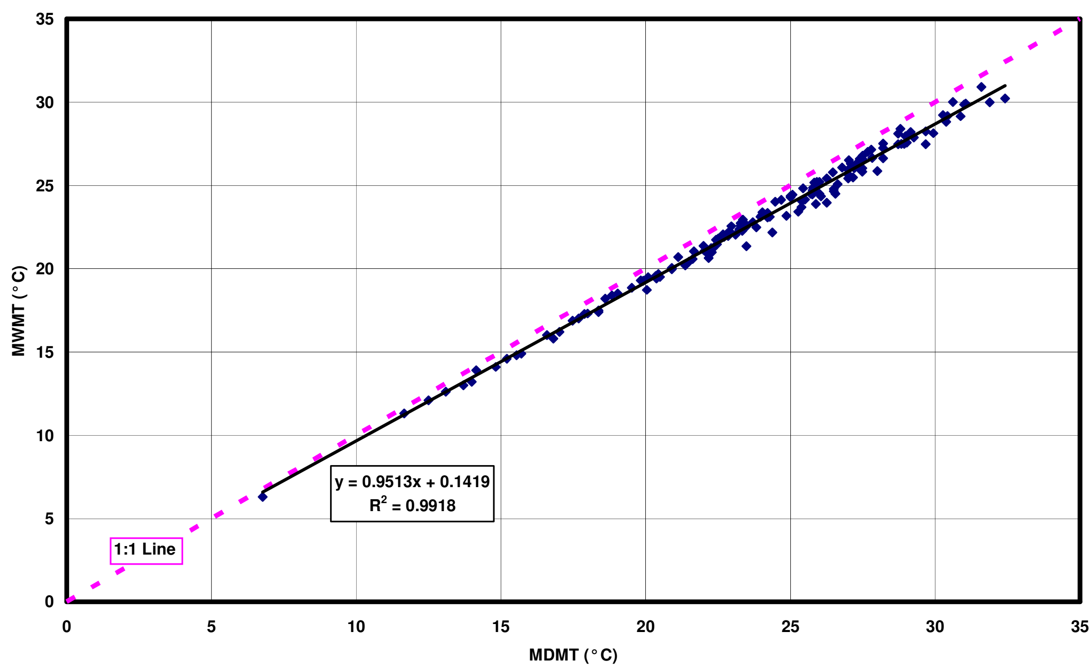


Figure 8. Comparison of MDMT and MDAT

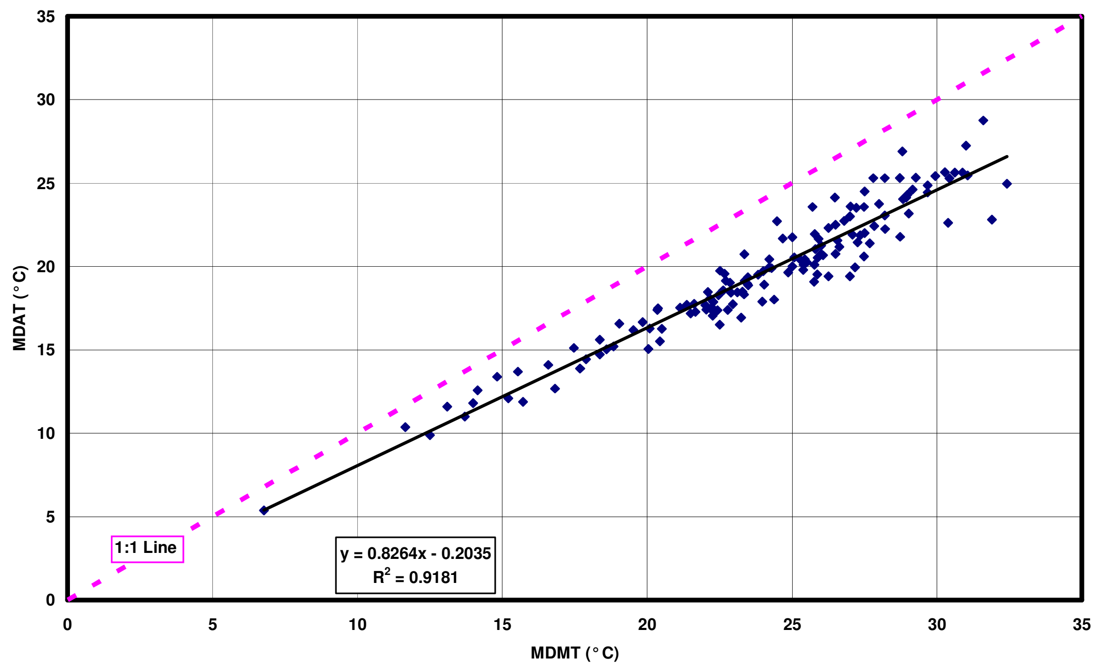
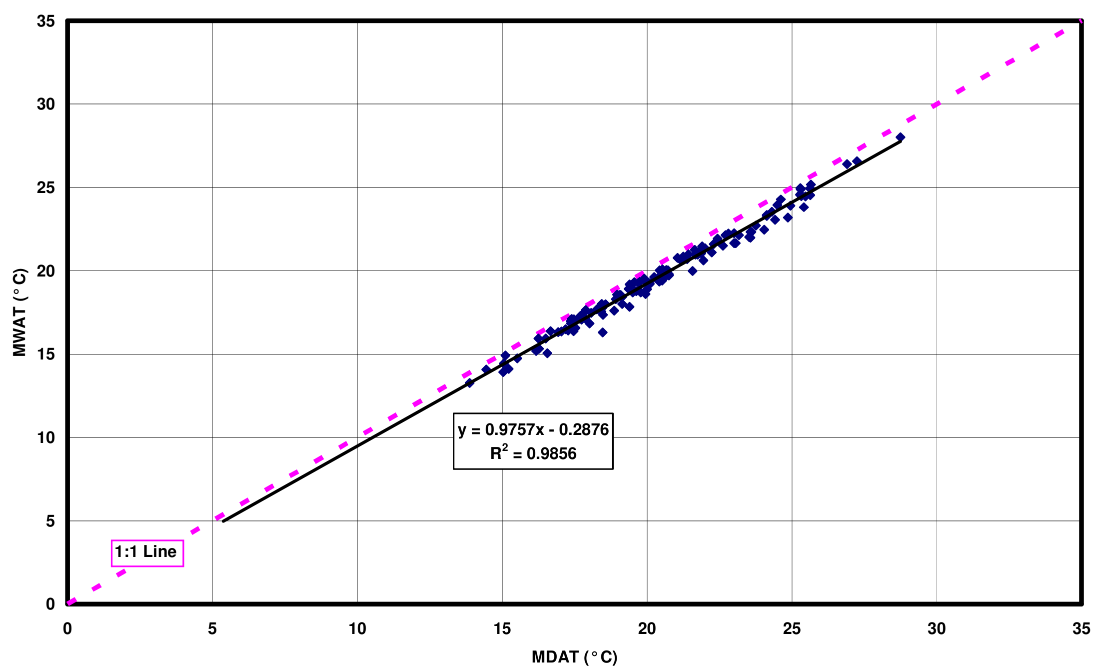


Figure 9. Comparison of MDAT and MWAT



Variability from Year to Year

The temperature metrics (MDMT, MWMT, MDAT, MWAT) presented in this report are expected to vary from year to year at all sites. Ranges of the results are presented in Table 2. These variations are due to a number of factors affecting the heat budget, such as flow (affected by irrigation use), climatological conditions, etc. The range in values can be rather large, however, considerable data are needed to obtain a truer measure of the temperature metric variations. As an example outside the study area, an evaluation of 24 years of data on the East Fork Carson River near Gardnerville (USGS Gage 10309000) showed MDMT values with a range of over 10º C (18.3º C to 29.4º C) for the period of record. Unfortunately, most of the monitoring sites examined for this study had only 5 years or less of summertime data. Nevertheless, some of the data showed significant variations from year to year with limited data (Table 4).

Table 4. Summary of Temperature Metric Ranges for Selected Sites

Site	Years of Data	Temperature Metric Range (º C)			
		MDMT	MWMT	MDAT	MWAT
B-1: Bruneau River near Hot Spring, ID (USGS Gage 13168500)	5	27.8 – 31.6 (3.8)	27.2 – 30.9 (3.7)	25.3 – 28.8 (3.5)	24.6 – 28.0 (3.4)
SF-12: Shack Creek (tributary to North Fork Salmon Falls Creek)	4	21.6 – 27.5 (5.9)	20.6 -26.0 (4.4)	17.1 – 20.6 (3.5)	16.4 – 19.6 (3.2)
SFLH-1: Secret Creek (tributary to South Fork Little Humboldt River)	3	17.9 – 25.9 (8.0)	17.3 – 23.9 (6.6)	14.4 – 20.5 (6.1)	13.9 – 19.4 (5.5)
SFLH-5: Sheep Creek (tributary to South Fork Little Humboldt River)	5	18.8 – 27.0 (8.2)	18.4 – 25.7 (7.3)	15.1 – 19.4 (4.3)	14.1 – 19.2 (5.1)

Of the 56 sites with continuous temperature data, SF-12 Shack Creek experienced some of the highest variations in temperature metrics. Figure 10 provides a comparison of maximum daily temperature for four different years. 2003 had significantly higher temperatures than the other three years. It is assumed that lower flows in 2003 led to increased water temperature, however no flow data are available to verify.

While Sites MR-2 (Marys River below Orange Bridge) and MR-3 (Marys River below Twin Buttes) have the most years of temperature of all the sites examined for this study, the data showed rather small ranges in the temperature metrics. During the 15-year period 1992-2006, MDMT varied only 2.5º C at Site MR-2 and 3º C at Site MR-3. However, these ranges do not provide an accurate picture of the variability of temperature metrics in Marys River. Largely due to extreme low flow to no flow conditions, there were limited temperature data for some summers. As a result, the MDAT/MWMT/MDAT/MWAT metrics could be calculated for only 7 years at MR-2 and 6 years at MR-3 from the 15-year record at the USGS stations. Flows at MR-2 dropped to zero in 6 out of the 15 years of flow records, while flows at MR-3 dropped to zero every year between late June and late August.

Figure 11 shows that July-August maximum daily temperatures in the upper Marys River (MR-2) inversely related to streamflow. The data suggest that the water quality standard (20º C) will most likely be exceeded when flows drop below 30-40 cfs during July-August (which is actually a common condition). Figure 12 shows a similar relationship at MR-3 however temperature standards are exceeded even during the higher flows.

Figure 10. Shack Creek (SF-7) - Maximum Daily Temperatures

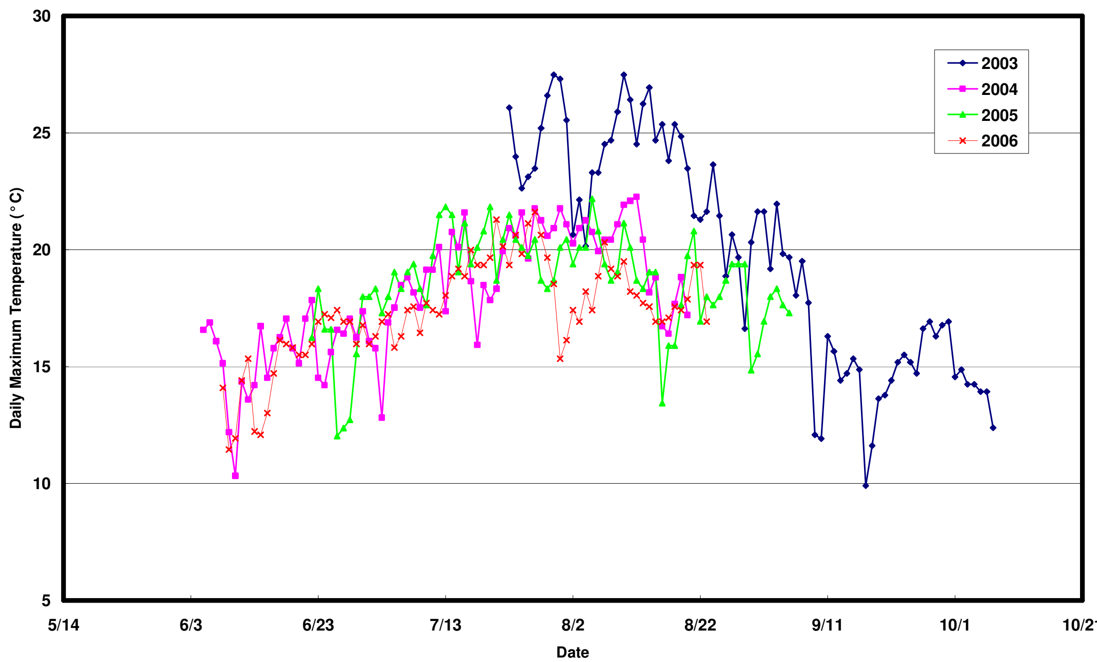


Figure 11. MR-2 - Marys River below Orange Bridge - Max. Daily Temperatures vs. Flow (July-August)

