APPENDIX E – QUAL2K STREAM TEMPERATURE MODELING FOR ASHLEY CREEK AND THE WHITEFISH RIVER

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E1.0 INTRODUCTION

Temperature impairments were assessed within Ashley Creek and the Whitefish River using a combination of instream temperature measurements, riparian shading assessments, mid-summer streamflow measurements, and modeling. The Ashley Creek and Whitefish River temperature assessment was conducted to aid in the development of total maximum daily loads (TMDLs) for temperature impaired stream segments in the Flathead-Stillwater TMDL Planning Area (TPA) (**Table E1-1**). Data collected during this assessment were used in the QUAL2K model to assess the influence of shading and streamflow on stream temperatures in Ashley Creek and the Whitefish River. The results of this assessment were compared to Montana's water quality standards for temperature to evaluate beneficial-use support and potential restoration strategies.

Table E1-1. Temperature Impairments in the Flathead-Stillwater TPA

Name	Waterbody ID	Length (miles)	Use Class	Location	Temperature Impairment
Ashley Creek	MT76O002_010	14.8	B-1	from Ashley Lake to Smith Lake	yes
Ashley Creek	MT76O002_020	13.4	B-2	from Smith Lake to bridge crossing on Kalispell airport road	no
Ashley Creek	MT76O002_030	11.8	C-2	from bridge crossing on Kalispell airport road to the confluence with the Flathead River	yes
Whitefish River	MT76P003_010	23.7	B-2	from Whitefish Lake to the confluence with the Stillwater River	yes

E1.1 MONTANA WATER QUALITY STANDARDS

Montana's water quality standard for temperature addresses a maximum allowable increase above the "naturally occurring" temperature to protect the existing thermal regime for fish and aquatic life. Among other uses, Ashley Creek and the Whitefish River are to be maintained suitable for the growth and propagation (for B-1 waters) or marginal propagation (for B-2 and C-2 waters) of salmonid fishes and associated aquatic life, waterfowl and furbearers. For waters classified as B-1, B-2 and C-2, the associated standard specific to temperature is as follows: "A 1°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 66°F; within the naturally occurring range of 66°F to 66.5°F, no discharge is allowed which will cause the water temperature to exceed 67°F; and where the naturally occurring water temperature is 66.5°F or greater, the maximum allowable increase in water temperature is 0.5°F. A 2°F per-hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55°F. A 2°F maximum decrease below naturally occurring water temperature is allowed within the range of 55°F to 32°F." [ARM 17.30.623(2e), ARM 17.30.624(2e) and ARM 17.30.627(2e)]. Temperature monitoring and modeling indicated that naturally occurring stream temperatures in Ashley Creek and the Whitefish River are likely greater than 66.5°F during portions of the summer months. Thus, the maximum allowable increase due to unmitigated human causes is likely to be 0.5°F during the hottest part of the summer.

E1.2 Temperature Thresholds

Special temperature considerations are warranted for the westslope cutthroat trout, which is listed by the State of Montana as a species of concern (Carlson, 2001). Research by (Bear et al., 2007) found that the upper incipient lethal temperature (UILT) for westslope cutthroat trout was 67°F, while the UILT for rainbow trout was 76°F. The UILT is the temperature that is considered to be survivable indefinitely by 50 percent of the population (Lohr, 1996). Although these temperature thresholds are used as a reference that likely causes impact to fish, they are not targeted temperatures and are not directly related to Montana's water quality standards.

E2.0 Temperature Assessment

The Ashley Creek and Whitefish River temperature assessment was performed in order to identify existing conditions and to determine if human caused disturbances have led to increased stream water temperatures. This assessment utilized field data and computer modeling to assess stream temperatures in relation to Montana's water quality standards.

E2.1 Field Data Collection

Field data used in this assessment were collected during the 2008 summer field season and included temperature measurements, streamflow measurements, and an assessment of riparian shading along Ashley Creek, the Whitefish River and selected tributary streams. Field methods are described in *Flathead Stillwater TMDL Planning Area Temperature and Instantaneous Flow Monitoring Sampling and Analysis Plan* (Montana Department of Environmental Quality, 2008).

E2.1.1 Temperature Measurements

Temperature monitoring was conducted on Ashley Creek and the Whitefish River between late-July and mid-September in 2008. The study timeframe examined stream temperatures during the period when streamflows tend to be lowest, water temperatures are warmest, and negative effects to the aquatic life beneficial use are likely most pronounced. Temperature monitoring consisted of placing temperature data logging devices at 20 sites in the Ashley Creek watershed and 11 sites in the Whitefish River watershed. Temperature monitoring sites were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width so that the temperature data collected during this assessment could be utilized in the QUAL2K model. A summary of temperature data is presented in **Attachment A**.

E2.1.2 Streamflow Measurements

Streamflow was measured at 14 sites in the Ashley Creek watershed and seven sites in the Whitefish River watershed during mid-August. Streamflow data collected during this assessment were used in the QUAL2K model to help determine if instream temperatures exceed Montana standards.

E2.1.3 Riparian Shading

Riparian shading was assessed at 12 sites along Ashley Creek and eight sites along the Whitefish River using a Solar Pathfinder, which measures the amount of shade at a site in one-hour intervals between 6 a.m. and 6 p.m. The Solar Pathfinder was utilized to assess riparian shading using the August template for the path of the sun. Shade was measured at three locations over a 200-foot reach at each site. In addition to the Solar Pathfinder readings, the following measurements were performed at each site for which riparian shading was assessed:

- Stream azimuth
- Bankfull width
- Wetted width
- Dominant tree species

Riparian shading data were used to assess existing and potential riparian shading conditions relative to the level of anthropogenic disturbance at a site. Measurements obtained with the Solar Pathfinder were used in the QUAL2K model to help determine if instream temperatures exceed Montana standards. Solar Pathfinder hourly shade measurements are presented in **Attachment B** and supplemental field data are presented in **Attachment C**.

E2.2 QUAL2K MODEL

The QUAL2K model was used to determine if human caused disturbances within the watersheds have increased the water temperature above the "naturally occurring" level and, if so, to what degree. The QUAL2K model is available at: http://www.epa.gov/ATHENS/wwqtsc/html/qual2k.html. Stream temperature, riparian shading and streamflow data collected in the summer of 2008 were used to calibrate the QUAL2K model for existing conditions. The potential to reduce stream temperatures was then modeled based on up to seven scenarios, including:

- Baseline (existing) scenario
- Shade scenario
- Water consumptive use scenario (only for Ashley Creek)
- Shade and water consumptive use scenario (only for Ashley Creek)
- Shade and 15% reduction of water withdrawn for irrigation scenario (only for Ashley Creek)
- Shade with no Kalispell wastewater treatment plant (WWTP) discharge present scenario (only for Ashley Creek)
- Shade with Kalispell WWTP discharge at the average naturally occurring stream temperature (only for Ashley Creek)

The QUAL2K model inputs and outputs are based on the metric system; results are presented in °F. Temperature values in °C are converted to °F using the equation:

$$°F = °C * 9/5 + 32$$

For comparison, conversion values between °C and °F are included in **Table E2-1**.

Table E2-1. Conversion Table °C to °F

°C	°F	°C	°F	°C	°F
1	33.8	11	51.8	21	69.8
2	35.6	12	53.6	22	71.6
3	37.4	13	55.4	23	73.4
4	39.2	14	57.2	24	75.2
5	41.0	15	59.0	25	77.0
6	42.8	16	60.8	26	78.8
7	44.6	17	62.6	27	80.6
8	46.4	18	64.4	28	82.4
9	48.2	19	66.2	29	84.2
10	50.0	20	68.0	30	86.0

E2.2.1 Data Sources and Model Assumptions

Data sources and model assumptions made during this assessment are described within the following sections. A more detailed discussion on specific model inputs for each data entry tab of the QUAL2K model is presented in **Attachment D**.

E2.2.1.1 Temperature Data

Temperature data collected in both Ashley Creek and the Whitefish River during the summer of 2008 were applied in the QUAL2K model.

Ashley Creek

Temperature data loggers were placed at 20 sites in the Ashley Creek watershed during the summer of 2008, including 17 mainstem locations and three tributaries (**Attachment E**). Data loggers were deployed between July 21st and 28th and retrieved between September 10th and 17th. One mainstem temperature data logger was lost (ASHL-12) resulting in temperature data for 16 Ashley Creek sites and three tributary sites.

The maximum daily temperature data were reviewed for all sites in the Ashley Creek watershed to identify the warmest day of the season. Maximum daily temperatures occurred between July 26th and August 18th, with 15 out of 19 seasonal maximum temperatures occurring on August 17th (**Attachment A**). Model results for Ashley Creek indicate a 15 day travel time and the QUAL2K model for Ashley Creek was run for the August 4th – 18th timeframe.

Whitefish River

Temperature data loggers were placed at 11 sites in the Whitefish River watershed, including nine mainstem locations and two tributaries (**Attachment E**). Data loggers were deployed between July 18th and 21st and retrieved between September 11th and 15th.

The maximum daily temperature data were reviewed for all sites in the Whitefish River watershed to identify the warmest day of the season. Maximum daily temperatures occurred between July 26th and August 18th, with seven out of 10 seasonal maximum temperatures occurring on August 18th (**Attachment A**). Model results indicate a two-day travel time in the Whitefish River and the QUAL2K model for the Whitefish River was run for the August 17th – 18th timeframe.

E2.2.1.2 Streamflow Data

Streamflow data collected in both Ashley Creek and the Whitefish River during the summer of 2008 were applied in the QUAL2K model.

Ashley Creek

Streamflow measurements were collected at 12 sites on Ashley Creek and two sites on tributary streams, including Porter Creek and Spring Creek (**Table E2-2, Attachment E**). Streamflow measurements on Ashley Creek were collected between August 15th and August 25th. Nine streamflow measurements were applied in the QUAL2K model from the mainstem of Ashley Creek along with both tributary streamflow measurements. Three mainstem flow measurements from Ashley Creek (ASHL-11, ASHL-19 and ASHL-20) were discarded because the data were collected in very slow moving portions of the stream where there was dense of aquatic vegetation, which may have reduced the accuracy of the velocity measurement. Several of the velocity readings at each of these sites were below 0.05 feet per second. According to the Marsh McBirney guidelines, velocities less than 0.05 feet per second are subject to error and may provide inaccurate readings (Marsh-McBirney, 1990).

In order to validate DEQ measurements, streamflow data collected during the 2008 temperature project were compared with streamflow measurements performed by the USGS at gaging station 12367800, which is located approximately 1.2 miles downstream of the Kalispell WWTP. The USGS water quality information serves as a useful and dependable validating tool as it is generated from a scientifically respected source that provides reviewed and published information. Upstream of the WWTP (ASHL-17) a flow of 4.6 cfs was measured during this project on August 19th, while the average discharge from the wastewater treatment plant in August of 2008 was 4.2 cfs. This hydrologic balance of 8.8 cfs compares well with the USGS estimate on August 19th of 9.5 cfs. Since there are no known water withdrawals downstream of the wastewater treatment plant, the 2008 temperature project measured values of 5.6 cfs and 5.9 cfs from sites ASHL-19 and ASHL-20, respectively, were determined to be in error and therefore discarded.

Table E2-2. Streamflow Data for Ashley Creek

Temperature Data Logger Site	Stream	Date	Streamflow (cfs)	Streamflow (cms)
ASHL-01	Ashley Creek	8/15/08	7.2	0.2024
ASHL-02	Ashley Creek	8/15/08	10.3	0.2920
ASHL-03	Ashley Creek	8/15/08	6.9	0.1955
ASHL-04	Ashley Creek	8/18/08	6.3	0.1792
ASHL-05	Ashley Creek	8/19/08	7.3	0.2055
ASHL-06	Ashley Creek	8/15/08	5.0	0.1416
ASHL-07	Porter Creek	8/25/08	2.9	0.0827
ASHL-11	Ashley Creek	8/22/08	11.9*	0.3370
ASHL-13	Ashley Creek	8/19/08	3.7	0.1042
ASHL-15	Ashley Creek	8/18/08	4.2	0.1175
ASHL-16	Spring Creek	8/19/08	2.4	0.0670
ASHL-17	Ashley Creek	8/19/08	4.6	0.1306
ASHL-19	Ashley Creek	8/21/08	5.6*	0.1578
ASHL-20	Ashley Creek	8/22/08	5.9*	0.1657

* Streamflow measurement discarded.

Whitefish River

Streamflow measurements were collected at five sites on the Whitefish River and two tributary streams, including Haskill Creek and Walker Creek (**Table E2-3, Attachment E**). Streamflow measurements in the Whitefish River were collected between August 11th and August 13th. Four streamflow measurements for the Whitefish River were applied in the QUAL2K model along with both tributary streamflow measurements. The streamflow measurement from WHTF-08 was discarded since it appeared to over-estimate the actual streamflow. Site WHTF-07 was located at the USGS gaging station 12366080. A mean daily streamflow measurement of 135 cfs at the USGS gaging station correlated well with the measured value of 133.7 cfs at WHTF-07 on August 13th, however as there were no significant tributary inputs identified for the 3.5 miles between WHTF-07 and WHTF-08, no significant increase in flow would be expected and therefore the WHTF-08 measurement was assumed to be in error.

Table E2-3. Streamflow Data for the Whitefish River

Temperature Data Logger Site	Stream	Date	Streamflow (cfs)	Streamflow (cms)
WHTF-01	Whitefish River	8/12/08	116.6	3.2918
WHTF-03	Haskill Creek	8/11/08	3.6	0.1004
WHTF-04	Walker Creek	8/11/08	0.6	0.0158
WHTF-06	Whitefish River	8/12/08	126.1	3.5590
WHTF-07	Whitefish River	8/13/08	133.7	3.7738
WHTF-08	Whitefish River	8/13/08	145.0*	4.0946
WHTF-11	Whitefish River	8/13/08	139.0	3.9226

* Streamflow measurement discarded.

E2.2.1.3 Streamside Shading

Streamside shading data collected in both Ashley Creek and the Whitefish River during the summer of 2008 were applied in the QUAL2K model.

Ashley Creek

Prior to field data collection, Ashley Creek was divided into 46 distinct reaches covering 44.6 miles based on the riparian vegetation type as observed in GIS using National Agricultural Imagery Program (NAIP) color aerial imagery from 2005, along with high-resolution color orthophotographs from May 24th, 2004 (**Attachment E**). Riparian vegetation reach types included forested, dense riparian, low/moderate riparian and open/pasture. Forested areas were dominated by coniferous vegetation, while dense riparian areas had a mix of deciduous trees and shrubs. Low/moderate riparian areas were comprised primarily of deciduous shrubs and herbaceous vegetation. Each reach was reviewed using aerial imagery of the predominant riparian vegetation and assigned a vegetation type using best professional judgment.

Streamside shading was assessed at 12 sites along Ashley Creek and the average amount of shade within each riparian vegetation reach type was calculated (**Table E2-4**). For reaches in which shade measurements were performed, the result was applied directly to the entire reach. For reaches in which no shade measurement was performed, the riparian vegetation reach type average was applied. The complete riparian shading dataset is presented in **Attachment B** and supplemental information for each assessed reach is presented in **Attachment C**. Riparian vegetation reach types as determined through GIS analysis of aerial imagery are presented in **Attachments E** and **F**, along with assumptions applied during the shade model scenario (see **Section E2.2.2.2**).

Table E2-4. Ashley Creek Riparian Vegetation Reach Type Average Hourly Shade Conditions

Riparian Vegetation Reach Type	Morning (AM)						Afternoon (PM)						Average Daily Shade
	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	
Forested	100%	100%	93%	76%	40%	50%	49%	77%	78%	89%	96%	100%	79%
Dense Riparian	89%	80%	75%	70%	64%	47%	53%	25%	33%	42%	93%	100%	64%
Low/Moderate Riparian	61%	34%	23%	14%	14%	10%	13%	11%	11%	12%	32%	58%	25%
Open/Pasture	30%	2%	0%	0%	0%	0%	0%	0%	0%	3%	18%	63%	10%

<u>Whitefish River</u>

Prior to field data collection, the Whitefish River was divided into 32 distinct reaches covering 24.8 miles based on the riparian vegetation type as observed in GIS using National Agricultural Imagery Program (NAIP) color aerial imagery from 2005, along with high-resolution color orthophotographs from May 24th, 2004 (**Attachment E**). Riparian vegetation reach types included dense riparian, low/moderate riparian and open/pasture. Dense riparian areas had a mix of deciduous trees and shrubs, while low/moderate riparian areas were comprised primarily of deciduous shrubs and herbaceous vegetation. Each reach was reviewed using aerial imagery of the predominant riparian vegetation and assigned a vegetation type using best professional judgment.

Streamside shading was assessed at eight sites along the Whitefish River and the average amount of shade within each riparian vegetation reach type was calculated (**Table E2-5**). For reaches in which shade measurements were performed, the result was applied directly to the entire reach. For reaches in which no shade measurement was performed, the riparian vegetation reach type average was applied. The complete riparian shading dataset is presented in **Attachment B** and supplemental information for each assessed reach is presented in **Attachment C**. Riparian vegetation reach types as determined through GIS analysis of aerial imagery are presented in **Attachments E** and **F**, along with assumptions applied during the shade model scenario (see **Section E2.2.3.2**).

Table E2-5. Whitefish River Riparian Vegetation Reach Type Average Hourly Shade Conditions

Riparian Vegetation Reach Type	Morning (AM)						Afternoon (PM)						Average Daily Shade
	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	
Dense Riparian	93%	70%	42%	42%	38%	20%	10%	13%	28%	39%	70%	94%	47%
Low/Moderate Riparian	72%	44%	26%	15%	10%	5%	7%	9%	27%	62%	76%	91%	37%
Open/Pasture	41%	22%	19%	11%	7%	4%	0%	0%	8%	11%	20%	22%	14%

E2.2.1.4 Climatic Data

Climatic data inputs for the QUAL2K model were obtained from the Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) site in Creston, Montana (http://www.usbr.gov/pn/agrimet/webaghrread.html) and included air temperature, dew point temperature and wind speed. The dew point temperature was adjusted by increasing the relative humidity by 15% based on local conditions within the stream corridor as measured in a similar assessment in the Big Hole River watershed (Flynn et al., 2008). In addition, cloud cover was assigned based on hourly measurements from the National Climatic Data Center (NCDC) at Kalispell Glacier Park International Airport.

E2.2.1.5 Hydrologic Balance
To evaluate tributary inflows, WWTP discharges, and irrigation water withdrawals along Ashley Creek and the Whitefish River, a hydrologic balance was created. Basic assumptions applied when developing the hydrologic balance include:

Streamflows were balanced at the outlet of each reach in which a data logger was located and flows were measured. Along Ashley Creek, streamflows were also balanced at the inlet and outlet of each of the three lakes that the streamflows through.

Where unmeasured tributaries were present in a reach, increases in streamflow were entirely attributed to the tributary inflows. When no tributaries were present, inputs were assumed to be either groundwater upwelling or un-identified surface water discharges.

Wastewater treatment plant discharges were estimated based on mean monthly data for August of 2008 obtained from the Montana DEQ Water Protection Bureau.

Decreases in streamflow were considered to be due to irrigation withdrawals, except when no irrigated agriculture was evident in the aerial imagery, in which case streamflow losses were considered due to either groundwater losses or evapotranspiration.

A detailed hydrologic balance for Ashley Creek and the Whitefish River is presented in **Attachment G**.

E2.2.2 Ashley Creek Model Scenarios
Seven model scenarios were examined for Ashley Creek; they include: 1) baseline (existing conditions), 2) shade, 3) water consumptive use, 4) shade and water consumptive use, 5) shade and 15% reduction of water withdrawn for irrigation, 6) shade with no Kalispell WWTP discharge present, and 7) shade with Kalispell WWTP discharge at the naturally occurring stream temperature. A channel morphology scenario is described in **Section E2.2.2.8**, but due to limited potential for improvement was not applied to the assessment.