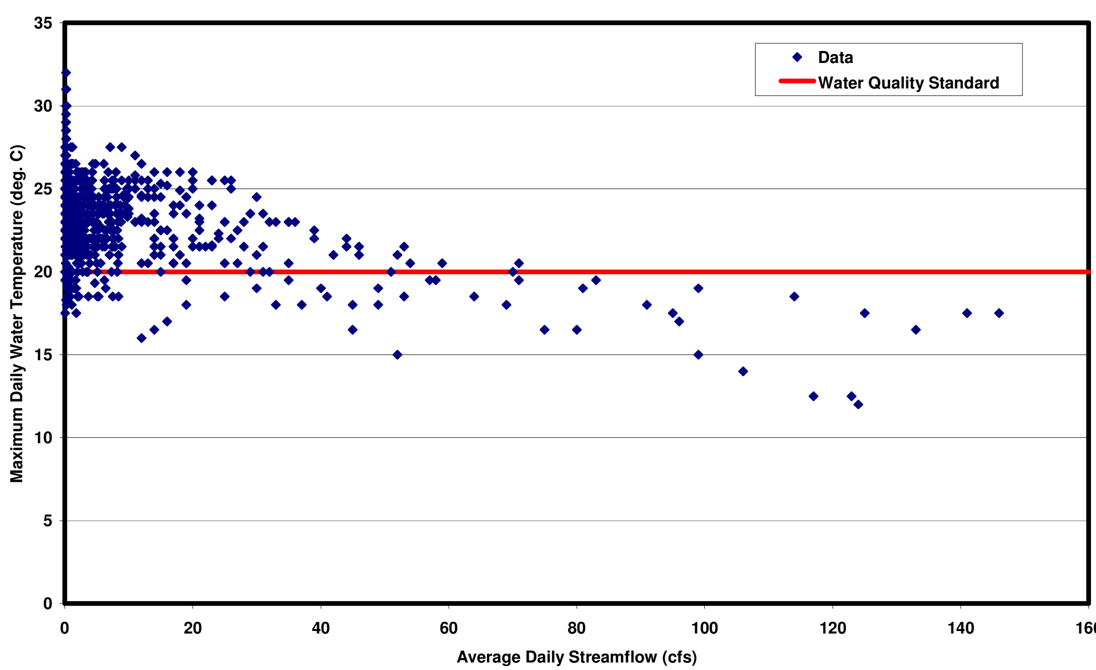
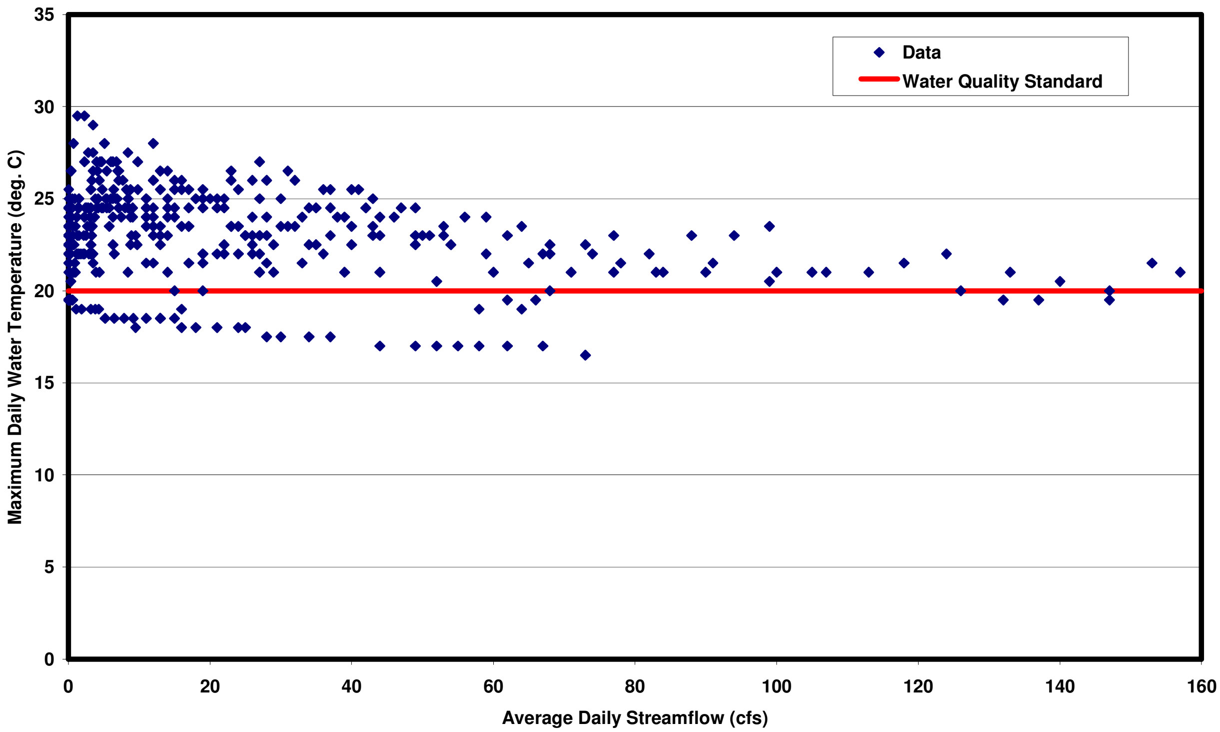
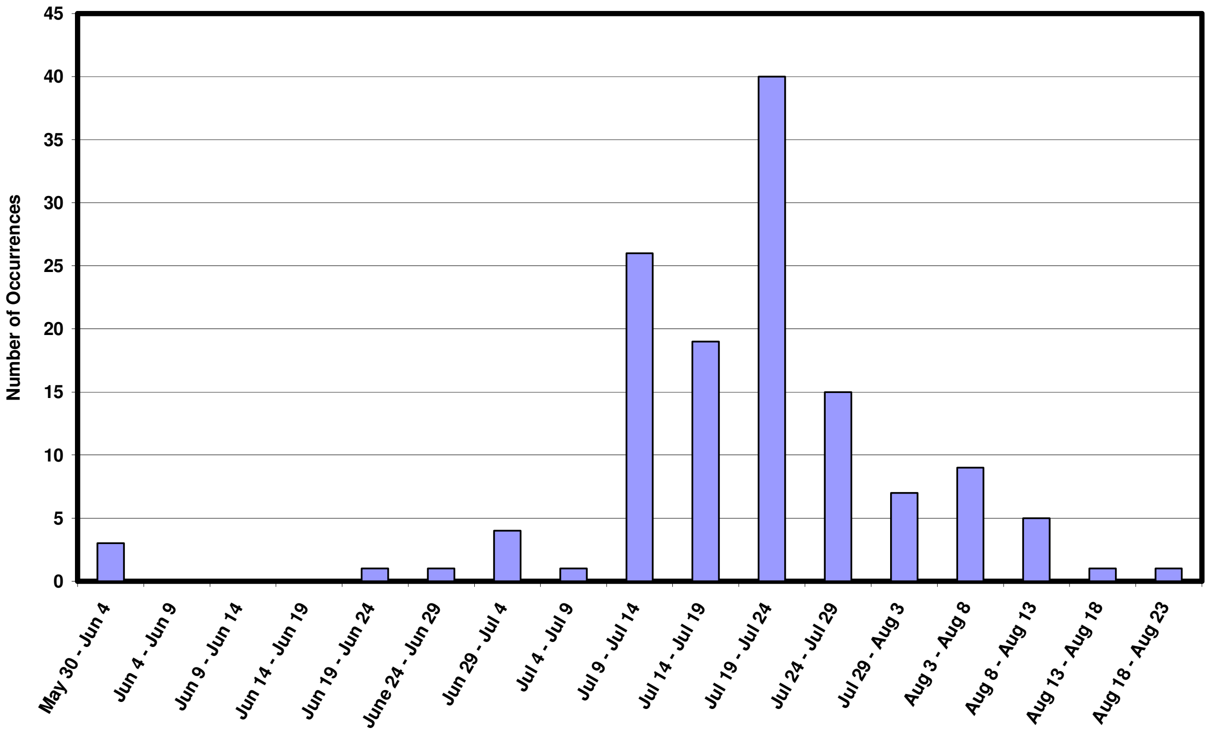


Figure 12. MR-3 - Marys River below Twin Buttes - Max. Daily Temperatures vs. Flow (July-August)



The time of year in which streams experience the peak temperatures is also variable from year to year depending upon flow (affected by irrigation use), climatological conditions, etc. An evaluation of the 128 years of data for 56 sites (excluding the NDOW sites without daily data) shows that the time at which the MDMT occurred ranged from May 31 to August 23, with most of the MDMTs falling in the July 9 – August 8 range (Figure 13).

Figure 13. Frequency of Time of Peak Temperature Occurrences for Study Sites



Temperature and Watershed Characteristics

Following is a discussion of some observed relationships between some temperature metrics and watershed characteristics: elevation, watershed area and topographic shading.

Monitoring Site Elevation: Figures 14 and 15 present plots of MDMT and MDAT values as varying with monitoring site elevation. As expected, increasing MDMT/MDAT values occur with drops in site elevation. Given the potential for high temporal and spatial variability within a stream and that other factors affect MDMT/MDAT, it is not surprising that there is a significant data spread at a given elevation.

It is interesting to note the monitoring sites below elevation 6,000 feet had MDMT values that were frequently above the 20 and 21° C water quality standards. Figure 14 indicates that many of the sites had MDMT values higher than those in the Jarbidge watershed at similar elevations. A partial explanation for this difference may be that the Jarbidge subwatersheds in the study tend to have higher maximum elevations resulting in more precipitation and flow, and higher elevation drops and overall higher watershed slopes, resulting in faster moving water with less time for heating to occur.

Figure 14. MDMT vs. Elevation - All Sites

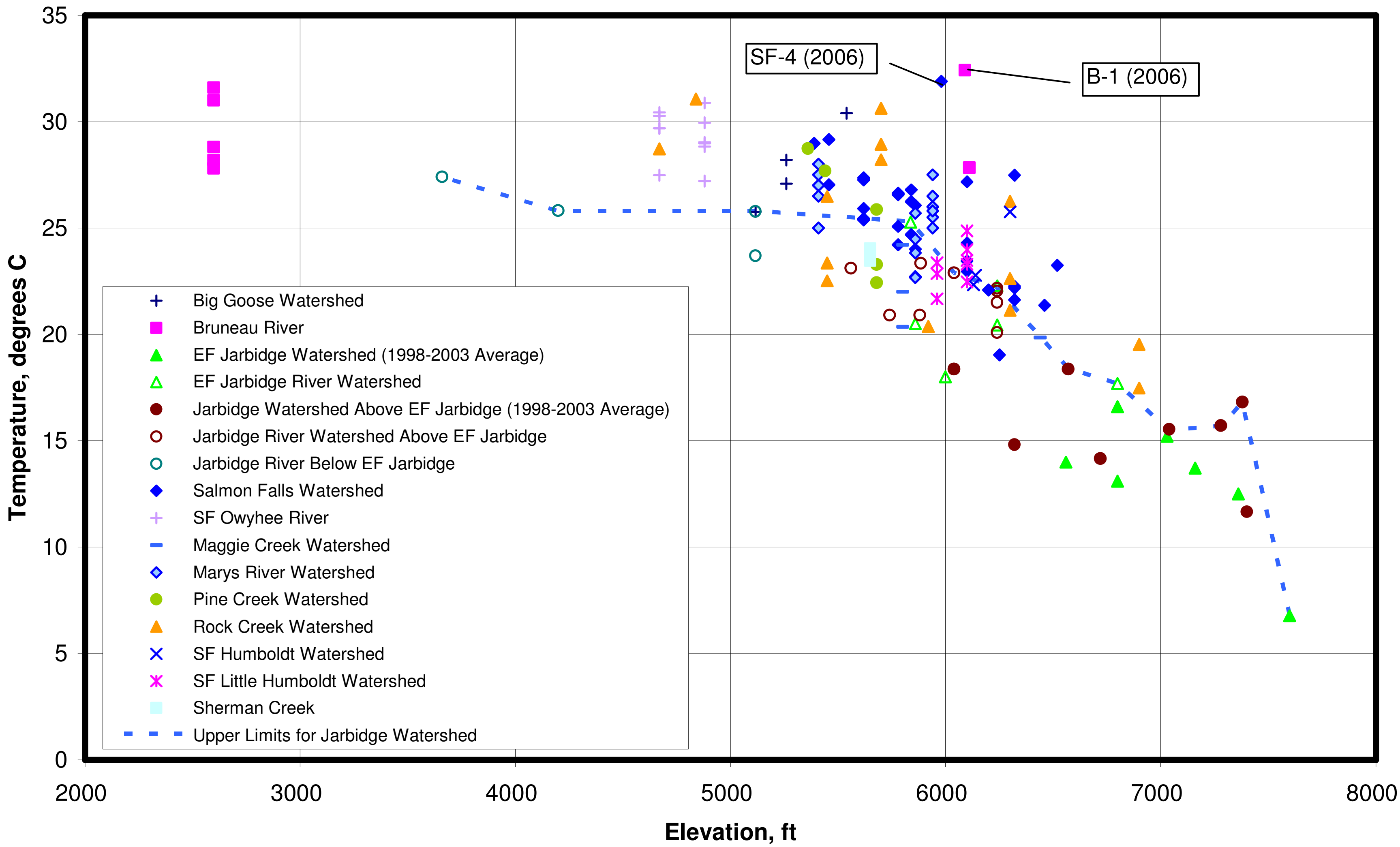
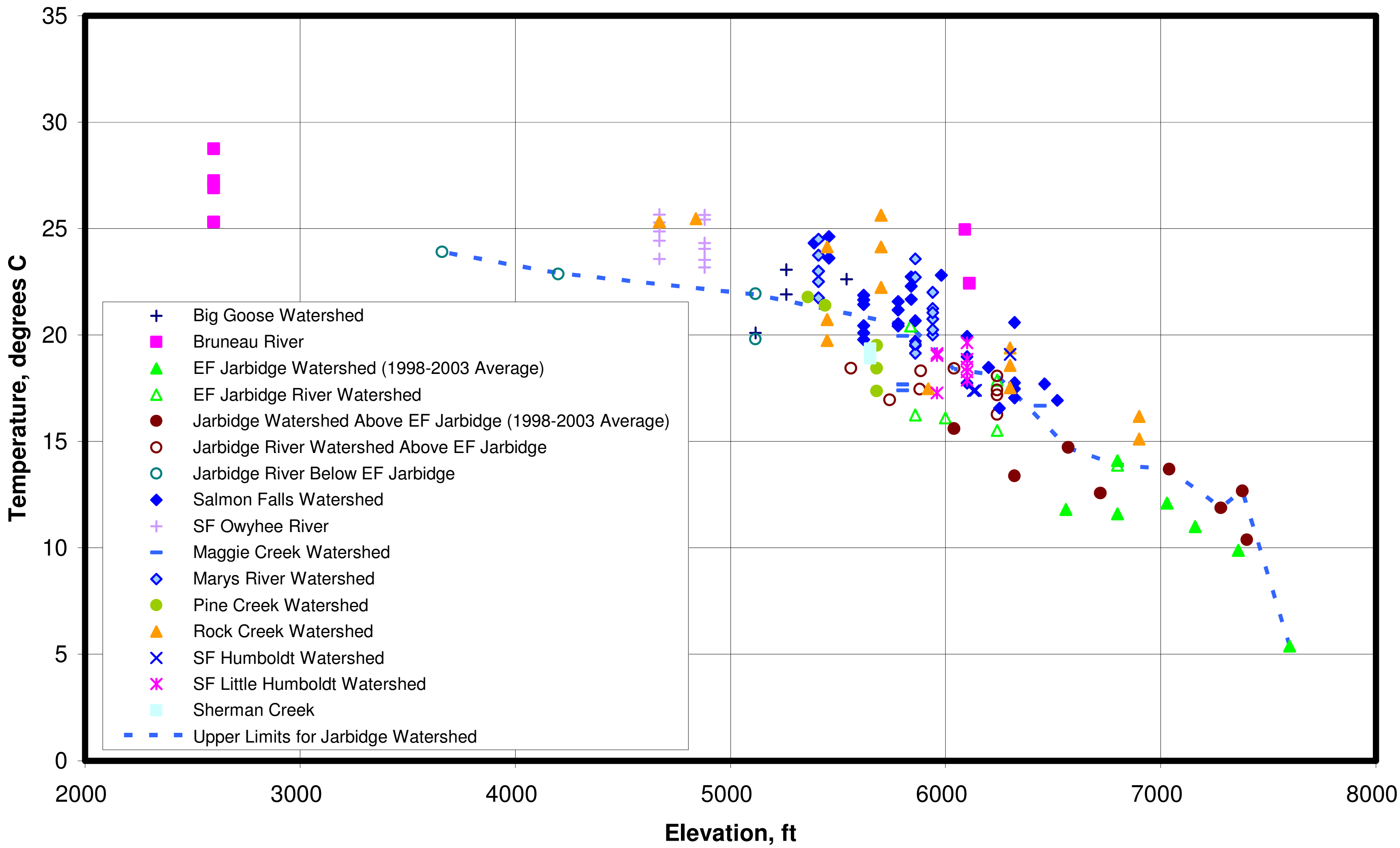


Figure 15. MDAT vs. Elevation - All Sites



A few points on Figure 14 stand out from the others. 2006 MDMT values at B-2 (Bruneau River) and SF-4 (Deer Creek) and the two highest of the entire dataset, and are over 5º C higher than MDMTs at other sites with similar elevations; and nearly 10º C higher than values in the Jarbidge drainage. Some of the difference between Site B-2 temperatures and Jarbidge temperatures (and in some cases other watershed temperatures) could be partially explained by the following factors:

- The watershed above B-2 has a maximum elevation of only 8170 feet while many of the subwatersheds in the Jarbidge drainage have maximum elevations of over 10,000 feet.
    - With a lower overall elevation, the B-2 watershed receives less precipitation and therefore would be expected to experience less flow, leading to higher stream temperatures. A study by the Northwest Power and Conservation Council (2004) shows average annual precipitation in the B-2 watershed to be about 1/3 of precipitation in the upper Jarbidge.
    - As a result, the B-2 watershed has a lower overall median slope (12%) compared to Jarbidge slopes (24 to 50%). A lower slope can lead to slower flow conditions allowing more time for the water to become heated.
- Aerial photography shows the upper Bruneau watershed to have significantly less forested area and riparian vegetation than the Jarbidge watershed.
- According to Mark Dean, BLM (2007), the stream flow in 2-mile river reach immediately above Site B-2 has been ponded and slowed due to beaver activities. Data shows a 4.6º C increase in the MDMT values through this 2-mile reach.

Site SF-4 (Deer Creek) in the Salmon Falls Creek watershed has the 2nd highest MDMT of the study dataset. Mark Dean, BLM (2007), has observed dry conditions at times at Site SF-4, but had no direct observation of dry conditions during the 2006 thermograph deployment. The 2006 thermograph data did not show any sporadic temperatures swings indicating a thermograph going from wet to dry conditions. However, the data show a very high maximum daily fluctuation (22.9º C) suggesting that the SF-4 data should be used with caution.

A closer look at some of the available data shows some interesting relationships. For example, a plot (Figure 16) of MDMT values for various sites on the East Fork Jarbidge and Jarbidge rivers (not on tributaries) shows that temperature vs. elevation relationships are similar. Johnson (2005) found that thermographs located at similar elevations (6240 feet) in each river indicated similar temperatures (See Table 5). Even though the Jarbidge River has had significant impacts from human activities, its temperatures are similar to those measured in the lesser impacted East Fork Jarbidge (Johnson, 2005). However, it should be recognized that the East Fork Jarbidge River watershed area at El. 6240 is approximately 1.75 times larger than the Jarbidge River watershed at El. 6240. As discussed in the following section, MDMT values tend to increase with increased watershed area. Even though EFJ-10 has a significantly larger watershed area, its MDMT values were the same as J-10 with the smaller area.

It must be noted that some of the stream temperatures may have been influenced by hot springs. Northwest Power and Conservation Council (2004) states that hot springs have a significant impact on the lower Bruneau River and its tributaries.

Figure 16. MDMT vs. Elevation - Mainstem of EF and Jarbidge Rivers

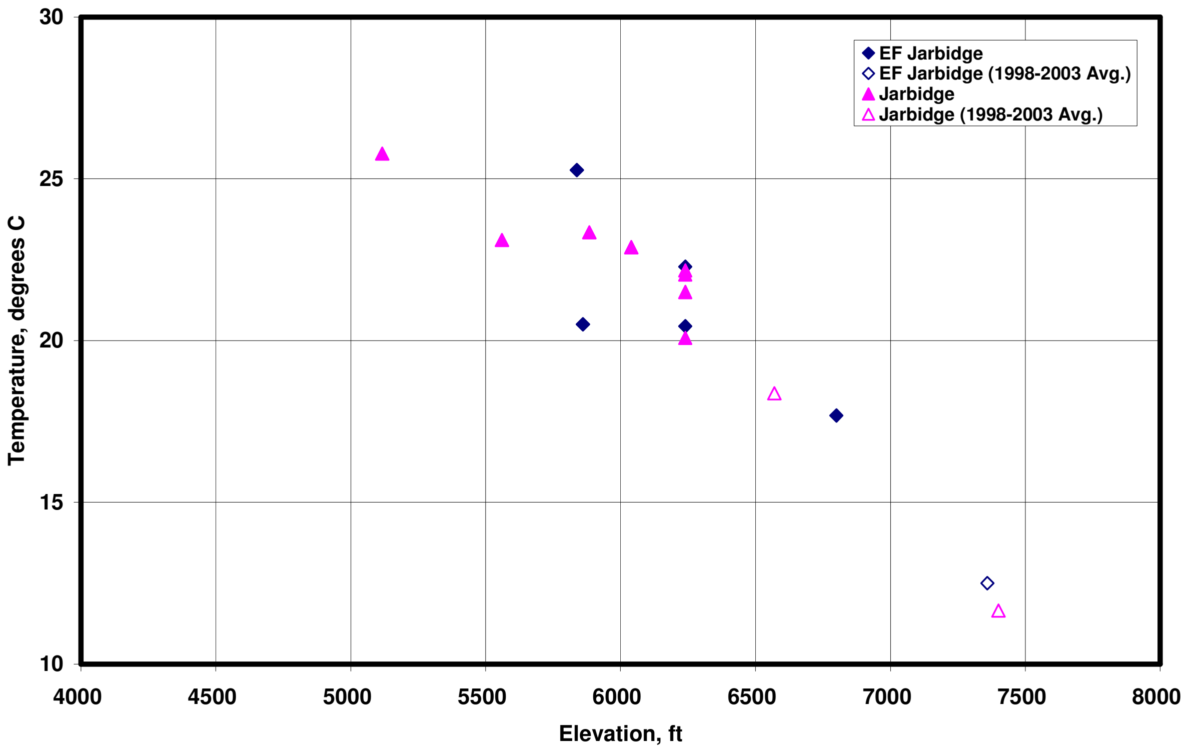


Table 5. Comparison of Temperature Metrics for 2 Sites on East Fork Jarbidge and Jarbidge River at Elevation 6240 Feet.

Year	Site	Area (sq. mi.)	Temperature Metric (° C)			
			MDMT	MWMT	MDAT	MWAT
2003	EFJ-10: EF Jarbidge River bel. Slide Ck.	42.1	22.3	21.0	17.9	17.1
	J-10: Jarbidge River above Jarbidge	24.0	22.2	21.0	18.1	17.5
2004	EFJ-10: EF Jarbidge River bel. Slide Ck.	42.1	20.4	19.7	15.5	14.7
	J-10: Jarbidge River above Jarbidge	24.0	20.1	19.5	16.3	15.3

Another interesting example of how various watershed characteristics can affect stream temperatures is summarized in Table 6. While Sites J-1, J-8 and EFJ-8 have nearly the same elevations, there is a noticeable difference between their MDMT and MDAT values. It could be speculated that the higher slopes and higher maximum elevations within the J-8 and EFJ-8 watersheds contributed to their lower temperatures.

Table 6. Comparison of 1998-2003 Average Temperature Metrics for 3 Sites in Jarbidge Watershed near Elevation 7,400 feet

Parameter	J-1: Deer Creek	J-8: Upper Jarbidge River	EFJ-8: Upper EF Jarbidge River
MDMT	16.8	11.7	12.5
MDAT	12.7	10.4	9.9
Site Elevation (feet)	7,380	7,400	7,360
Watershed Area (sq. mi.)	1.74	3.68	5.85
Max. Elevation (feet)	8,970	10,510	10,530
Median Slope	30%	49%	50%

A plot of maximum daily temperature values compared to elevation (Figure 17) yields a similar relationship with that developed by Vannote and Sweeney (1980) (see Figure 2). That is, variations in daily temperature fluctuations from minimum to maximum tend to be higher for the higher elevation streams (lower stream order) and lower for the lower elevation streams (higher stream order). According to Mark Dean (2007), the SF-4: Deer Creek site can experience ephemeral flow conditions however no dry conditions were observed in the field. While the continuous data do not seem to indicate that the thermograph was out of the water at anytime during the monitoring, the high temperature fluctuation value (22.9º C) suggest that the SF-4 data may need to be used with caution.

Watershed Area above Monitoring Site: Figures 18 and 19 and presents plots of MDMT and MDAT values as varying with watershed area above monitoring sites. In general, increasing MDMT/MDAT values occur with increases in watershed area. For those sites with watershed areas greater than 50 square miles, MDMT values were frequently above the 20 and 21° C water quality standards. As discussed in the previous section, given the potential for high temporal and spatial variability within a stream and that other factors affect MDMT, it is not surprising that there is a significant data spread at a given area.

Figure 18 indicates that many of the sites had MDMT values higher than those in the Jarbidge watershed with similar watershed areas. A partial explanation for this difference may be that the Jarbidge subwatersheds in the study tend to have higher maximum elevations resulting in more precipitation and flow, and higher elevation drops and overall higher watershed slopes, resulting in faster moving water with less time for heating to occur.