E2.2.2.1 Baseline (Existing Conditions) Scenario
Once the calibration steps were performed, the QUAL2K model was run for the baseline scenario, which is intended to represent the existing conditions in Ashley Creek. This model run utilized all measured field data, with the assumptions described in **Section E2.2.1**. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. The modeled maximum temperatures exhibit a pattern similar to the maximum measured values with an average error of 4.1% (**Figure E2-1)**. Subsequent model scenarios were compared to the results of the baseline model and not to the field measured values to assure consistency when evaluating the potential to reduce stream temperatures.

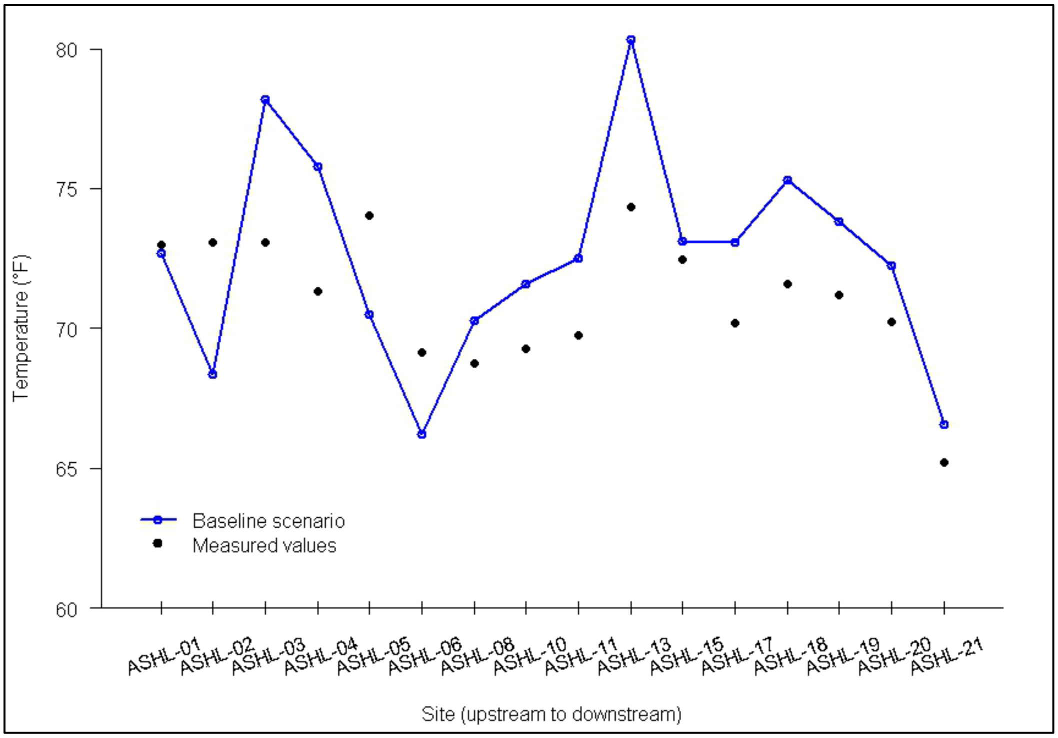

Figure E2-1. Ashley Creek QUAL2K Baseline (Existing Conditions) Scenario (maximum temperatures shown)

E2.2.2.2 Shade Scenario

In the shade scenario, areas with presently diminished shade conditions were changed to a reference condition based on field measured shade values and GIS analysis. The input from the Kalispell WWTP was not adjusted from the baseline scenario. In this scenario, it was determined that the watershed upstream of Smith Lake would naturally be forested except in reaches that appeared to occur in natural meadow environments, where the natural condition was considered to be "open/pasture." Most of the reaches of Ashley Creek downstream of Smith Lake were determined to have dense riparian vegetation as the reference condition with the two reaches having the potential for "open/pasture." For the shade scenario, a total of 10 reaches (3.8 miles) were altered to a forested vegetation type and 12 reaches (19.6 miles) were altered to a dense riparian vegetation type (**Table E2-6**). Thus, riparian shade density was increased along a total of 23.4 miles of Ashley Creek, which is 52% of the total length (44.7 miles). Reference shade values were developed based on riparian vegetation reach type average hourly shade values (see **Table E2-4**). An evaluation of existing shade and potential shade as assigned in the shade scenario is presented for each reach in **Attachment F**.

Table E2-6. Ashley Creek Existing Conditions and Shade Scenario Riparian Vegetation Reach Types

Riparian Vegetation Reach Type	Baseline (Existing Conditions) Scenario		Shade Scenario*	
	Number of Reaches	Length (Miles)	Number of Reaches	Length (Miles)
Forested	10	5.0	20	8.8
Dense Riparian	3	5.4	15	25.0
Low/Moderate Riparian	12	17.0	0	0.0
Open/Pasture	18	14.4	8	8.0
Lake	3	2.9	3	2.9

* Applied in all scenarios that incorporate the Shade Scenario.

The results of the shade scenario indicate that an increase in streamside shading along Ashley Creek would lead to a decrease in stream water temperature of 0 – 10.81°F (**Figure E2-2**; **Table E2-7**).

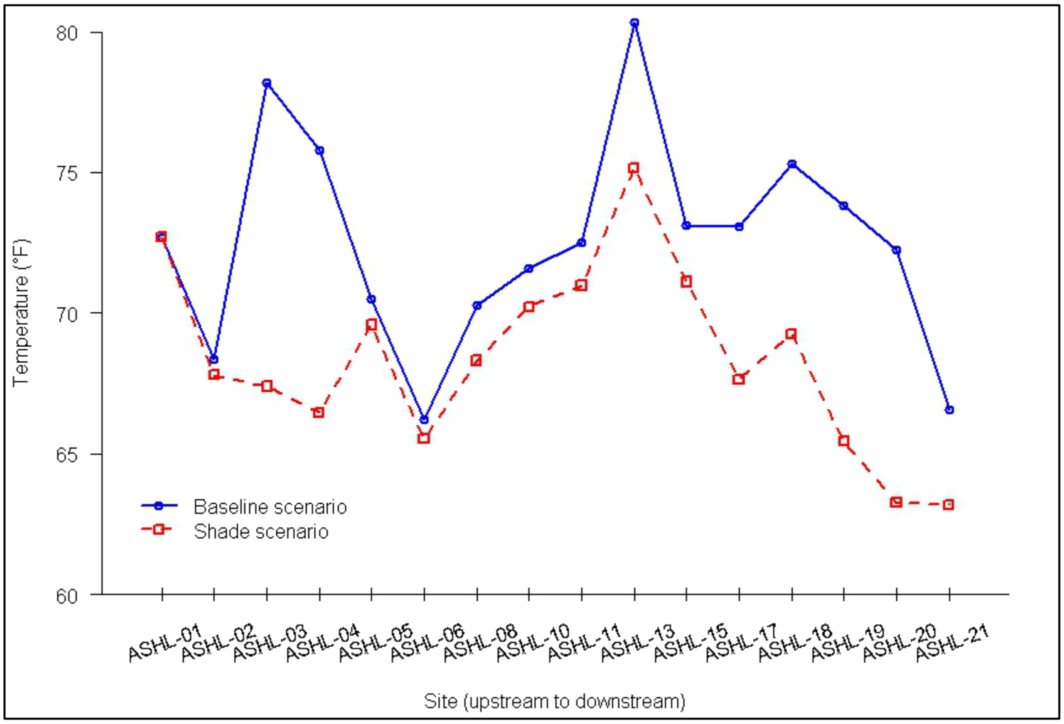

Figure E2-2. Ashley Creek QUAL2K Shade Scenario (maximum temperatures shown)

Table E2-7. Ashley Creek QUAL2K Shade Scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.40	**10.81**
ASHL-04	40.51	75.78	66.46	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.54	**0.68**
ASHL-08	31.93	70.26	68.32	**1.95**
ASHL-10	30.53	71.59	70.22	**1.37**
ASHL-11	29.65	72.51	70.98	**1.53**
ASHL-13	24.36	80.31	75.16	**5.15**
ASHL-15	21.40	73.13	71.11	**2.02**
ASHL-17	17.11	73.09	67.65	**5.44**
ASHL-18	13.39	75.31	69.26	**6.06**
ASHL-19	6.02	73.84	65.44	**8.39**
ASHL-20	3.27	72.25	63.26	**8.99**
ASHL-21	0.26	66.56	63.19	**3.37**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.3 Water Consumptive Use Scenario

The water consumptive use scenario describes the thermal effect of irrigation and domestic water uses on water temperatures in Ashley Creek. This scenario was modeled by removing existing water diversions from the study reach as identified in the hydrologic balance (**Attachment G**). The current modeling effort included irrigation withdrawals identified in seven reaches: ASH5, ASH9, ASH11, ASH13, ASH25, ASH31 and ASH37. Additional irrigation withdrawals not identified through field measurements in 2008 may be present, but were not accounted for in this modeling exercise. This scenario indicated that increased streamflows would lead to a decrease in water temperatures in Ashley Creek (**Figure E2-3**; **Table E2-8**). Due to a lack of measurements of irrigation withdrawals throughout the system, the results of the water consumptive use scenario should be interpreted with caution. If more detailed flow data for the irrigation network become available, this scenario may need to be reevaluated.