Figure 17. Maximum Daily Temperature Change

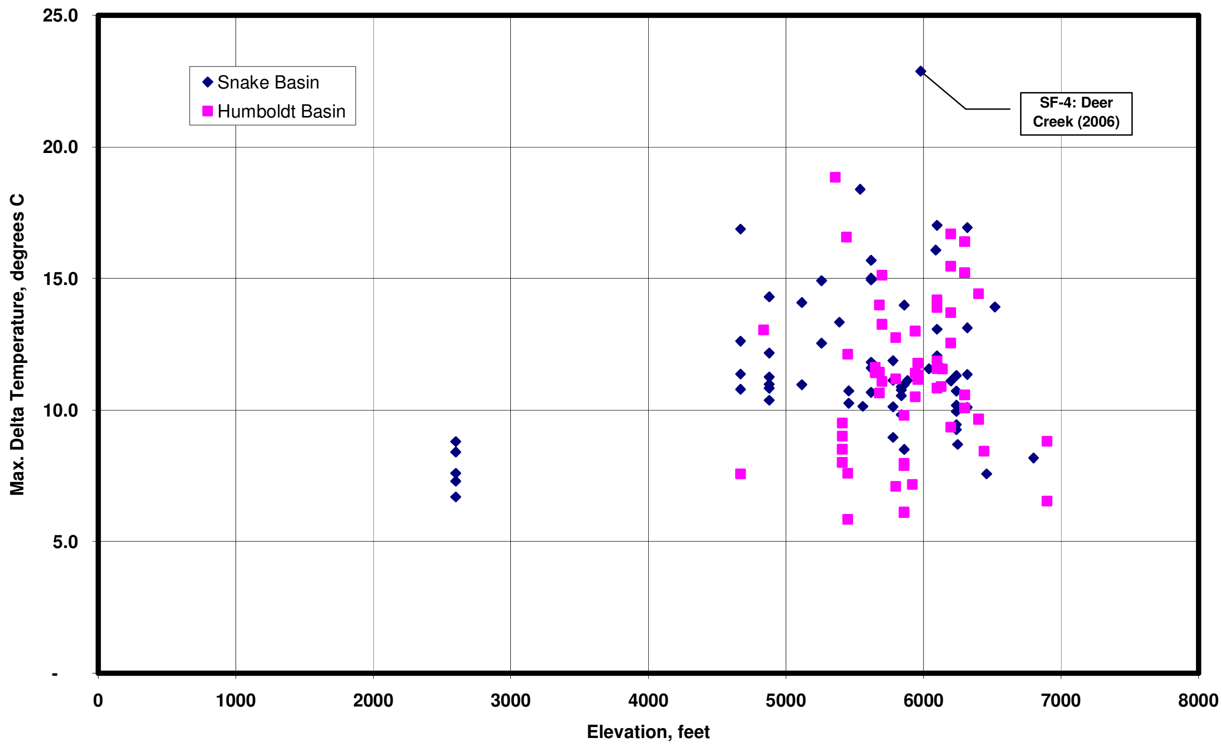


Figure 18. MDMT vs. Watershed Area - All Sites

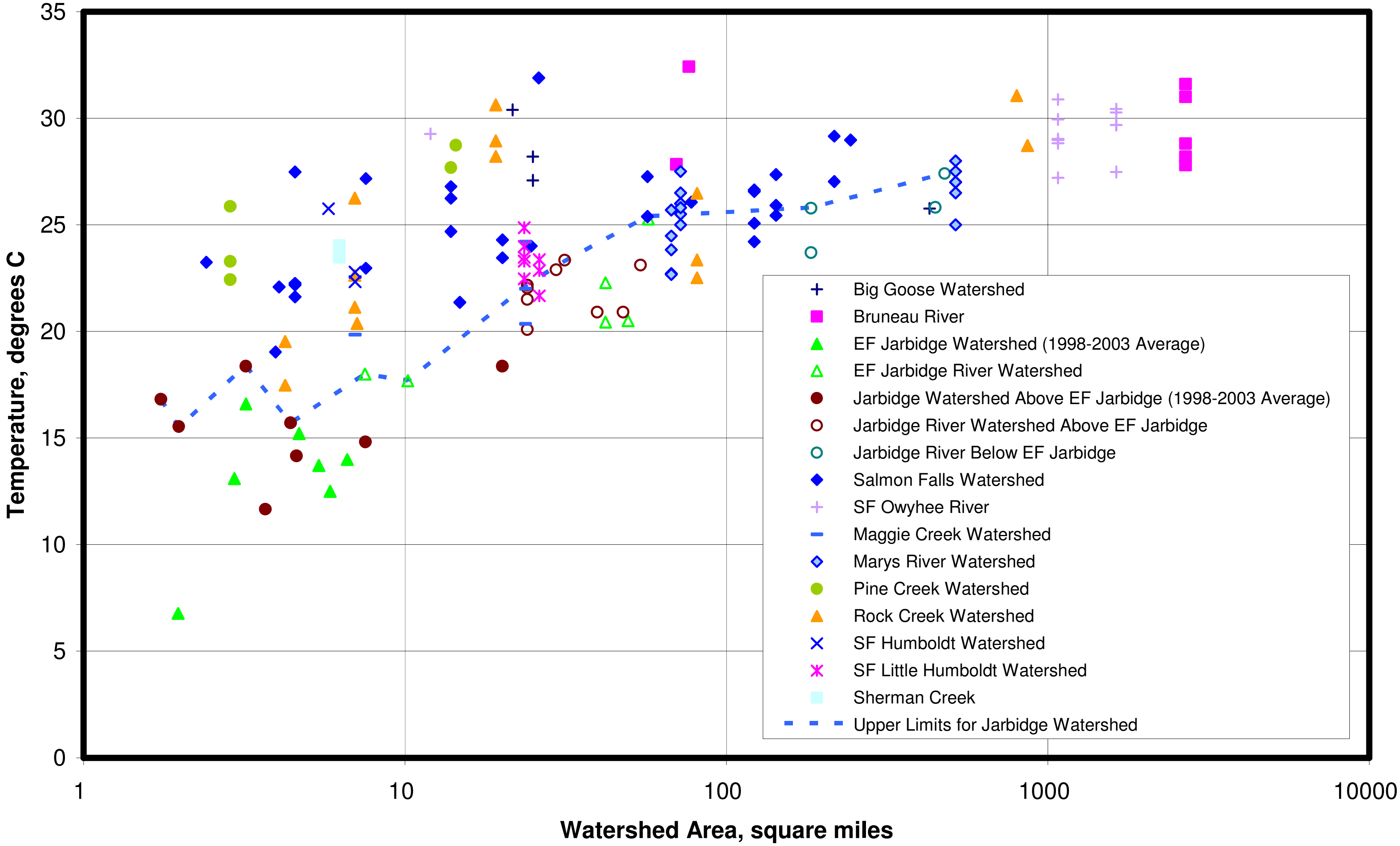
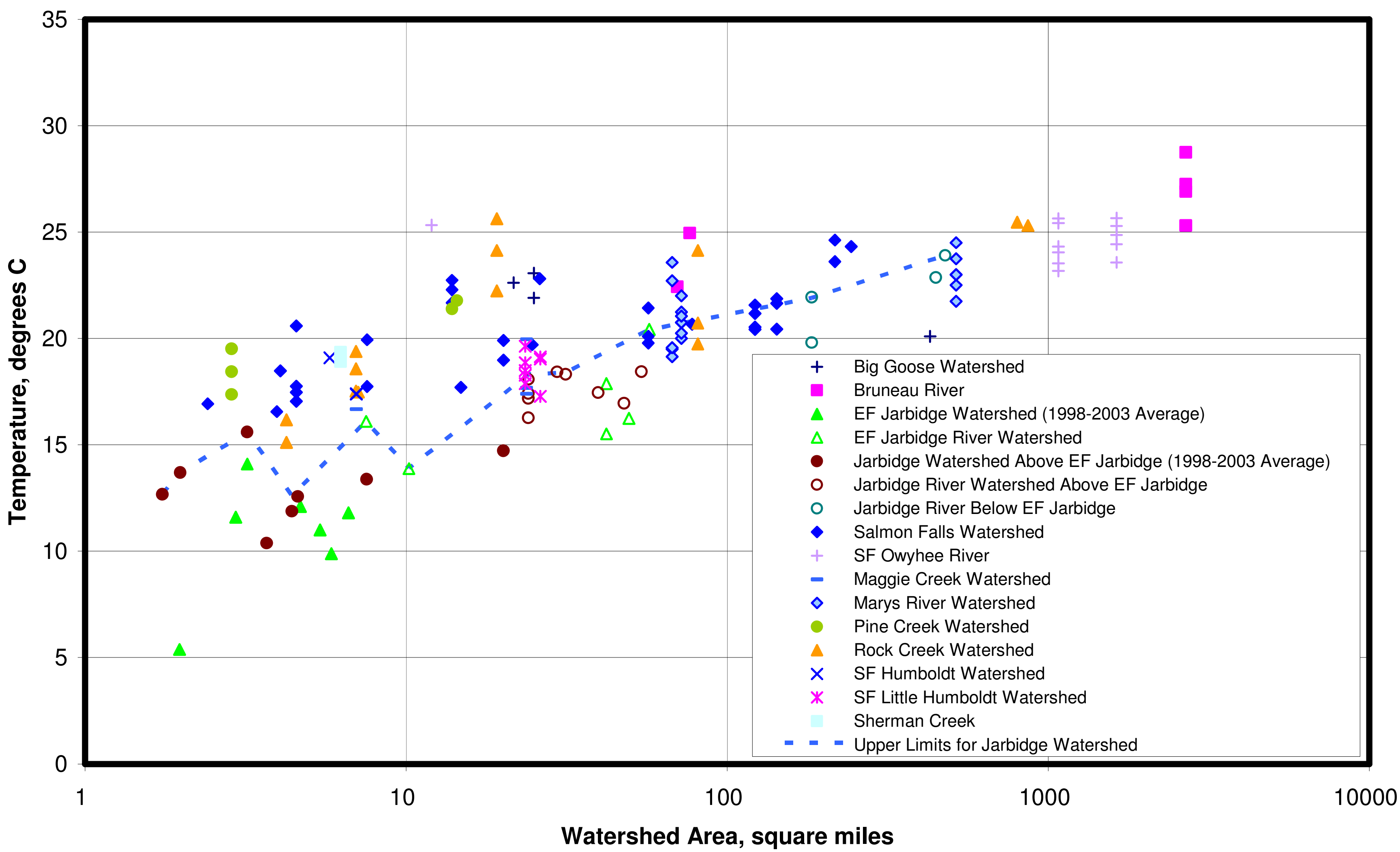


Figure 19. MDAT vs. Watershed Area - All Sites

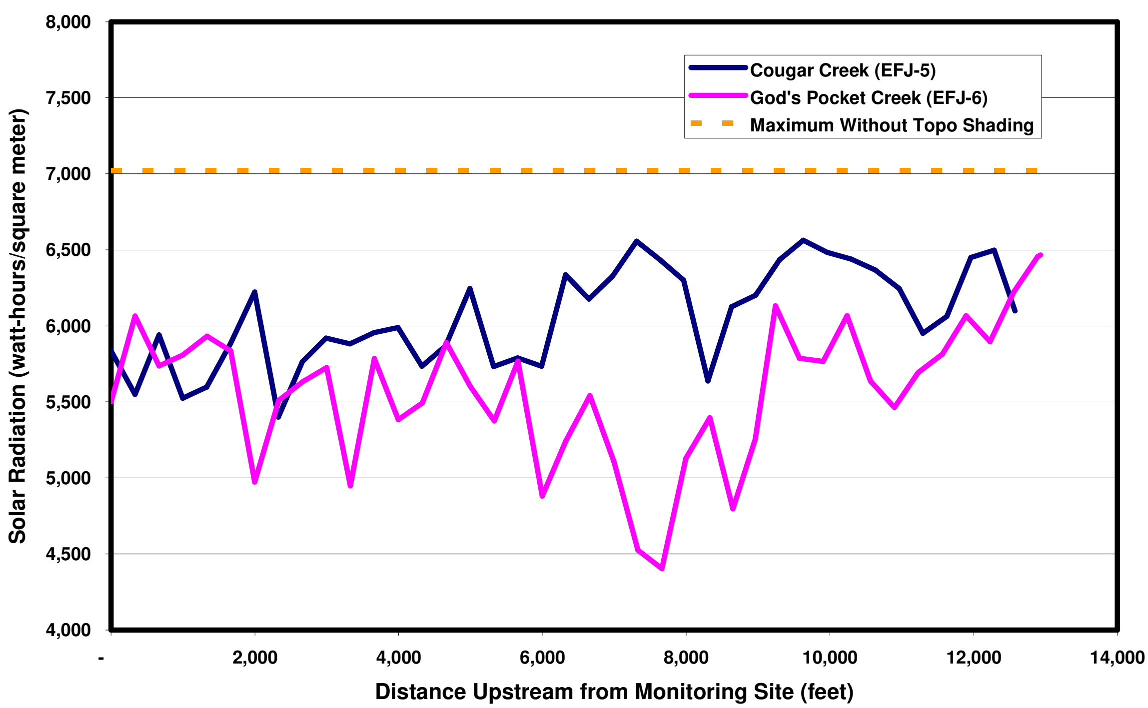


Topographic Shading: Even though EFJ-5 (Cougar Creek) and EFJ-6 (God's Pocket Creek) have similar site elevations and watershed areas, there is a significant difference in the average MDMT and MDAT metrics for 1998-2003 (Table 7). There are a number of potential factors, including topographic shading, that could contribute to this difference. A closer examination of the watershed characteristics shows that EFJ-6 is a long (21,000 feet) narrow (5,300 feet) basin oriented north-south; EFJ-5 has similar length and width characteristics but with a difference shape and orientation (Figure 21). To examine potential differences in topographic shading between these 2 basins, the solar radiation calculator within ESRI's SpatialAnalyst™ was used to calculate profiles of solar radiation along the valley bottoms in each basin. The analyses show that the total solar radiation (for August 1) was generally higher in EFJ-5 (average = 6100 W-h/m^2) than EFJ-6 (average = 5600 W-h/m^2) (Figure 20) which could explain in part the higher temperatures in EJ-5. Figure 20 also shows that both EFJ-5 and EFJ-6 had significant levels of topographic shading compared to the maximum potential daily radiation without any topographic shading (7000 W-h/m^2).

Table 7. Comparison of MDMT and MDAT for EFJ-5 and EFJ-6

Parameter	EFJ-5: Cougar Creek	EFJ-6: God's Pocket Creek
MDMT	16.6	13.1
MDAT	14.1	11.6
Site Elevation (feet)	6,800	6,800
Watershed Area (sq. miles)	3.2	2.95
Max. Elevation (feet)	10,690	10,080

Figure 20. August 1 Solar Radiation at Valley Bottom - Cougar Creek (EFJ-5) and God's Pocket Creek (EFJ-6)



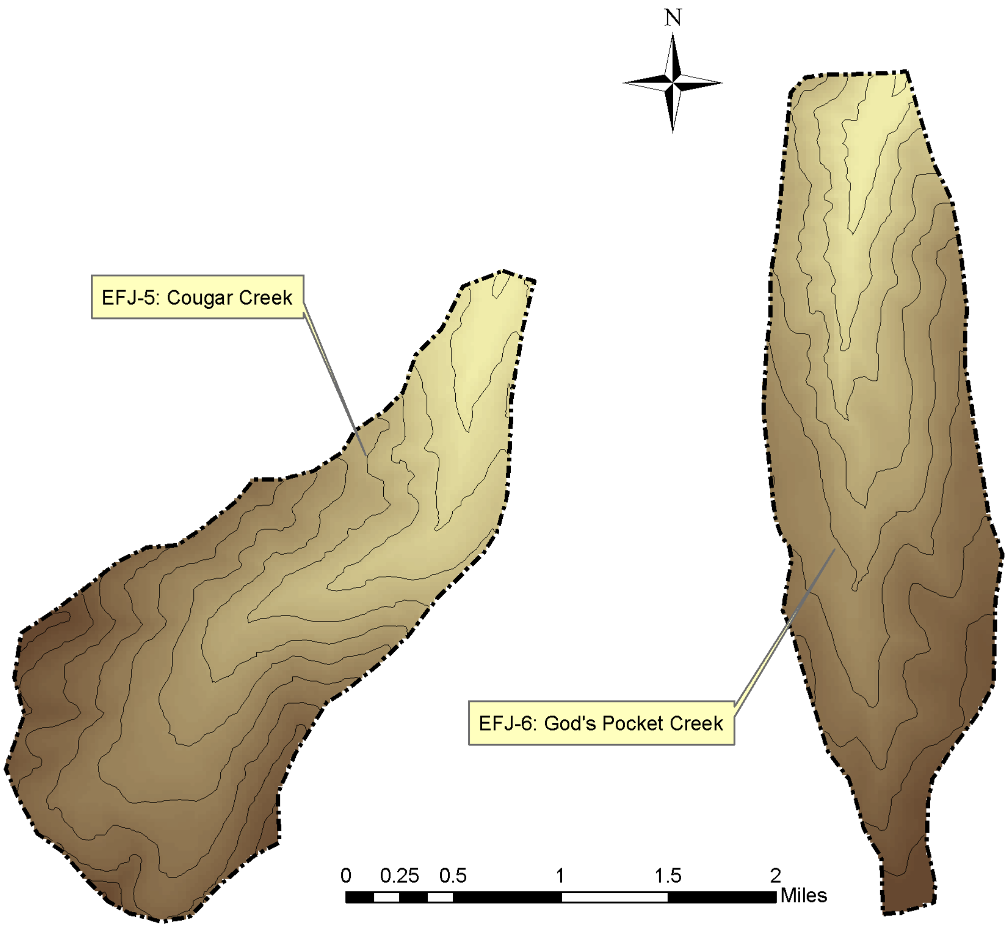


Figure 21. Cougar Creek and God's Pocket Creek Watersheds

Spatial Variability

When evaluating streams for compliance with temperature standards, the spatial variability of temperatures in the real world is an important consideration when collecting thermograph data. Monitoring in a given location may only be indicative of temperatures in an isolated area of the stream. As discussed above, stream temperatures within the study watershed tended to increase as the streams flowed from higher to lower elevations. However, some of the sites evaluated shows some significant spatial variability in relatively short distances.