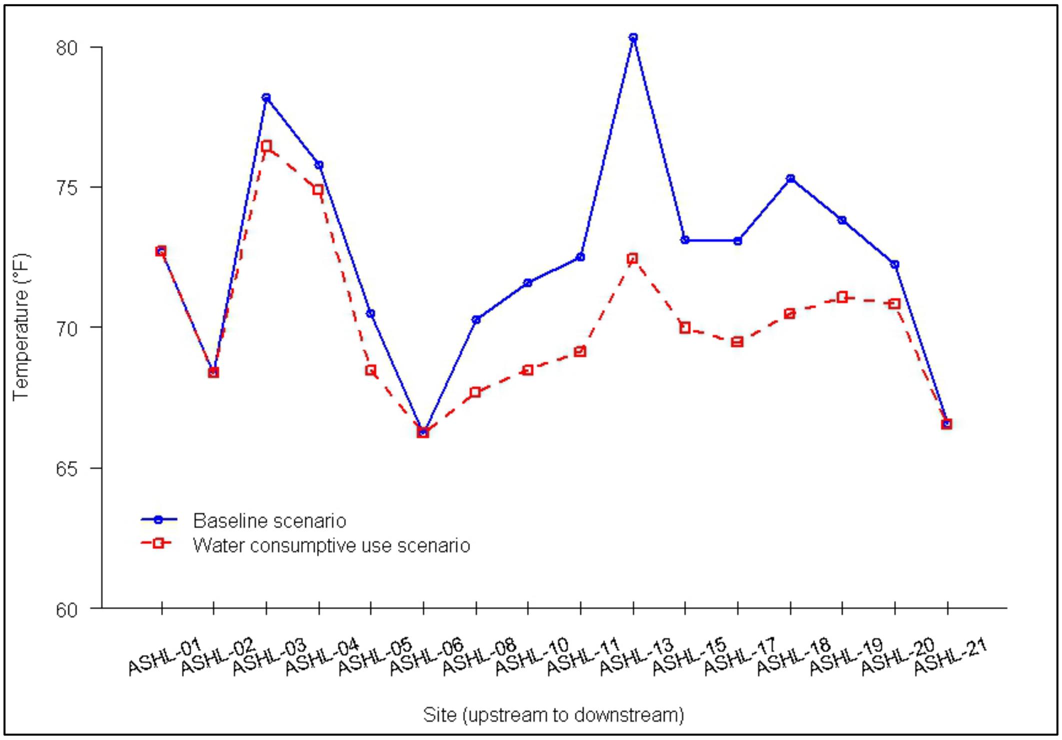

Figure E2-3. Ashley Creek QUAL2K Water Consumptive Use Scenario (maximum temperatures shown)

Table E2-8. Ashley Creek QUAL2K Water Consumptive Use Scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Water Consumptive Use Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	68.38	0.00
ASHL-03	41.41	78.21	76.44	**1.77**
ASHL-04	40.51	75.78	74.89	**0.89**
ASHL-05	37.66	70.49	68.48	**2.01**
ASHL-06	35.69	66.22	66.22	0.00
ASHL-08	31.93	70.26	67.68	**2.58**
ASHL-10	30.53	71.59	68.48	**3.12**
ASHL-11	29.65	72.51	69.12	**3.39**
ASHL-13	24.36	80.31	72.46	**7.86**

Table E2-8. Ashley Creek QUAL2K Water Consumptive Use Scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Water Consumptive Use Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-15	21.40	73.13	69.98	**3.15**
ASHL-17	17.11	73.09	69.47	**3.62**
ASHL-18	13.39	75.31	70.48	**4.84**
ASHL-19	6.02	73.84	71.07	**2.77**
ASHL-20	3.27	72.25	70.83	**1.42**
ASHL-21	0.26	66.56	66.53	0.03

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.4 Shade and Water Consumptive Use Scenario

The shade and water consumptive use scenario reflects the temperature regime that would be expected absent of the influence of man on nonpoint sources. Factors applied in the shade scenario (reference shade) and the water consumptive use scenario (no irrigation withdrawals) were applied to run this scenario. The results of this scenario indicate stream temperatures would naturally be lower than the existing condition along much of Ashley Creek (**Figure E2-4**; **Table E2-9**).

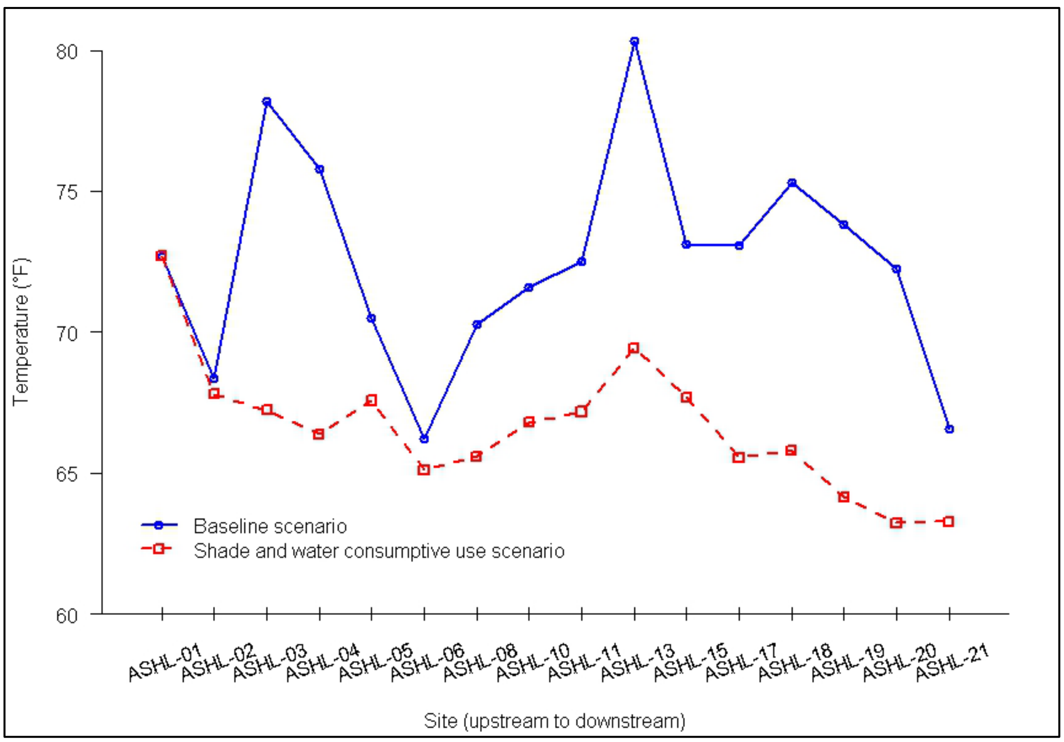

Figure E2-4. Ashley Creek QUAL2K Shade and water consumptive use scenario (maximum temperatures shown)

Table E2-9. Ashley Creek QUAL2K Shade and water consumptive use scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade and Water Consumptive Use Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.23	**10.98**
ASHL-04	40.51	75.78	66.38	**9.39**
ASHL-05	37.66	70.49	67.57	**2.92**
ASHL-06	35.69	66.22	65.12	**1.10**
ASHL-08	31.93	70.26	65.58	**4.68**
ASHL-10	30.53	71.59	66.79	**4.80**
ASHL-11	29.65	72.51	67.18	**5.33**
ASHL-13	24.36	80.31	69.44	**10.87**
ASHL-15	21.40	73.13	67.69	**5.44**
ASHL-17	17.11	73.09	65.54	**7.55**
ASHL-18	13.39	75.31	65.79	**9.52**
ASHL-19	6.02	73.84	64.16	**9.68**
ASHL-20	3.27	72.25	63.23	**9.02**
ASHL-21	0.26	66.56	63.28	**3.28**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.5 Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario

The Shade and 15% reduction of water withdrawn for irrigation scenario defines water temperature conditions resulting from the implementation of BMPs that would allow the shade condition to improve to potential and a 15% reduction in water withdrawal for irrigation (i.e., leaving 15% of the currently withdrawn water in the stream). This scenario included the shade scenario (reference shade) along with a 15% decrease in withdrawal from Ashley Creek attained through irrigation and domestic water use efficiency. This was estimated by reducing the seven identified irrigation withdrawals by 15%. Reducing the identified irrigation withdrawal volume by 15% is considered to be minimal based on the efficiency estimates of (Howell and Stewart, 2003) (Negri et al., 1989) (Natural Resources Conservation Service, 1997), and (Osteen et al., 2012) for different irrigation practices. Based on this scenario, it appears there is the potential for a reduction in instream temperatures relative to the baseline scenario (**Figure E2-5**; **Table E2-10**).

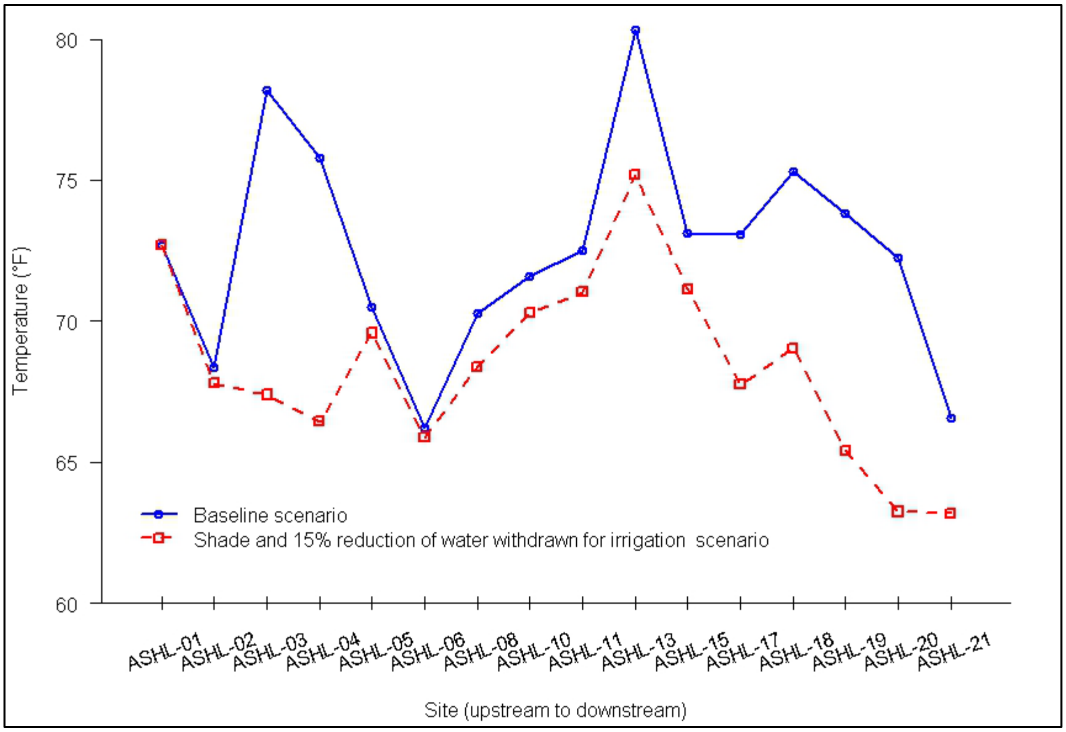

Figure E2-5. Ashley Creek QUAL2K Shade and 15% reduction of water withdrawn for irrigation scenario (maximum temperatures shown)

Table E2-10. Ashley Creek QUAL2K Shade and 15% reduction of water withdrawn for irrigation scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.39	**10.82**
ASHL-04	40.51	75.78	66.45	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.88	0.34
ASHL-08	31.93	70.26	68.38	**1.88**
ASHL-10	30.53	71.59	70.29	**1.30**
ASHL-11	29.65	72.51	71.04	**1.47**
ASHL-13	24.36	80.31	75.19	**5.12**
ASHL-15	21.40	73.13	71.14	**1.99**
ASHL-17	17.11	73.09	67.75	**5.34**
ASHL-18	13.39	75.31	69.05	**6.26**
ASHL-19	6.02	73.84	65.42	**8.42**
ASHL-20	3.27	72.25	63.25	**9.00**
ASHL-21	0.26	66.56	63.18	**3.38**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

The added benefit of keeping 15% of the water diverted in the stream appears to be limited when compared to the shade scenario alone (**Table E2-11**). Increasing the instream flows in addition to meeting shade targets resulted in no change at four sites, a decrease in temperature reduction (i.e., increased temperature) at seven sites, and an increase in temperature reduction (i.e., decreased temperature) at five sites. The increases in temperature reduction were less than 0.05°F at four of the five sites.

Table E2-11. Temperature change from the Baseline (existing) condition scenario using the Shade and 15% Reduction of Water Withdrawn for Irrigation and Shade model scenarios

Site	Baseline Scenario Temperature (°F) – Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario Temperature (°F)	Baseline Scenario Temperature (°F) – Shade Scenario Temperature (°F)	Difference
ASHL-01	0.00	0.00	0.00
ASHL-02	0.58	0.58	0.00
ASHL-03	10.82	10.81	0.00
ASHL-04	9.32	9.32	0.01
ASHL-05	0.91	0.91	0.00
ASHL-06	0.34	0.68	-0.34
ASHL-08	1.88	1.95	-0.07
ASHL-10	1.30	1.37	-0.07
ASHL-11	1.47	1.53	-0.06
ASHL-13	5.12	5.15	-0.03
ASHL-15	1.99	2.02	-0.03
ASHL-17	5.34	5.44	-0.10
ASHL-18	6.26	6.06	0.21
ASHL-19	8.42	8.39	0.03
ASHL-20	9.00	8.99	0.01
ASHL-21	3.38	3.37	0.01

E2.2.2.6 Shade with no Kalispell WWTP Discharge Scenario

This scenario included the same alterations made to the model for the shade scenario but in this case the input of effluent discharge from the Kalispell WWTP was removed. This models the naturally occurring temperature of Ashley Creek from the WWTP location (13.05 miles from the mouth) downstream in the absence of the WWTP discharge (**Figure E2-6**; **Table E2-12**). This model resulted in an average naturally occurring temperature near the WWTP location (13.39 miles from the mouth) of 61.95°F (**Table E2-13**).

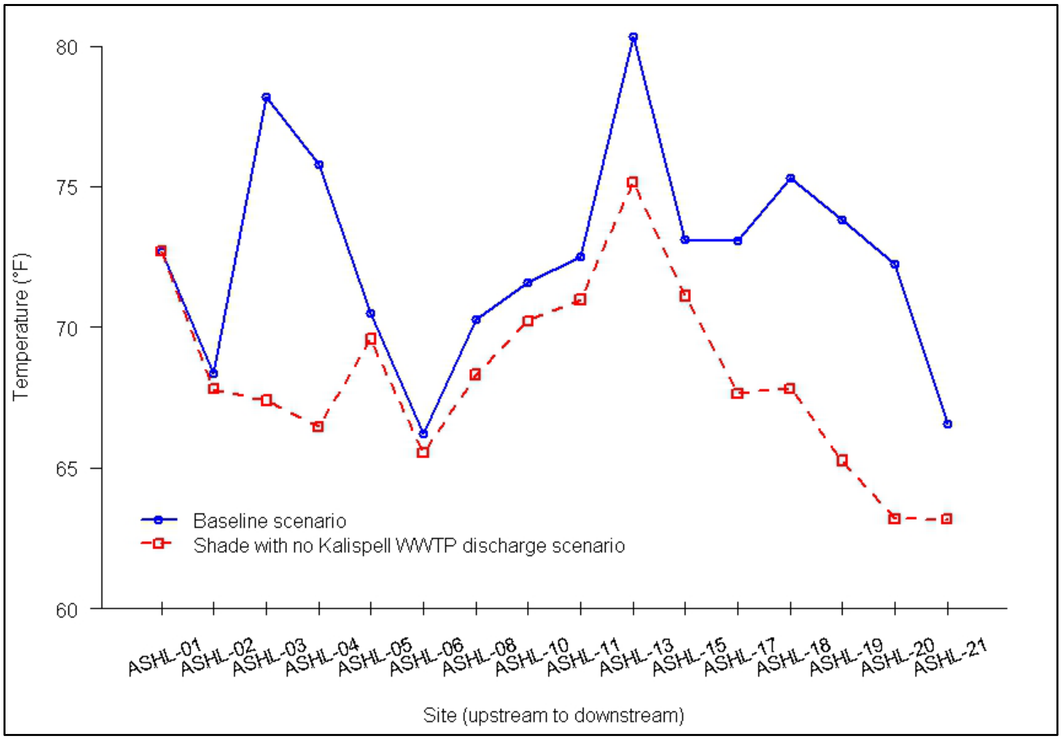

Figure E2-6. Ashley Creek QUAL2K Shade with no Kalispell WWTP discharge scenario (maximum temperatures shown)

Table E2-12. Ashley Creek QUAL2K Shade with no Kalispell WWTP discharge scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with no Kalispell WWTP discharge Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.40	**10.81**
ASHL-04	40.51	75.78	66.46	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.54	**0.68**
ASHL-08	31.93	70.26	68.32	**1.95**
ASHL-10	30.53	71.59	70.22	**1.37**
ASHL-11	29.65	72.51	70.98	**1.53**
ASHL-13	24.36	80.31	75.16	**5.15**
ASHL-15	21.40	73.13	71.11	**2.02**
ASHL-17	17.11	73.09	67.65	**5.44**
ASHL-18	13.39	75.31	67.82	**7.49**
ASHL-19	6.02	73.84	65.26	**8.58**
ASHL-20	3.27	72.25	63.18	**9.07**
ASHL-21	0.26	66.56	63.17	**3.40**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

Table E2-13. Average Temperatures (°F) from the Shade with no Kalispell WWTP Discharge Scenario downstream of ASHL-17

Model Reach	Data Logger Site	Distance (mi)	QUAL2K Shade with no Kalispell WWTP Discharge Scenario Average Temperature (°F)
ASC39	**ASHL-17**	17.11	62.07
ASC39		15.25	**62.01**
ASC39	**ASHL-18**	13.39	**61.95**
ASC40		12.17	61.95
ASC40		11.60	61.94
ASC40		11.02	61.94
ASC41		10.27	61.93
ASC41		9.36	61.93
ASC41		8.45	61.92
ASC42		7.60	61.94
ASC42		6.81	61.97
ASC42	**ASHL-19**	6.02	61.99
ASC43		5.27	62.00
ASC43		4.56	62.01
ASC43		3.84	62.02
ASC44	**ASHL-20**	3.27	62.04
ASC44		2.84	62.07
ASC44		2.41	62.06
ASC45		2.09	62.07
ASC45		1.88	62.08
ASC45		1.67	62.09
ASC46		1.30	62.10
ASC46		0.78	62.12
ASC46	**ASHL-21**	0.26	62.13
Terminus		0.00	62.13

Bolded temperature values were used for other analyses in the main document and in Section E2.2.2.7

E2.2.2.7 Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario

This scenario included the same alterations made to the model for the shade scenario but in this case the input of effluent from the Kalispell WWTP was set to the average naturally occurring stream temperature of 61.95°F (based on the shade scenario with no Kalispell WWTP discharge; **Section E2.2.2.6; Table E2-13**). Based on this scenario, it appears there is the potential for a reduction of instream temperatures relative to the baseline scenario (**Figure E2-7**; **Table E2-14**).