For example, monitoring at 2 locations on Pearl Creek (tributary to Huntington Creek/South Fork Humboldt River) flowing out of the Ruby Mountains revealed a significant drop in temperature after the stream flowed out of the canyon. Between SFH-1 and SFH-3 (located nearly 5,000 apart, see Figure 22), the 2006 MDMT decreased 2.5º C (from 25.8º C to 22.3º C). Mark Dean, BLM, (collector of thermograph data) has hypothesized that the "*…temperature drop is occurring as the stream crosses the piedmont boundary transitioning from a bedrock stream to one with much larger hyporheic influence along the fan remnants of the Ruby Mountains."* (Dean, 2007).

Some streams can experience dramatic temperature increases in short distances. For example, Trout Creek (tributary to Pine Creek). Between PC-1 and PC-2 (located about 5,000 apart), the 2006 MDMT increased 4.4º C (from 23.3º C to 27.7º C) possibly due in part to significant contributions of warmer water from South Fork Trout Creek (Figure 23). A plot of the 2006 data for PC-1 and PC-2 (Figure 24) show that PC-2 maximum daily temperatures were consistently about 4º C higher than PC-1.

The upper Bruneau River also experienced significant temperature increases in a distance of less than 2 miles (Figure 25). Between B-1 and B-2, the 2006 MDMT increased 4.6º C (from 27.8º C to 32.4º C). Figure 26 shows that B-2 maximum daily temperatures were consistently higher than the B-1 temperatures until mid-September. According to Mark Dean (2007), BLM, this stretch of the river is backed up by beaver ponds resulting in slow moving water.

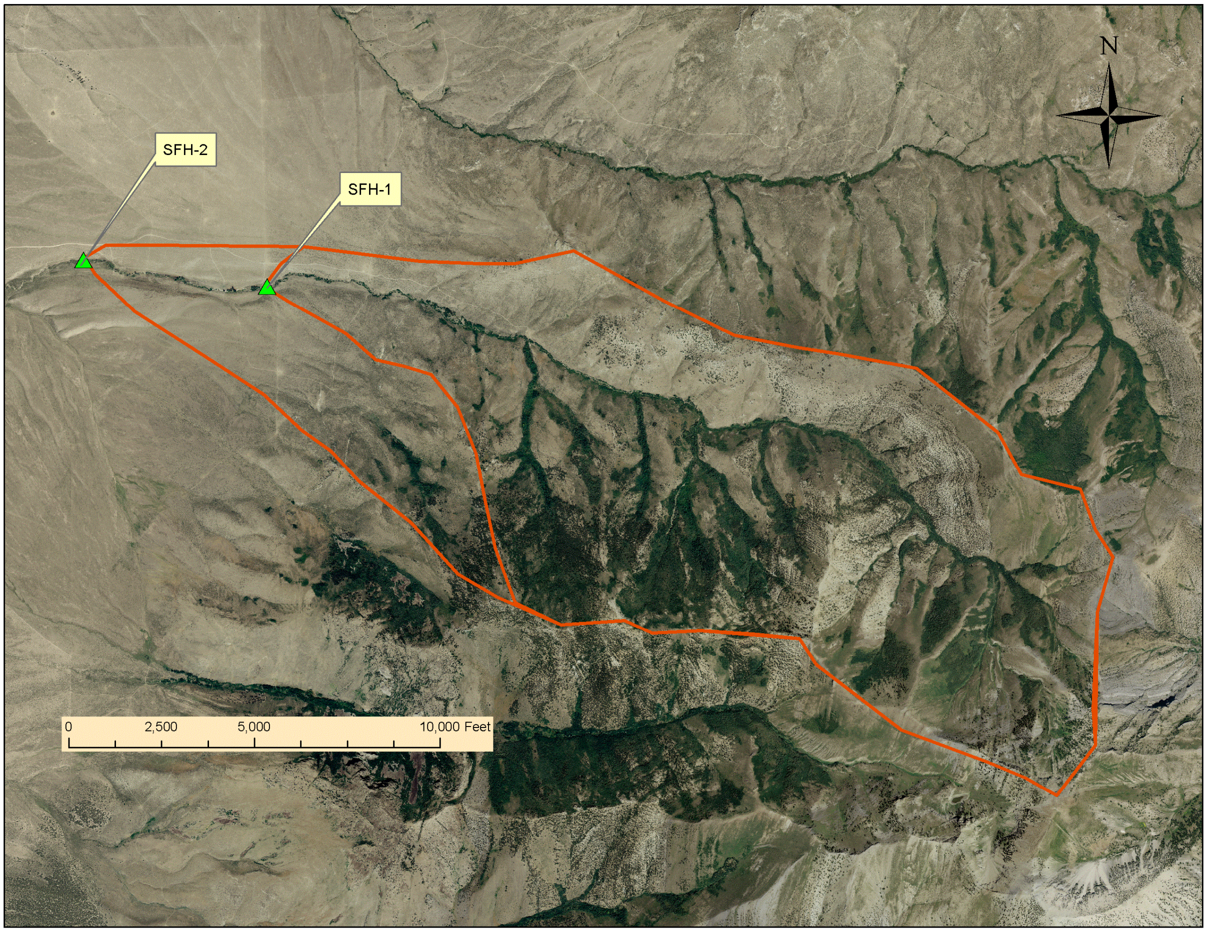


Figure 22. Pearl Creek Monitoring Sites and Watershed Boundaries

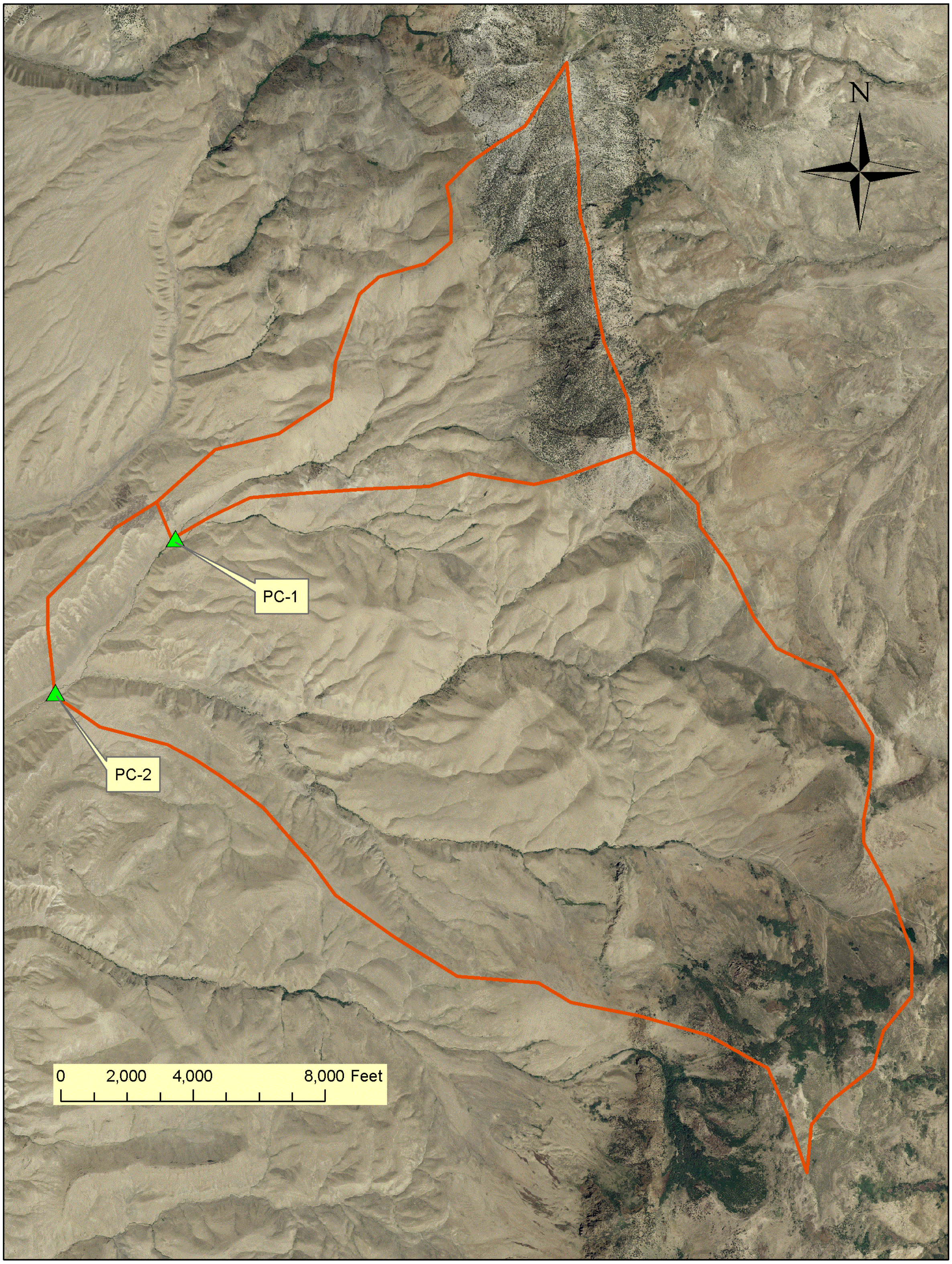
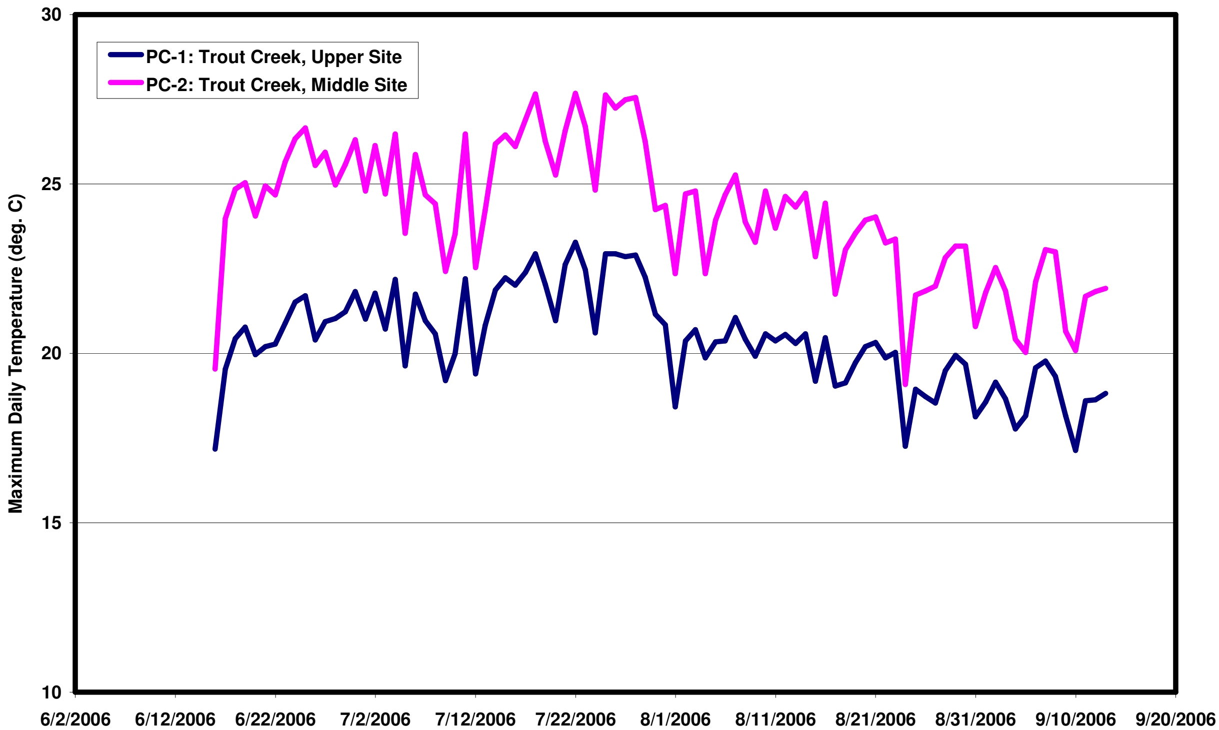


Figure 23. Trout Creek Monitoring Sites and Watershed Areas

Figure 24. Trout Creek Maximum Daily Temperatures at PC-1 and PC-2 in 2006



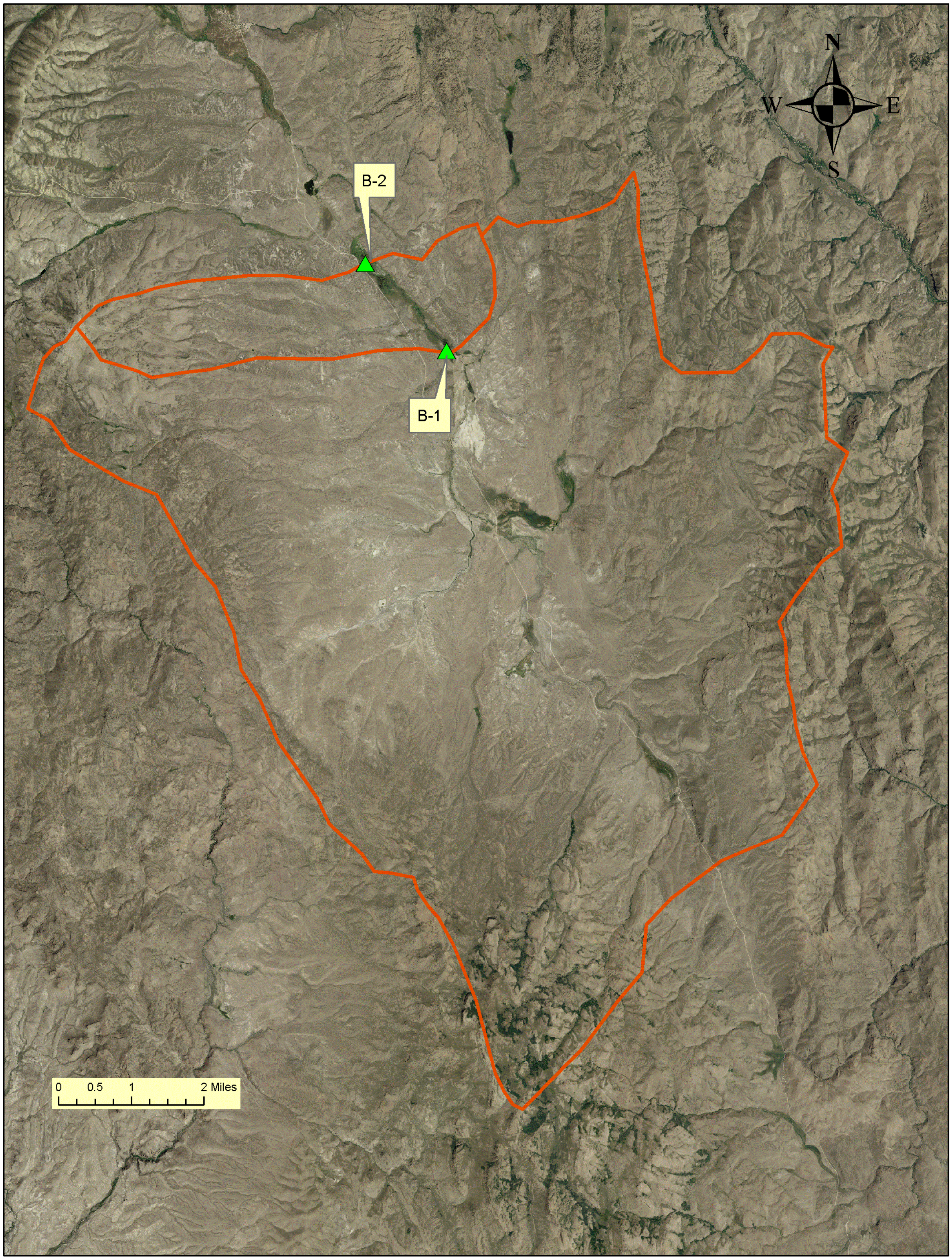
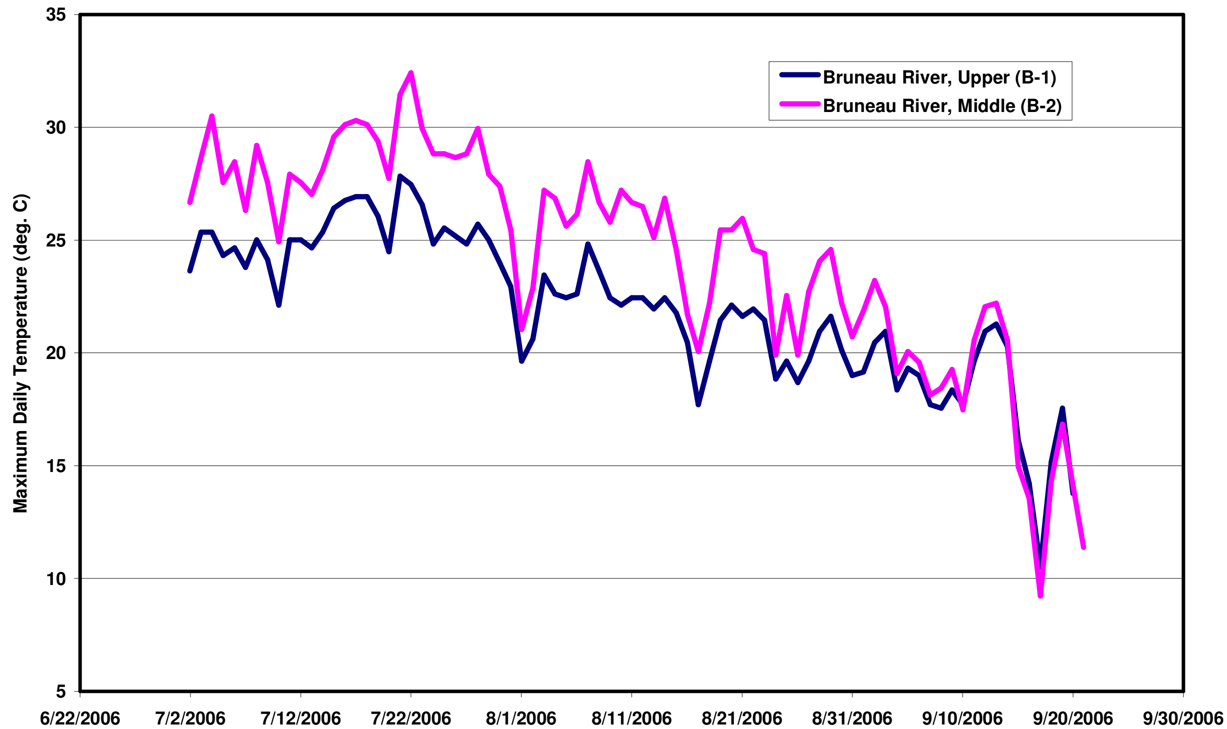


Figure 25. Upper Bruneau River Monitoring Sites and Watershed Areas

Figure 26. Bruneau River Maximum Daily Temperatures at B-1 and B-2 in 2006



Conclusions

The temperature data for 71 stream sites in Northeastern Nevada show some general relationships between the temperature metrics and site elevation, watershed area, and watershed slope/elevation. Much more detailed monitoring and analyses would be needed to better understand the temperature conditions of these waters and the factors most influencing the temperatures. An understanding of a stream's temperature conditions and the contributing factors are needed before measures can be taken to improve temperatures conditions.

Of the 56 sites with detailed data (excluding 15 NDOW sites), only five sites had no exceedances of the temperature water quality standards. All of the five sites were located above elevation 5800 feet. Nevada has similar temperature standards for other streams throughout the state. Many of these streams/watersheds with similar elevation and watershed conditions and it is suspected that these waters also have temperatures in exceedance of the standards. NDEP faces the challenge of evaluating these standards for their appropriateness and achievability. Stream temperatures are determined by numerous factors, some of which are beyond of the control of humans, and some of which are beyond the purview of the Clean Water Act (such as streamflow). Determining reasonably achievable temperature standards for a water can be an intensive undertaking, requiring significant field data and analysis.

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Appendix A

Watershed Characteristics and Temperature Metrics for Study Sites

Table A-1. Watershed Characteristics and Temperature Metrics for Study Sites – Snake River Basin