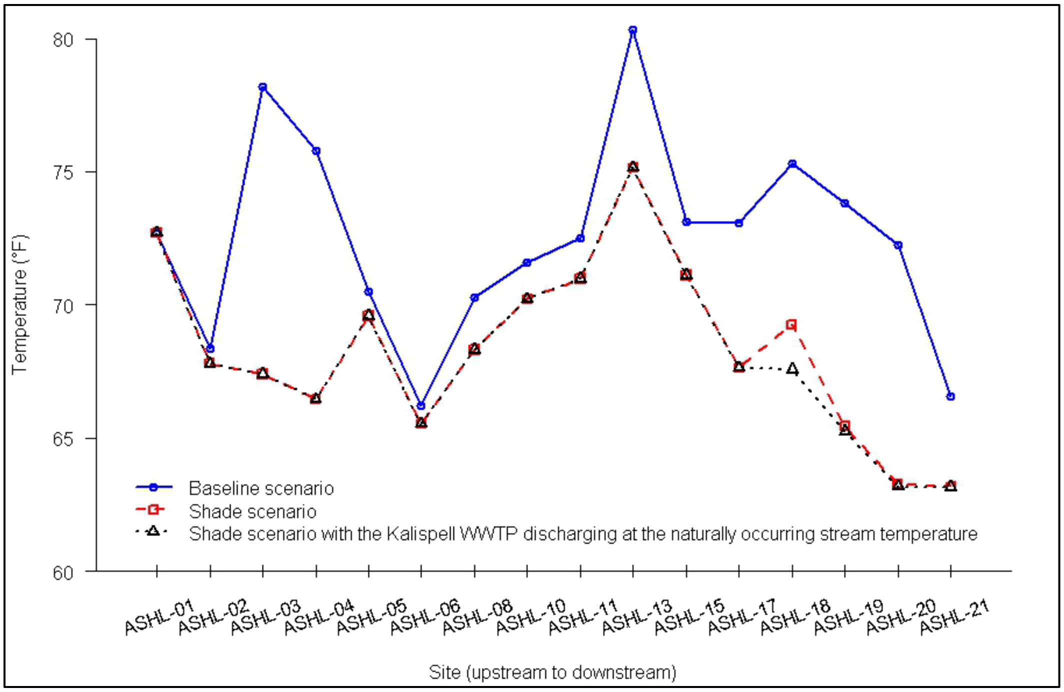

Figure E2-7. Ashley Creek QUAL2K Shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario (maximum temperatures shown)

Table E2-14. Ashley Creek QUAL2K Shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.40	**10.81**
ASHL-04	40.51	75.78	66.46	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.54	**0.68**
ASHL-08	31.93	70.26	68.32	**1.95**
ASHL-10	30.53	71.59	70.22	**1.37**
ASHL-11	29.65	72.51	70.98	**1.53**
ASHL-13	24.36	80.31	75.16	**5.15**
ASHL-15	21.40	73.13	71.11	**2.02**
ASHL-17	17.11	73.09	67.65	**5.44**
ASHL-18	13.39	75.31	67.57	**7.74**
ASHL-19	6.02	73.84	65.26	**8.58**
ASHL-20	3.27	72.25	63.18	**9.07**
ASHL-21	0.26	66.56	63.17	**3.39**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.8 Channel Morphology Scenario
When applying the QUAL2K model in temperature assessments, a channel morphology scenario that examines the influence of channel overwidening is often applied. However, field measurements and observations suggest there was minimal potential to reduce stream channel width. Thus, the channel morphology modeling scenario was not applied to the Ashley Creek temperature assessment.

E2.2.3 Whitefish River Model Scenarios
Two model scenarios were examined for the Whitefish River: 1) baseline (existing conditions) scenario and 2) shade scenario. A channel morphology scenario is described in **Section E2.2.3.3**, but due to limited potential for improvement was not applied to the assessment. A water consumptive use scenario is described in **Section E2.2.3.4**, but no irrigation diversions or return flows were observed on the Whitefish River in 2008 and this scenario was not applied to the assessment.

E2.2.3.1 Baseline Scenario
Once the calibration steps were performed, the QUAL2K model was run for the baseline scenario, which is intended to represent existing conditions in the Whitefish River. This model run utilized all measured field data, with the assumptions described in **Section E2.2.1** of this document. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. The modeled maximum temperatures exhibit a pattern similar to the maximum measured values with an average error of 1.4% (**Figure E2-8**). Subsequent model scenarios were compared to the results of the baseline model and not to the field measured values to assure consistency when evaluating the potential to reduce stream temperatures.

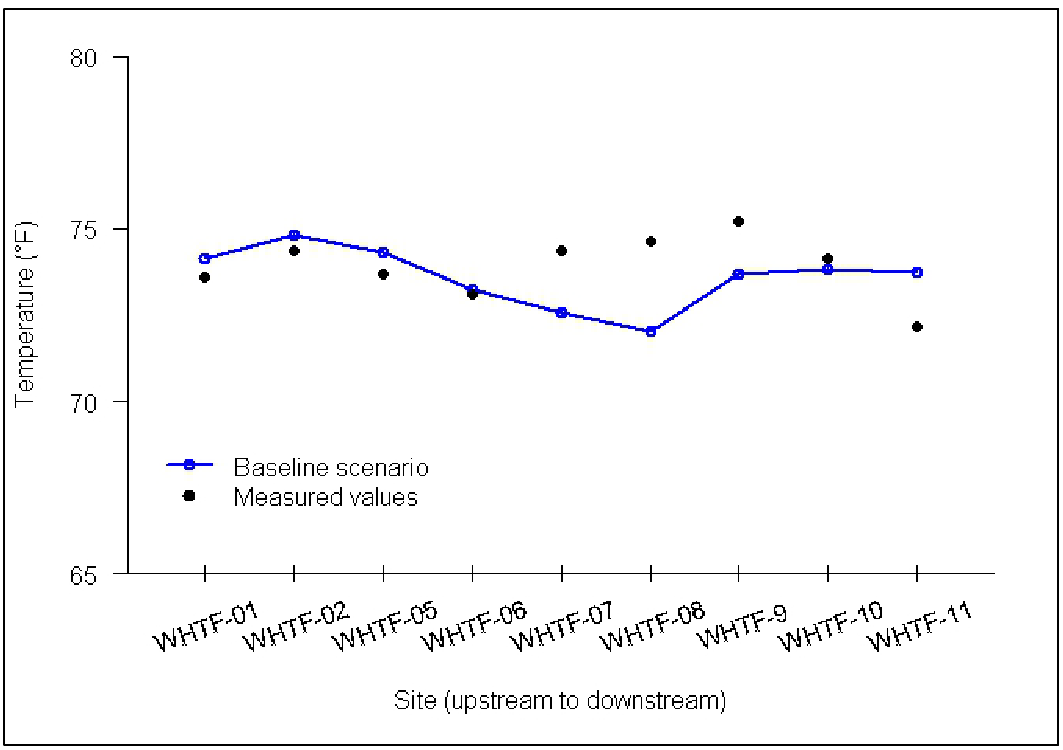

Figure E2-8. Whitefish River QUAL2K Baseline (Existing Conditions) Scenario (maximum temperatures shown)

E2.2.3.2 Shade Scenario

In the shade scenario, areas with presently diminished shade conditions were changed to a reference condition based on field measured shade values and GIS analysis. In this scenario, it was determined that the entire length of the Whitefish River would be lined by dense riparian vegetation. A total of 25 reaches (16.2 miles) were altered to a dense riparian vegetation type (**Table E2-15**). Thus, riparian shade density was increased along a total of 16.2 miles of the Whitefish River, which is 65% of the total length (24.8 miles). Dense riparian vegetation reference shade values were developed based on the reach type average hourly shade values (see **Table E2-5**). An evaluation of existing shade and potential shade as assigned in the shade scenario is presented for each reach in **Attachment F**.

Table E2-15. Whitefish River Existing Conditions and Shade Scenario Riparian Vegetation Reach Types

Riparian Vegetation Reach Type	Baseline (Existing Conditions) Scenario		Shade Scenario	
	Number of Reaches	Length (Miles)	Number of Reaches	Length (Miles)
Dense Riparian	7	8.6	32	24.8
Low/Moderate Riparian	20	15.2	0	0.0
Open/Pasture	5	1.0	0	0.0

The results of the shade scenario indicate that an increase in streamside shading along the Whitefish River would lead to a decrease in stream water temperatures (**Figure E2-9**; **Table E2-16**). In the absence of changes that could be made to channel morphology and water consumptive use (**Sections E2.2.3.3** and **E2.2.3.4**) this scenario represents implementation of all reasonable land, soil, and water conservation practices and thus the naturally occurring condition.

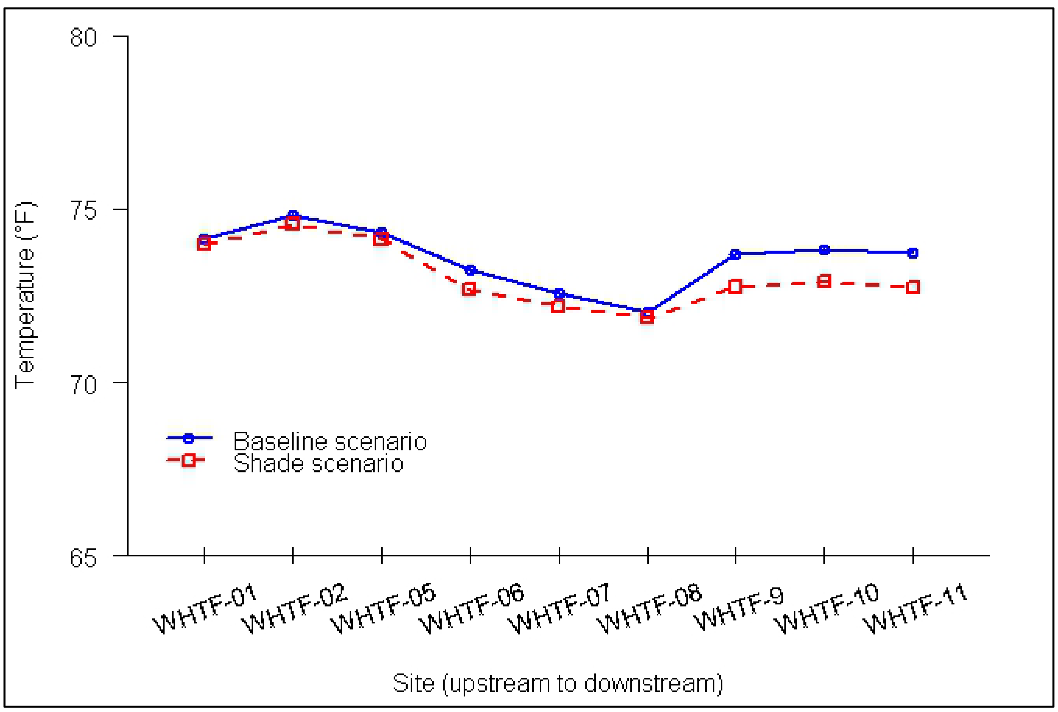

Figure E2-9. Whitefish River QUAL2K Shade Scenario (maximum temperatures shown)

Table E2-16. Whitefish River QUAL2K Shade Scenario (maximum temperatures shown)

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
WHTF-01	24.48	74.13	73.98	0.15
WHTF-02	23.20	74.81	74.55	0.26
WHTF-05	18.70	74.34	74.12	0.21
WHTF-06	15.48	73.26	72.67	**0.58**
WHTF-07	12.81	72.57	72.19	0.38
WHTF-08	8.97	72.02	71.87	0.15
WHTF-09	5.36	73.70	72.75	**0.96**
WHTF-10	2.82	73.84	72.90	**0.94**
WHTF-11	0.10	73.73	72.73	**1.00**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.3.3 Channel Morphology Scenario

When applying the QUAL2K model in temperature assessments, a channel morphology scenario that examines the influence of channel overwidening is often applied. However, field measurements and observations suggest there was minimal potential to reduce stream channel width. Thus, the channel morphology modeling scenario was not applied to the Whitefish River temperature assessment.