Site ID	Stream	Site	Hydrographic Region	Watershed	Site Elevation (ft)	Max. Elevation (ft)	Median Elevation (ft)	Median Slope (%)	Basin Area, sq. mi.	Water Quality Standard (deg. C)	Year	Date of Max. Temp	Days since April 30	MDMT	No. of Days > WQS	MDWT	Date of MDAT	Days since April 30	MDAT	MWAT (maximum 7-day average)	Max. Delta	Max. 7-day Avg. Delta	Comments on Temperature Data
BG-1	Little Goose Creek	Little Goose Creek	Snake River	Big Goose	5540	7720	6310	12	21.6	Trib - 21	2006	7/21	82	30.4	100	28.8	7/21	82	22.6	21.5	18.4	16.2	
BG-2	Trout Creek	Trout Creek (Big Bend)	Snake River	Big Goose	5260	8040	6470	27	25	Trib - 21	2005	7/12	73	28.2	62	27.2	7/22	83	23.1	21.7	14.9	11.6	
BG-2	Trout Creek	Trout Creek (Big Bend)	Snake River	Big Goose	5260	8040	6470	27	25	Trib - 21	2006	7/20	81	27.1	51	26.3	7/26	87	21.9	21.5	12.5	11.1	
BG-3	Goose Creek	Goose Creek	Snake River	Big Goose	5117	8130	6120	16	428.6	21	2000	7/23	84	25.8	63	24.7	8/2	94	20.1	19.2	14.1	12.9	
B-1	Bruneau River	Upper Bruneau River	Snake River	Bruneau	6110	8170	6540	12	69.9	21	2006	7/20	81	27.8	50	26.6	7/20	81	22.4	21.9	11.7	10.4	
B-2	Bruneau River	Lower Bruneau River	Snake River	Bruneau	6090	8170	6520	11	76.5	21	2006	7/21	82	32.4	62	30.2	7/21	82	25.0	23.9	16.1	14.3	
B-3	Bruneau River	Bruneau River	Snake River	Bruneau	2599	10800	5630	13	2680	NA (in Idaho)	1997	8/6	98	28.2	NA	27.5	8/24	116	25.3	24.6	6.7	6.0	
B-3	Bruneau River	Bruneau River	Snake River	Bruneau	2599	10800	5630	13	2680	NA (in Idaho)	2000	7/28	89	31.6	NA	30.9	8/3	95	28.8	28.0	8.4	6.6	
B-3	Bruneau River	Bruneau River	Snake River	Bruneau	2599	10800	5630	13	2680	NA (in Idaho)	2004	7/15	76	31.0	NA	29.9	7/15	76	27.3	26.6	8.8	8.0	
B-3	Bruneau River	Bruneau River	Snake River	Bruneau	2599	10800	5630	13	2680	NA (in Idaho)	2005	8/10	102	27.8	NA	27.2	8/9	101	25.3	25.0	7.3	6.3	
B-3	Bruneau River	Bruneau River	Snake River	Bruneau	2599	10800	5630	13	2680	NA (in Idaho)	2006	7/24	85	28.8	NA	28.4	7/24	85	26.9	26.4	7.6	6.3	
EFJ-1	Dave Creek	Upper Dave Creek	Snake River	EF Jarbidge	7600	9920	8670	24	1.97	Trib - 21	1998-2003			6.8		6.3			5.4				Temperature data from report
EFJ-2	Dave Creek	Lower Dave Creek	Snake River	EF Jarbidge	6000	9920	7520	23	7.51	Trib - 21	2006			18.0		17.3			16.1	15.6			Temperature metrics from BLM - no HOBO data
EFJ-3	Slide Creek	Slide Creek	Snake River	EF Jarbidge	7160	9470	8450	31	5.4	Trib - 21	1998-2003			13.7		13.0			11.0				
EFJ-4	Robinson Creek	Upper Robinson Creek	Snake River	EF Jarbidge	7030	9010	8090	27	4.69	Trib - 21	1998-2003			15.2		14.6			12.1				Temperature data from report
EFJ-5	Cougar Creek	Lower Cougar Creek	Snake River	EF Jarbidge	6800	10690	8770	49	3.2	Trib - 21	1998-2003			16.6		16.0			14.1				Temperature data from report
EFJ-6	Gods Pocket Creek	Gods Pocket Creek	Snake River	EF Jarbidge	6800	10080	8500	44	2.95	Trib - 21	1998-2003			13.1		12.6			11.6				Temperature data from report
EFJ-7	Fall Creek	Fall Creek	Snake River	EF Jarbidge	6560	10800	8670	48	6.62	Trib - 21	1998-2003			14.0		13.2			11.8				Temperature data from report
EFJ-8	Jarbidge River, East Fork	Upper EF Jarbidge	Snake River	EF Jarbidge	7360	10530	8860	50	5.85	21	1998-2003			12.5		12.1			9.9				Temperature data from report
EFJ-9	Jarbidge River, East Fork	EF Jarbidge above Cougar Creek	Snake River	EF Jarbidge	6800	10530	8630	51	10.21	21	2004	8/12	104	17.7	0	17.0	8/12	104	13.9	13.3	8.2	7.8	
EFJ-10	Jarbidge River, East Fork	EF Jarbidge below Slide Creek	Snake River	EF Jarbidge	6240	10800	8290	46	42.11	21	2003	7/22	83	22.3	10	21.0	7/22	83	17.9	17.1	10.2	9.5	
EFJ-10	Jarbidge River, East Fork	EF Jarbidge below Slide Creek	Snake River	EF Jarbidge	6240	10800	8290	46	42.11	21	2004	8/10	102	20.4	0	19.7	8/18	110	15.5	14.7	11.3	10.5	
EFJ-11	Jarbidge River, East Fork	EF Jarbidge above Robinson	Snake River	EF Jarbidge	5860	10800	8100	45	49.5	21	1997	8/6	98	20.5	0	19.5	8/6	98	16.3	15.9	8.5	7.8	
EFJ-12	Jarbidge River, East Fork	EF Jarbidge below Robinson	Snake River	EF Jarbidge	5838	10800	8040	43	57.18	21	2003	7/22	83	25.3	40	23.4	7/22	83	20.4	19.3	10.9	10.3	
J-1	Deer Creek	Upper Deer Creek	Snake River	Jarbidge	7380	8970	8040	30	1.74	Trib - 21	1998-2003			16.8		15.8			12.7				Temperature data from report
J-2	Pine Creek	Upper Pine Creek	Snake River	Jarbidge	7280	9480	8420	43	4.41	Trib - 21	1998-2003			15.7		14.9			11.9				Temperature data from report
J-3	Fox Creek	Fox Creek	Snake River	Jarbidge	7040	9540	8320	43	1.98	Trib - 21	1998-2003			15.5		14.8			13.7				Temperature data from report
J-4	Jack Creek	Upper Jack Creek	Snake River	Jarbidge	6720	10720	8540	39	4.6	Trib - 21	1998-2003			14.2		13.9			12.6				Temperature data from report
J-5	Jack Creek	Lower Jack Creek	Snake River	Jarbidge	6320	10720	8210	39	7.53	Trib - 21	1998-2003			14.8		14.1			13.4				Temperature data from report
J-6	Jack Creek	Jack Creek near mouth	Snake River	Jarbidge	5880	10720	8050	39	8.2	Trib - 21	2006	7/27	88	17.0	0	16.2	7/26	87	14.7	14.2	5.6	4.9	
J-7	Bear Creek	Lower Bear Creek	Snake River	Jarbidge	6040	8970	7830	37	3.2	20	1998-2003			18.4		17.4			15.6				Temperature data from report
J-7a	Buck Creek	Buck Creek	Snake River	Jarbidge	5300	8370	6950	17	28.63	NA (in Idaho)	2006	8/7	99	19.9	NA	19.3	7/25	86	17.6	17.4	5.9	5.5	
J-8	Jarbidge River	Upper Jarbidge River	Snake River	Jarbidge	7400	10510	8760	49	3.68	21	1998-2003			11.7		11.3			10.4				Temperature data from report
J-9	Jarbidge River	Jarbidge River - Pine Creek Campground	Snake River	Jarbidge	6570	10720	8300	49	20.1	21	1998-2003			18.4		17.5			14.7				Temperature data from report
J-10	Jarbidge River	Jarbidge River above Town	Snake River	Jarbidge	6240	10720	8250	50	24.03	21	2001	8/6	98	22.0	8	21.1	3/16	-45	17.4	16.8	10.7	9.3	
J-10	Jarbidge River	Jarbidge River above Town	Snake River	Jarbidge	6240	10720	8250	50	24.03	21	2002	7/12	73	21.5	2	20.4	7/13	74	17.2	16.5	9.9	9.2	
J-10	Jarbidge River	Jarbidge River above Town	Snake River	Jarbidge	6240	10720	8250	50	24.03	21	2003	7/22	83	22.2	8	21.0	7/22	83	18.1	17.5	9.2	8.7	
J-10	Jarbidge River	Jarbidge River above Town	Snake River	Jarbidge	6240	10720	8250	50	24.03	21	2004	7/15	76	20.1	0	19.5	7/15	76	16.3	15.3	9.4	9.0	
J-11	Jarbidge River	Jarbidge River at Cemetery Road	Snake River	Jarbidge	6040	10770	8110	48	29.56	21	2002	7/12	73	22.9	27	22.2	7/25	86	18.4	17.5	11.6	10.9	
J-12	Jarbidge River	Jarbidge River above Jack Creek	Snake River	Jarbidge	5885	10770	8030	47	31.42	21	2001	8/6	98	23.3	33	22.3	8/4	96	18.3	17.8	11.1	9.9	
J-12a	Jarbidge River	Jarbidge River below Jack Creek	Snake River	Jarbidge	5880	10770	8040	46	39.63	21	2006	7/27	88	20.9	0	20.0	7/26	87	17.5	17.0	8.8	7.6	
J-12b	Jarbidge River	Jarbidge River below Deer Creek	Snake River	Jarbidge	5740	10770	7910	44	47.72	21	2006	8/7	99	20.9	0	20.0	7/26	87	17.0	16.5	8.9	8.5	
J-13	Jarbidge River	Jarbidge River at Freighter's Defeat Draw	Snake River	Jarbidge	5560	10770	7790	41	54.06	21	2001	8/7	99	23.1	21	22.0	8/7	99	18.4	17.8	10.1	9.4	
J-15	Jarbidge River	Jarbidge River (below EF Jarbidge)	Snake River	Jarbidge (main and EF)	5117	10800	7400	33	183.5	21	2000	8/2	94	25.8	49	24.9	8/2	94	21.9	20.6	11.0	10.1	
J-15	Jarbidge River	Jarbidge River (below EF Jarbidge)	Snake River	Jarbidge (main and EF)	5117	10800	7400	33	183.5	21	2006			23.7		22.8			19.8	19.1			Temperature metrics from BLM - no HOBO data
J-16	Jarbidge River	Jarbidge River below Poison Creek	Snake River	Jarbidge (main and EF)	4200	10800	6370	18	446.65	NA (in Idaho)	2006	7/27	88	25.8	43	25.2	7/25	86	22.9	22.5	8.7	6.5	
J-17	Jarbidge River	Jarbidge River at Bruneau River	Snake River	Jarbidge (main and EF)	3660	10800	6200	17	477.96	NA (in Idaho)	2006			27.4		26.6			23.9	23.1			Temperature metrics from BLM - no HOBO data
SF-1	Deer Creek, West Fork	West Fork Deer Creek c	Snake River	Salmon Falls	6520	8210	7040	25	2.41	Trib - 20	2005	7/12	73	23.2	37	22.4	7/13	74	16.9	16.3	13.9	13.5	
SF-2	Deer Creek, West Fork	West Fork Deer Creek b	Snake River	Salmon Falls	6250	8210	6890	26	3.96	Trib - 20	2005	7/12	73	19.0	0	18.5	7/22	83	16.6	15.1	8.7	7.4	
SF-3	Deer Creek, West Fork	West Fork Deer Creek a	Snake River	Salmon Falls	6200	8210	6870	27	4.06	Trib - 20	2005	7/22	83	22.1	20	21.0	7/22	83	18.5	16.3	11.1	9.5	
SF-4	Deer Creek	Deer Creek	Snake River	Salmon Falls	5980	8570	6840	21	26.1	Trib - 20	2006	7/27	88	31.9	74	30.0	7/24	85	22.8	22.2	22.9	19.9	Site may have gone dry at times
SF-5	Camp Creek	Camp Creek, Upper	Snake River	Salmon Falls	6460	10010	8130	43	14.8	20	2006	7/27	88	21.4	10	20.2	7/27	88	17.7	17.3	7.6	7.2	
SF-6	Camp Creek	Camp Creek, Lower	Snake River	Salmon Falls	5860	10010	7380	28	24.7	20	2006	7/16	77	24.0	31	23.2	7/26	87	19.7	19.3	11.0	9.5	
SF-7	Shack Creek	Shack Creek	Snake River	Salmon Falls	6320	7660	7120	18	4.55	Trib - 20	2003	7/30	91	27.5	39	26.0	8/14	106	20.6	19.6	16.9	14.1	
SF-7	Shack Creek	Shack Creek	Snake River	Salmon Falls	6320	7660	7120	18	4.55	Trib - 20	2004	7/25	86	22.3	25	21.2	8/12	104	17.1	16.4	13.1	11.5	
SF-7	Shack Creek	Shack Creek	Snake River	Salmon Falls	6320	7660	7120	18	4.55	Trib - 20	2005	8/5	97	22.2	21	20.6	7/22	83	17.5	16.4	11.4	10.3	
SF-7	Shack Creek	Shack Creek	Snake River	Salmon Falls	6320	7660	7120	18	4.55	Trib - 20	2006	7/27	88	21.6	7	20.6	7/26	87	17.8	17.4	10.1	0.0	
SF-8	Cottonwood Creek, North Fork	NF Cottonwood Creek	Snake River	Salmon Falls	6100	9380	7340	28	7.56	Trib - 20	2004	7/15	76	27.2	49	25.5	7/15	76	19.9	18.6	17.0	15.3	
SF-8	Cottonwood Creek, North Fork	NF Cottonwood Creek	Snake River	Salmon Falls	6100	9380	7340	28	7.56	Trib - 20	2005	7/16	77	23.0	24	22.6	7/13	74	17.7	17.1	13.1	11.9	
SF-9	Cottonwood Creek, South Fork	SF Cottonwood Creek	Snake River	Salmon Falls	6100	10170	7720	36	20.1	20	2005	7/12	73	23.5	42	22.7	8/1	93	19.0	18.6	11.6	11.0	
SF-9	Cottonwood Creek, South Fork	SF Cottonwood Creek	Snake River	Salmon Falls	6100	10170	7720	36	20.1	20	2006	7/17	78	24.3	47	23.1	7/23	84	19.9	19.5	12.1	11.5	
SF-10	Sun Creek (SF Salmon Falls)	Sun Creek (SF Salmon Falls)	Snake River	Salmon Falls	5860	9500	6650	17	77.8	Trib - 20	2006	7/27	88	26.1	62	24.3	7/27	88	20.7	20.1	14.0	12.0	
SF-11	Jakes Creek, North Fork	NF Jakes Creek	Snake River	Salmon Falls	5840	7920	6740	20	13.9	Trib - 21	2003	7/21	82	26.8	81	26.1	7/24	85	22.7	22.1	10.8	10.1	
SF-11	Jakes Creek, North Fork	NF Jakes Creek	Snake River	Salmon Falls	5840	7920	6740	20	13.9	Trib - 21	2004	7/14	75	26.3	102	25.4	7/19	80	22.3	21.6	9.8	9.0	
SF-11	Jakes Creek, North Fork	NF Jakes Creek	Snake River	Salmon Falls	5840	7920	6740	20	13.9	Trib - 21	2005	7/23	84	24.7	77	24.1	7/22	83	21.7	21.0	10.6	8.8	
SF-12	Salmon Falls, South Fork	SF Salmon Falls	Snake River	Salmon Falls	5780	10010	6760	19	122.1	20	2003	7/21	82	26.6	55	25.1	7/26	87	21.2	20.6	11.9	9.7	
SF-12	Salmon Falls, South Fork	SF Salmon Falls	Snake River	Salmon Falls	5780	10010	6760	19	122.1	20	2004	7/15	76	26.6	60	24.5	7/15	76	21.6	20.0	11.1	10.3	
SF-12	Salmon Falls, South Fork	SF Salmon Falls	Snake River	Salmon Falls	5780	10010	6760	19	122.1	20	2005	7/14	75	25.1	56	24.4	7/14	75	20.5	20.1	10.1	8.8	
SF-12	Salmon Falls, South Fork	SF Salmon Falls	Snake River	Salmon Falls	5780	10010	6760	19	122.1	20	2006	7/21	82	24.2	53	23.4	7/27	88	20.4	20.0	9.0	8.2	
SF-13	Hot Creek	Hot Creek above Shoshone Creek	Snake River	Salmon Falls	5620	8130	6230	12	56.8	NA (in Idaho)	2000	6/4	35	25.4	NA	23.7	8/2	94	19.8	18.7	15.0	12.9	
SF-13	Hot Creek	Hot Creek above Shoshone Creek	Snake River	Salmon Falls	5620	8130	6230	12	56.8	NA (in Idaho)	2002	5/31	31	25.4	NA	24.1	7/14	75	20.1	19.2	14.9	12.1	
SF-13	Hot Creek	Hot Creek above Shoshone Creek	Snake River	Salmon Falls	5620	8130	6230	12	56.8	NA (in Idaho)	2003	7/21	82	27.3	NA	26.2	7/20	81	21.4	21.0	15.7	14.6	

Table A-2. Watershed Characteristics and Temperature Metrics for Study Sites – Snake and Humboldt River Basin