E2.2.3.4 Water Consumptive Use Scenario

No irrigation withdrawals or return flows were identified along the Whitefish River based on measurements made during this assessment. Thus, the water consumptive use scenario was not explored. However, if additional information becomes available regarding irrigation withdrawals and return flows, this scenario may need to be reevaluated.

E2.3 Modeled Temperatures Relative to Montana Standards

Comparing the baseline scenario with the naturally occurring scenario for both Ashley Creek and the Whitefish River indicated that the water quality standard for temperature is exceeded in both waterbodies.

E2.3.1 Ashley Creek

The shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario (naturally occurring) indicated that maximum water temperatures of 63.17 – 75.16°F can be expected in Ashley Creek. Thus, the maximum allowable increase due to unmitigated human causes at these temperatures is 0.5 – 1.0°F. Based on the QUAL2K model results, the standard was exceeded at 14 out of 16 temperature monitoring sites in 2008 (**Table E2-17**). Model scenarios indicate that an increase in shade, an increase in streamflow, and a decrease in the Kalispell WWTP effluent temperature would help reduce water temperatures in Ashley Creek.

Table E2-17. Ashley Creek Temperatures Relative to Montana's Water Quality Standards

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario Maximum Temperature (°F)	Temperature Change allowed by the Standard (°F)	Modeled Temperature Change (°F)
ASHL-01	25.73	72.70	72.70	0.50	0.00
ASHL-02	25.17	68.38	67.80	0.50	**0.58**
ASHL-03	23.40	78.21	67.40	0.50	**10.81**

Table E2-17. Ashley Creek Temperatures Relative to Montana's Water Quality Standards

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario Maximum Temperature (°F)	Temperature Change allowed by the Standard (°F)	Modeled Temperature Change (°F)
ASHL-04	22.18	75.78	66.46	0.54	**9.32**
ASHL-05	19.84	70.49	69.58	0.50	**0.91**
ASHL-06	18.97	66.22	65.54	1.00	0.68
ASHL-08	18.42	70.26	68.32	0.50	**1.95**
ASHL-10	15.14	71.59	70.22	0.50	**1.37**
ASHL-11	13.30	72.51	70.98	0.50	**1.53**
ASHL-13	10.63	80.31	75.16	0.50	**5.15**
ASHL-15	8.32	73.13	71.11	0.50	**2.02**
ASHL-17	3.74	73.09	67.65	0.50	**5.44**
ASHL-18	2.03	76.00	67.57	0.50	**8.43**
ASHL-19	0.16	73.90	65.26	1.00	**8.64**
ASHL-20	0.00	72.27	63.18	1.00	**9.09**
ASHL-21	0.00	66.56	63.17	1.00	**3.39**

Bolded values indicate that the water quality standard is being exceeded.

E2.3.2 Whitefish River

The shade scenario (naturally occurring) indicated that maximum water temperatures of 71.87 – 74.55°F can be expected in the Whitefish River. Thus, the maximum allowable increase due to unmitigated human causes at these temperatures is 0.5°F. Based on the QUAL2K model results, the standard was exceeded at four out of nine temperature monitoring sites in 2008 (**Table E2-18**). Model scenarios indicate that an increase in shade would help reduce water temperatures in the Whitefish River.

Table E2-18. Whitefish River Temperatures Relative to Montana's Water Quality Standards

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade Scenario Maximum Temperature (°F)	Temperature Change Allowed by the Standard (°F)	Modeled Temperature Change (°F)
WHTF-01	14.42	74.13	73.98	0.50	0.15
WHTF-02	11.62	74.81	74.55	0.50	0.26
WHTF-05	9.62	74.34	74.12	0.50	0.21
WHTF-06	7.96	73.26	72.67	0.50	**0.58**
WHTF-07	5.57	72.57	72.19	0.50	0.38
WHTF-08	3.33	72.02	71.87	0.50	0.15
WHTF-09	1.75	73.70	72.75	0.50	**0.96**
WHTF-10	0.06	73.84	72.90	0.50	**0.94**
WHTF-11	0.00	73.73	72.73	0.50	**1.00**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E3.0 CONCLUSIONS

Major findings and restoration recommendations include:

- Temperature data collected in 2008 and the results of this QUAL2K modeling effort suggest that Ashley Creek and the Whitefish River fail to meet Montana's standard for temperature during low flow periods in the middle of summer.

- In Ashley Creek, modeling indicated that increased shading along 23.4 miles of Ashley Creek (52%) would lead to a decrease of instream temperatures. Decreasing the temperature of effluent being discharged from the Kalispell WWTP and increased instream flow would lead to additional decreases in water temperatures.

- In the Whitefish River, modeling indicated that increased shading along 16.2 miles (65%) would lead to a decrease in water temperatures.

Limitations of this study include a lack of detailed flow measurements for tributary streams and the irrigation network, as well as the reliance on a simplified hydrologic balance based on limited data points, including a basic analysis of the interaction between Ashley Creek and the three lakes it flows through: Lone, Monroe (between ASHL-04 and ASHL-05) and Smith (between ASHL-11 and ASHL-12). Thus, the results of this assessment may need to be reevaluated as additional information becomes available.

E4.0 References

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ATTACHMENT EA – 2008 TEMPERATURE DATA SUMMARY

Summary Temperature Data for Ashley Creek and Whitefish River Temperature Logger Sites