Site ID	Stream	Site	Hydrographic Region	Watershed	Site Elevation (ft)	Max. Elevation (ft)	Median Elevation (ft)	Median Slope (%)	Basin Area, sq. mi.	Water Quality Standard (deg. C)	Year	Date of Max. Temp	Days since April 30	MDMT	No. of Days > WQS	MDWT	Date of MDAT	Days since April 30	MDAT	MWAT (maximum 7-day average)	Max. Delta	Max. 7-day Avg. Delta	Comments on Temperature Data
SF-14	Shoshone Creek	Shoshone Creek above Hot Creek	Snake River	Salmon Falls	5620	7510	6120	9	142.6	NA (in Idaho)	2000	7/21	82	25.4	NA	24.8	8/2	94	20.4	19.7	11.6	10.8	
SF-14	Shoshone Creek	Shoshone Creek above Hot Creek	Snake River	Salmon Falls	5620	7510	6120	9	142.6	NA (in Idaho)	2002	7/12	73	27.4	NA	26.1	7/14	75	21.9	21.1	11.8	10.6	
SF-14	Shoshone Creek	Shoshone Creek above Hot Creek	Snake River	Salmon Falls	5620	7510	6120	9	142.6	NA (in Idaho)	2003	7/21	82	25.9	NA	25.2	7/21	82	21.6	21.3	10.7	9.2	
SF-15	Shoshone Creek	Shoshone Creek below Magic Springs	Snake River	Salmon Falls	5458	8130	6140	11	216.4	NA (in Idaho)	2000	7/17	78	27.0	NA	26.5	8/2	94	23.6	22.3	10.3	9.5	
SF-15	Shoshone Creek	Shoshone Creek below Magic Springs	Snake River	Salmon Falls	5458	8130	6140	11	216.4	NA (in Idaho)	2003	7/21	82	29.2	NA	28.2	7/21	82	24.6	24.3	10.7	9.8	
SF-16	Shoshone Creek	Shoshone Creek at NV/ID stateline	Snake River	Salmon Falls	5389	8130	6090	11	243.6	21	2003	7/23	84	29.0	101	28.0	7/25	86	24.3	23.5	13.3	12.1	
SFO-1	Owyhee River, South Fork	SF Owyhee River at Old USGS Gage	Snake River	SF Owyhee	4880	10310	6100	17	1074.4	21	1999	7/26	87	27.2	59	26.0	7/13	74	23.5	22.0	10.4	9.3	
SFO-1	Owyhee River, South Fork	SF Owyhee River at Old USGS Gage	Snake River	SF Owyhee	4880	10310	6100	17	1074.4	21	2000	7/21	82	29.0	89	27.6	7/21	82	23.2	22.1	12.2	10.9	
SFO-1	Owyhee River, South Fork	SF Owyhee River at Old USGS Gage	Snake River	SF Owyhee	4880	10310	6100	17	1074.4	21	2001	7/3	64	28.8	95	27.5	7/4	65	24.0	22.4	14.3	11.4	
SFO-1	Owyhee River, South Fork	SF Owyhee River at Old USGS Gage	Snake River	SF Owyhee	4880	10310	6100	17	1074.4	21	2002	7/13	74	29.9	86	28.1	7/13	74	25.4	23.8	11.0	9.4	
SFO-1	Owyhee River, South Fork	SF Owyhee River at Old USGS Gage	Snake River	SF Owyhee	4880	10310	6100	17	1074.4	21	2003	7/22	83	30.9	58	29.2	7/22	83	25.6	24.5	10.8	10.3	
SFO-1	Owyhee River, South Fork	SF Owyhee River at Old USGS Gage	Snake River	SF Owyhee	4880	10310	6100	17	1074.4	21	2006	7/21	82	30.3	75	29.2	7/24	85	25.7	25.2	11.3	9.6	
SFO-2	Owyhee River, South Fork	SF Owyhee River at Pipeline	Snake River	SF Owyhee	4670	10310	5860	13	1632.7	21	1999	7/12	73	27.5	73	25.8	7/12	73	23.6	22.0	10.8	9.3	
SFO-2	Owyhee River, South Fork	SF Owyhee River at Pipeline	Snake River	SF Owyhee	4670	10310	5860	13	1632.7	21	2000	8/2	94	29.7	87	28.2	8/2	94	24.4	23.1	12.6	11.1	
SFO-2	Owyhee River, South Fork	SF Owyhee River at Pipeline	Snake River	SF Owyhee	4670	10310	5860	13	1632.7	21	2001	7/3	64	29.7	95	27.5	7/4	65	24.9	23.2	16.9	14.6	
SFO-2	Owyhee River, South Fork	SF Owyhee River at Pipeline	Snake River	SF Owyhee	4670	10310	5860	13	1632.7	21	2003	7/22	83	30.4	59	29.2	7/22	83	25.3	24.5	11.4	9.9	
SFO-2	Owyhee River, South Fork	SF Owyhee River at Pipeline	Snake River	SF Owyhee	4670	10310	5860	13	1632.7	21	2006	7/21	82	29.3	75	27.9	7/21	82	25.3	24.5	10.9	9.2	
MC-1	Toro Canyon	Toro Canyon	Humboldt River	Maggie Creek	6440	8630	7350	34	7	Trib - 20	2006	7/22	83	19.8	0	19.3	22-Jul	83	16.7	16.4	8.4	7.5	
MC-2	Beaver Creek	Beaver Creek	Humboldt River	Maggie Creek	5800	8630	7070	37	23.7	Trib - 20	2003	7/23	84	24.2	72	23.1	23-Jul	84	20.0	19.4	12.8	11.5	
MC-2	Beaver Creek	Beaver Creek	Humboldt River	Maggie Creek	5800	8630	7070	37	23.7	Trib - 20	2004	7/14	75	22.0	33	21.4	15-Jul	76	17.7	17.1	11.2	10.1	
MC-2	Beaver Creek	Beaver Creek	Humboldt River	Maggie Creek	5800	8630	7070	37	23.7	Trib - 20	2006	7/27	88	20.4	7	19.6	22-Jul	83	17.4	17.0	7.1	6.5	
MR-1	Hanks Creek	Hanks Creek	Humboldt River	Marys River	5860	8140	6690	19	67.4	Trib - 20	2002	7/11	72	24.5	54	24.0	13-Jul	74	22.7	22.1	6.1	5.0	
MR-1	Hanks Creek	Hanks Creek	Humboldt River	Marys River	5860	8140	6690	19	67.4	Trib - 20	2003	7/23	84	25.7	74	24.5	23-Jul	84	23.6	22.3	6.1	5.4	
MR-1	Hanks Creek	Hanks Creek	Humboldt River	Marys River	5860	8140	6690	19	67.4	Trib - 20	2004	7/14	75	23.8	37	22.5	14-Jul	75	19.5	18.7	9.8	8.7	
MR-1	Hanks Creek	Hanks Creek	Humboldt River	Marys River	5860	8140	6690	19	67.4	Trib - 20	2005	7/14	75	22.7	22	21.9	14-Jul	75	19.1	18.4	7.9	7.0	
MR-1	Hanks Creek	Hanks Creek	Humboldt River	Marys River	5860	8140	6690	19	67.4	Trib - 20	2006	7/22	83	22.7	35	22.1	24-Jul	85	19.6	19.3	8.0	7.0	
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt River	Marys River	5940	10560	7410	36	72	20	1993	7/23	84	25.0	55	24.3	4-Aug	96	20.0	18.9	13.0	11.7	
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt River	Marys River	5940	10560	7410	36	72	20	1997	8/6	98	26.0	67	24.5	24-Aug	116	20.8	19.7	13.0	11.6	
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt River	Marys River	5940	10560	7410	36	72	20	1999	7/12	73	25.5	67	24.1	24-Aug	116	20.3	19.6	13.0	11.9	
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt River	Marys River	5940	10560	7410	36	72	20	2002	7/11	72	27.5	57	26.8	12-Jul	73	22.0	21.4	13.0	11.8	
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt River	Marys River	5940	10560	7410	36	72	20	2004	7/31	92	26.5	57	24.8	15-Jul	76	20.8	19.8	13.0	11.4	
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt River	Marys River	5940	10560	7410	36	72	20	2005	7/20	81	26.0	35	25.2	16-Jul	77	21.3	20.9	10.5	8.9	
MR-2	Marys River	Marys River below Orange Bridge (10313400)	Humboldt River	Marys River	5940	10560	7410	36	72	20	2006	7/21	82	25.8	38	24.9	21-Jul	82	21.1	20.8	11.4	10.0	
MR-3	Marys River	Marys River bel. Twin Buttes (10315600)	Humboldt River	Marys River	5410	10560	6420	16	516	20	1993	8/1	93	27.0	60	25.9	4-Aug	96	23.0	22.3	9.0	8.2	
MR-3	Marys River	Marys River bel. Twin Buttes (10315600)	Humboldt River	Marys River	5410	10560	6420	16	516	20	1995	8/4	96	27.0	52	25.4	5-Aug	97	23.0	21.6	9.5	8.6	
MR-3	Marys River	Marys River bel. Twin Buttes (10315600)	Humboldt River	Marys River	5410	10560	6420	16	516	20	1996	7/13	74	28.0	53	25.9	13-Jul	74	23.8	22.7	8.5	7.8	
MR-3	Marys River	Marys River bel. Twin Buttes (10315600)	Humboldt River	Marys River	5410	10560	6420	16	516	20	1997	7/21	82	26.5	64	24.6	21-Jul	82	22.5	21.7	8.0	6.5	
MR-3	Marys River	Marys River bel. Twin Buttes (10315600)	Humboldt River	Marys River	5410	10560	6420	16	516	20	1998	8/5	97	25.0	46	24.4	18-Jul	79	21.8	21.0	8.5	7.5	
MR-3	Marys River	Marys River bel. Twin Buttes (10315600)	Humboldt River	Marys River	5410	10560	6420	16	516	20	2006	7/21	82	27.5	51	26.6	21-Jul	82	24.5	23.9	8.0	6.8	
PC-1	Trout Creek	Upper Trout Creek	Humboldt River	Pine Creek	5680	8690	6860	34	2.86	Trib - NA	2004	7/15	76	25.9	NA	24.8	15-Jul	76	19.5	18.9	14.0	13.1	
PC-1	Trout Creek	Upper Trout Creek	Humboldt River	Pine Creek	5680	8690	6860	34	2.86	Trib - NA	2005	7/14	75	22.4	NA	21.7	14-Jul	75	17.4	17.0	10.7	10.1	
PC-1	Trout Creek	Upper Trout Creek	Humboldt River	Pine Creek	5680	8690	6860	34	2.86	Trib - NA	2006	7/21	82	23.3	NA	22.6	7/21	82	18.4	18.0	11.4	10.7	
PC-2	Trout Creek	Middle Trout Creek	Humboldt River	Pine Creek	5440	8690	6680	28	13.9	Trib - NA	2006	7/17	78	27.7	NA	27.0	7/24	85	21.4	20.7	16.6	15.6	
PC-3	Trout Creek	Lower Trout Creek	Humboldt River	Pine Creek	5360	8690	6640	27	14.4	Trib - NA	2004	6/2	33	28.7	NA	27.5	7/15	76	21.8	21.1	18.8	18.0	
RC-1	Rock Creek	Another upper Rock Creek	Humboldt River	Rock Creek	6900	8570	7860	30	4.24	20	2001	8/3	95	19.5	0	18.8	7/4	65	16.2	15.2	8.8	8.1	
RC-1	Rock Creek	Another upper Rock Creek	Humboldt River	Rock Creek	6900	8570	7860	30	4.24	20	2006	7/25	86	17.5	0	16.9	7/25	86	15.1	14.9	6.5	6.0	
RC-2	Rock Creek	Upper Rock Creek	Humboldt River	Rock Creek	4840	8570	5750	14	799.7	34	2005	7/14	75	31.1	0	29.9	7/14	75	25.5	24.5	13.1	12.0	
RC-3	Rock Creek	Lower Rock Creek	Humboldt River	Rock Creek	4670	8570	5740	13	865.4	34	2005	7/14	75	28.7	0	28.1	7/15	76	25.3	24.9	7.6	7.1	
RC-4	Lewis Creek	Lewis Creek	Humboldt River	Rock Creek	6300	8410	7160	27	6.98	Trib - 20	2004	7/15	76	26.3	36	24.0	7/15	76	19.4	17.8	16.4	14.9	
RC-4	Lewis Creek	Lewis Creek	Humboldt River	Rock Creek	6300	8410	7160	27	6.98	Trib - 20	2005	7/19	80	21.1	12	20.7	7/22	83	17.5	16.6	10.6	9.5	
RC-4	Lewis Creek	Lewis Creek	Humboldt River	Rock Creek	6300	8410	7160	27	6.98	Trib - 20	2006	7/21	82	22.6	16	21.8	7/22	83	18.6	18.0	10.1	9.5	
RC-5	Nelson Creek	Upper Nelson Creek	Humboldt River	Rock Creek	5920	7640	6780	28	7.1	Trib - 20	2006	7/3	64	20.4	2	19.4	7/4	65	17.5	17.1	7.2	5.8	
RC-6	Nelson Creek	Lower Nelson Creek	Humboldt River	Rock Creek	5700	8410	6780	26	19.2	Trib - 20	2003	7/23	84	28.2	98	26.6	7/26	87	22.2	21.1	15.1	14.0	
RC-6	Nelson Creek	Lower Nelson Creek	Humboldt River	Rock Creek	5700	8410	6780	26	19.2	Trib - 20	2004	7/15	76	28.9	97	27.5	7/15	76	24.1	23.3	13.3	11.0	
RC-6	Nelson Creek	Lower Nelson Creek	Humboldt River	Rock Creek	5700	8410	6780	26	19.2	Trib - 20	2005	7/19	80	30.6	38	30.0	7/19	80	25.6	24.9	11.1	10.1	
RC-7	Willow Creek	Willow Creek	Humboldt River	Rock Creek	5450	8410	6380	20	81.1	20	2003	7/26	87	26.5	70	25.8	7/24	85	24.1	23.4	7.6	7.2	
RC-7	Willow Creek	Willow Creek	Humboldt River	Rock Creek	5450	8410	6380	20	81.1	20	2005	7/13	74	22.5	30	21.8	7/13	74	19.7	19.3	12.1	10.6	
RC-7	Willow Creek	Willow Creek	Humboldt River	Rock Creek	5450	8410	6380	20	81.1	20	2006	7/3	64	23.4	39	22.4	7/3	64	20.7	20.0	5.8	5.3	
SFH-1	Pearl Creek	Pearl Creek, Upper	Humboldt River	SF Humboldt River	6300	10400	7710	40	5.78	Trib - 20	2006	7/27	88	25.8	70	24.5	7/27	88	19.1	18.5	15.2	13.9	
SFH-2	Pearl Creek	Pearl Creek, Middle	Humboldt River	SF Humboldt River	6140	10400	7550	37	7	Trib - 20	2006	7/27	88	22.8	48	22.0	7/27	88	17.4	17.1	11.6	10.9	
SFH-3	Pearl Creek	Pearl Creek, Lower	Humboldt River	SF Humboldt River	6130	10400	7540	36	7	Trib - 20	2006	7/27	88	22.3	29	21.2	7/27	88	17.4	16.8	10.9	10.0	
SFLH-1	Secret Creek	Secret Creek	Humboldt River	SF Little Humboldt	6400	8150	7390	22	3.29	Trib - 20	2003	7/23	84	25.9	58	23.9	7/23	84	20.5	19.4	14.4	13.7	
SFLH-1	Secret Creek	Secret Creek	Humboldt River	SF Little Humboldt	6400	8150	7390	22	3.29	Trib - 20	2005	7/15	76	18.6	0	18.2	8/8	100	15.0	13.9	9.7	9.3	
SFLH-1	Secret Creek	Secret Creek	Humboldt River	SF Little Humboldt	6400	8150	7390	22	3.29	Trib - 20	2006	7/26	87	17.9	0	17.3	7/26	87	14.4	14.1	9.6	8.8	
SFLH-2	Sheep Creek	Sheep Creek	Humboldt River	SF Little Humboldt	6200	8290	6870	19	6.44	Trib 20	2002	7/12	73	22.5	30	21.7	7/13	74	16.5	15.9	13.7	12.2	
SFLH-2	Sheep Creek	Sheep Creek	Humboldt River	SF Little Humboldt	6200	8290	6870	19	6.44	Trib 20	2003	7/23	84	24.4	46	22.2	7/23	84	18.0	16.8	15.5	14.2	
SFLH-2	Sheep Creek	Sheep Creek	Humboldt River	SF Little Humboldt	6200	8290	6870	19	6.44	Trib 20	2004	7/16	77	27.0	92	25.7	7/16	77	19.4	19.2	16.7	15.7	
SFLH-2	Sheep Creek	Sheep Creek	Humboldt River	SF Little Humboldt	6200	8290	6870	19	6.44	Trib 20	2005	7/22	83	18.8	0	18.4	7/22	83	15.2	14.1	9.3	8.9	
SFLH-2	Sheep Creek	Sheep Creek	Humboldt River	SF Little Humboldt	6200	8290	6870	19	6.44	Trib 20	2006	7/5	66	20.0	1	18.7	7/5	66	15.1	14.4	12.6	10.8	
SFLH-3	SF Little Humboldt River	below Oregon Flat	Humboldt River	SF Little Humboldt	6100	8320	7000	21	23.5	20	2002	6/28	59	24.9	31	23.2	7/13	74	19.6	18.8	13.9	12.4	
SFLH-3	SF Little Humboldt River	below Oregon Flat	Humboldt River	SF Little Humboldt	6100	8320	7000	21	23.5	20	2003	7/23	84	23.5	12	21.3	7/23	84	18.9	17.6	10.8	9.6	
SFLH-3	SF Little Humboldt River	below Oregon Flat	Humboldt River	SF Little Humboldt	6100	8320	7000	21	23.5	20	2004	7/14	75	24.0	58	23.1	7/19	80	17.9	17.6	14.2	13.2	
SFLH-3	SF Little Humboldt River	below Oregon Flat	Humboldt River	SF Little Humboldt	6100	8320	7000	21	23.5	20	2005	7/15	76	23.3	37	22.7	8/8	100	18.5	17.4	11.9	11.3	
SFLH-3	SF Little Humboldt River	below Oregon Flat	Humboldt River	SF Little Humboldt	6100	8320	7000	21	23.5	20	2006	6/24	55	22.5	24	21.5	6/25	56	18.3	17.7	11.6	10.8	
SFLH-4	SF Little Humboldt River	Above Pole Creek	Humboldt River	SF Little Humboldt	5960	8320	6960	21	26.2	20	2002	7/12	73	21.7	8	21.0	7/13	74	17.3	16.4	11.8	10.1	
SFLH-4	SF Little Humboldt River	Above Pole Creek	Humboldt River	SF Little Humboldt	5960	8320	6960	21	26.2	20	2005	7/15	76	23.4	38	22.9	7/22	83	19.1	18.0	11.3	10.8	
SFLH-4	SF Little Humboldt River	Above Pole Creek	Humboldt River	SF Little Humboldt	5960	8320	6960	21	26.2	20	2005	7/22	83	22.9	29	22.0	7/22	83	19.0	18.5	11.2	10.3	
SC-1	Sherman Creek	Upper Sherman Creek	Humboldt River	Sherman Creek	5650	7240	6530	26	6.25	NA	2005	7/12	73	24.0	NA	23.4	7/15	76	18.9	18.3	11.6	11.2	
SC-1	Sherman Creek	Upper Sherman Creek	Humboldt River	Sherman Creek	5650	7240	6530	26	6.25	NA	2006	7/21	82	23.5	NA	22.5	7/22	83	19.4	18.9	11.4	10.6	