Site Name	Lat	Long	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages				Days >50 F	Days >59 F	Days >70 F	Hours >50 F	Hours >59 F	Hours >70 F	Warmest day of 7-day max			Agency
					Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	Δ T							Date	Maximum	Minimum	
ASHL-01	48.1049	114.3704	07/23/08	09/10/08	08/17/08	75.6	09/10/08	45.5	09/10/08	27.9	07/27/08	73.7	67.4	6.3	50	50	28	1198.0	1071.5	316.5	07/27/08	75.2	68.9	DEQ
ASHL-02	48.1041	114.3613	07/23/08	09/10/08	08/17/08	76.5	09/10/08	46.5	09/10/08	26.9	07/27/08	73.9	63.9	10.0	50	48	29	1199.0	962.0	186.5	07/27/08	75.5	65.4	DEQ
ASHL-03	48.0929	114.3607	07/23/08	09/09/08	08/17/08	76.3	09/08/08	50.0	08/04/08	15.0	07/26/08	73.9	61.7	12.2	49	46	24	1174.0	872.5	179.0	07/26/08	76.0	62.6	DEQ
ASHL-04	48.0857	114.3602	07/23/08	09/15/08	08/17/08	74.6	09/08/08	49.6	08/04/08	13.5	07/26/08	72.3	61.4	10.8	55	49	18	1317.0	885.5	148.0	07/26/08	74.6	62.3	DEQ
ASHL-05	48.0728	114.3907	07/23/08	09/16/08	08/17/08	76.2	09/11/08	56.3	08/04/08	10.1	07/28/08	74.9	66.5	8.4	56	56	31	1343.5	1195.0	302.5	07/25/08	75.5	65.7	DEQ
ASHL-06	48.06	114.3344	07/23/08	09/09/08	08/17/08	72.8	09/08/08	49.6	08/05/08	11.8	08/16/08	70.2	61.0	9.3	49	44	10	1173.0	837.5	72.0	08/17/08	72.8	62.5	DEQ
ASHL-07	48.0555	114.3348	07/23/08	09/09/08	07/26/08	62.2	09/06/08	47.6	08/29/08	8.1	07/26/08	61.4	55.1	6.3	49	23	0	1081.0	169.0	0.0	07/26/08	62.2	55.7	DEQ
ASHL-08	48.0527	114.2951	07/23/08	09/15/08	08/17/08	72.5	09/02/08	51.9	08/04/08	8.9	08/17/08	70.2	63.9	6.3	55	41	8	1319.5	867.5	52.5	08/17/08	72.5	66.0	DEQ
ASHL-09	48.0534	114.294	07/23/08	09/15/08	08/18/08	72.8	09/02/08	51.8	08/14/08	8.1	08/17/08	70.4	64.0	6.4	55	43	8	1319.5	896.0	61.5	08/17/08	72.8	65.7	DEQ
ASHL-18	48.1029	114.1832	07/23/08	09/15/08	08/17/08	76.4	09/08/08	53.2	08/29/08	9.7	08/17/08	73.3	66.2	7.1	55	54	21	1319.5	1038.0	199.0	08/17/08	76.4	67.7	DEQ
ASHL-10	48.0604	114.2842	07/24/08	09/15/08	08/17/08	72.8	09/02/08	52.7	07/25/08	8.8	07/27/08	70.6	64.1	6.5	54	39	12	1295.5	870.5	78.0	07/26/08	72.8	64.9	DEQ
ASHL-11	48.0621	114.2735	07/23/08	09/15/08	08/17/08	73.7	09/02/08	52.7	08/04/08	7.5	08/17/08	71.8	65.8	6.0	55	45	13	1319.5	915.0	86.0	08/17/08	73.7	67.5	DEQ
ASHL-13	48.0958	114.2546	07/23/08	09/09/08	08/17/08	79.8	09/08/08	50.0	08/23/08	16.8	08/16/08	76.8	64.1	12.7	49	48	30	1175.5	936.5	200.0	08/17/08	79.8	65.2	DEQ
ASHL-15	48.1112	114.2342	07/23/08	09/09/08	08/17/08	76.5	09/08/08	49.6	08/16/08	13.0	08/16/08	73.9	63.1	10.8	49	46	23	1173.0	875.0	175.0	08/17/08	76.5	64.0	DEQ
ASHL-16	48.1133	114.2014	07/29/08	09/16/08	08/17/08	66.9	09/02/08	48.8	08/06/08	6.9	08/17/08	65.1	59.8	5.3	50	29	0	1167.0	502.0	0.0	08/17/08	66.9	61.1	DEQ
ASHL-17	48.112	114.1952	07/29/08	09/10/08	08/17/08	73.1	09/08/08	50.5	08/06/08	11.1	08/07/08	70.9	62.6	8.3	44	32	13	1055.5	663.0	84.5	08/09/08	72.8	65.4	DEQ
ASHL-19	48.0845	114.1707	07/23/08	09/15/08	08/17/08	73.9	09/02/08	55.1	08/06/08	7.1	07/27/08	72.4	67.7	4.7	55	49	20	1319.5	1013.0	236.0	07/28/08	73.6	67.9	DEQ
ASHL-20	48.0807	114.1441	07/22/08	09/11/08	07/26/08	73.3	09/06/08	57.6	07/25/08	5.1	07/27/08	72.7	69.6	3.2	52	52	20	1247.5	1197.5	345.5	07/26/08	73.3	69.7	DEQ
ASHL-21	48.0924	114.124	07/22/08	09/15/08	07/27/08	69.7	09/15/08	56.8	07/22/08	7.5	07/27/08	69.3	66.2	3.1	56	56	0	1343.5	1177.5	0.0	07/27/08	69.7	64.2	DEQ
WHTF-01	48.414	114.351	07/19/08	09/11/08	08/18/08	73.7	09/11/08	57.1	08/05/08	8.5	08/16/08	72.4	67.4	5.0	55	55	26	1319.5	1292.5	145.0	08/18/08	73.7	68.4	DEQ
WHTF-02	48.2404	114.2004	07/19/08	09/11/08	08/18/08	74.4	09/11/08	54.4	09/11/08	7.6	08/16/08	72.9	67.2	5.7	55	55	27	1319.5	1244.0	206.0	08/17/08	74.4	67.5	DEQ
WHTF-04	48.2238	114.1802	07/22/08	09/14/08	07/26/08	68.0	09/14/08	46.0	07/25/08	9.2	07/25/08	66.9	59.8	7.1	55	36	0	1245.5	622.5	0.0	07/26/08	68.0	59.6	DEQ
WHTF-05	48.2211	114.1807	07/22/08	09/14/08	08/18/08	73.7	09/14/08	56.3	07/25/08	7.1	08/16/08	72.6	67.7	4.9	55	55	26	1319.5	1243.0	244.5	08/17/08	73.7	68.6	DEQ
WHTF-06	48.2031	114.1626	07/22/08	09/11/08	08/18/08	73.3	09/11/08	57.8	08/29/08	4.3	08/17/08	71.7	69.0	2.7	52	52	17	1247.5	1205.0	209.0	08/18/08	73.3	70.8	DEQ
WHTF-07	48.3197	114.2784	07/22/08	09/10/08	08/18/08	74.5	09/02/08	56.8	08/24/08	5.5	08/17/08	72.8	68.1	4.7	51	51	22	1223.5	1153.0	228.0	08/18/08	74.5	69.4	DEQ
WHTF-08	48.2907	114.2889	07/22/08	09/10/08	08/18/08	74.6	09/08/08	54.4	08/05/08	9.1	08/16/08	72.8	65.7	7.1	51	51	19	1223.5	1041.5	169.5	08/17/08	74.6	66.6	DEQ
WHTF-09	48.1522	114.1716	07/22/08	09/10/08	08/18/08	75.2	09/08/08	53.4	08/05/08	11.2	08/16/08	73.3	64.8	8.5	51	51	26	1223.5	1040.5	219.5	08/17/08	75.2	65.6	DEQ
WHTF-10	48.1424	114.1732	07/22/08	09/10/08	08/17/08	74.3	09/08/08	53.8	08/05/08	11.1	07/28/08	72.9	64.1	8.8	51	51	25	1223.5	1028.0	187.0	07/26/08	74.3	64.8	DEQ
WHTF-11	48.125	114.1712	07/22/08	09/10/08	07/26/08	73.2	09/02/08	54.4	07/25/08	9.4	07/27/08	71.9	64.4	7.5	51	49	17	1223.5	993.5	112.5	07/26/08	73.2	64.6	DEQ

ATTACHMENT EB – SOLAR PATHFINDER HOURLY SHADE MEASUREMENTS

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
ASC4-1	Transect 1	3	5	7	10	9	10	8	10	2	8	5	3	80
ASC4-2	Transect 2	3	5	8	8	1	8	4	10	9	8	5	3	72
ASC4-3	Transect 3	3	5	8	8	1	1	9	12	10	7	3	3	70
ASC4	**Average %**	**100%**	**100%**	**96%**	**87%**	**31%**	**53%**	**58%**	**89%**	**70%**	**96%**	**87%**	**100%**	***80%***
ASC10-1	Transect 1	3	1	0	0	0	0	0	0	0	0	1	3	8
ASC10-2	Transect 2	2	0	0	0	0	0	0	0	0	0	2	3	7
ASC10-3	Transect 3	1	0	0	0	0	0	0	0	0	0	3	3	7
ASC10	**Average %**	**67%**	**7%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**40%**	**100%**	***18%***
ASC16-1	Transect 1	3	5	8	2	0	7	12	6	9	8	5	3	68
ASC16-2	Transect 2	3	5	7	6	6	8	10	12	10	8	5	3	83
ASC16-3	Transect 3	3	5	7	7	0	0	0	10	10	8	5	3	58
ASC16	**Average %**	**100%**	**100%**	**92%**	**50%**	**17%**	**42%**	**61%**	**78%**	**97%**	**100%**	**100%**	**100%**	***78%***
ASC17-1	Transect 1	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC17-2	Transect 2	0	0	0	0	0	0	0	0	0	2	2	3	7
ASC17-3	Transect 3	1	0	0	0	0	0	0	0	0	0	0	1	2
ASC17	**Average %**	**11%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**8%**	**13%**	**56%**	***7%***
ASC22-1	Transect 1	3	5	7	8	11	11	0	4	10	8	5	3	75
ASC22-2	Transect 2	3	5	7	9	9	0	4	10	10	8	5	3	73
ASC22-3	Transect 3	3	5	8	10	6	9	6	9	0	1	5	3	65
ASC22	**Average %**	**100%**	**100%**	**92%**	**90%**	**72%**	**56%**	**28%**	**64%**	**67%**	**71%**	**100%**	**100%**	***78%***
ASC31-1C	Transect 1 - center	2	0	0	0	0	0	0	0	0	0	0	0	2
ASC31-1L	Transect 1 - left	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC31-1R	Transect 1 - right	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC31-2C	Transect 2 - center	0	0	0	0	0	0	0	0	0	0	0	0	0
ASC31-2L	Transect 2 - left	0	0	0	0	0	0	0	0	0	0	0	2	2
ASC31-2R	Transect 2 - right	0	0	0	0	0	0	0	0	0	0	0	3	3
ASC31-3C	Transect 3 - center	0	0	0	0	0	0	0	0	0	0	0	0	0
ASC31-3L	Transect 3 - left	0	0	0	0	0	0	0	0	0	0	0	2	2
ASC31-3R	Transect 3 - right	1	0	0	0	0	0	0	0	0	0	0	0	1
ASC31	**Average %**	**11%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**33%**	***4%***
ASC33-1C	Transect 1 - center	0	0	0	0	0	0	0	0	0	0	2	3	5
ASC33-1L	Transect 1 - left	1	0	0	0	0	0	0	0	1	8	5	3	18
ASC33-1R	Transect 1 - right	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC33-2C	Transect 2 - center	1	0	0	0	0	0	0	0	0	0	0	1	2
ASC33-2L	Transect 2 - left	3	1	0	0	0	0	0	0	0	0	0	1	5
ASC33-2R	Transect 2 - right	0	0	0	0	0	0	0	0	1	2	3	3	9
ASC33-3C	Transect 3 - center	3	5	2	0	0	0	0	0	0	0	1	3	14
ASC33-3L	Transect 3 - left	3	2	0	0	0	0	0	0	0	0	3	3	11
ASC33-3R	Transect 3 - right	3	5	7	9	5	4	1	0	0	0	0	0	34
ASC33	**Average %**	**52%**	**29%**	**13%**	**10%**	**5%**	**4%**	**1%**	**0%**	**2%**	**14%**	**31%**	**67%**	***19%***
ASC35-1	Transect 1	2	3	7	7	6	7	10	4	0	2	4	3	55
ASC35-2	Transect 2	3	5	5	6	5	1	4	3	0	1	5	3	41
ASC35-3	Transect 3	3	4	6	8	12	9	5	2	10	7	5	3	74
ASC35	**Average %**	**89%**	**80%**	**75%**	**70%**	**64%**	**47%**	**53%**	**25%**	**33%**	**42%**	**93%**	**100%**	***64%***
ASC36-1	Transect 1	1	0	0	0	0	0	0	5	10	8	5	3	32

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
ASC36-2	Transect 2	0	0	0	0	0	0	0	0	0	0	0	2	2
ASC36-3	Transect 3	3	3	5	10	10	2	11	5	0	0	0	0	49
ASC36	**Average %**	**44%**	**20%**	**21%**	**33%**	**28%**	**6%**	**31%**	**28%**	**33%**	**33%**	**33%**	**56%**	***30%***
ASC39-1C	Transect 1 - center	2	0	0	0	9	7	0	0	0	0	0	0	18
ASC39-1L	Transect 1 - left	2	0	0	0	0	0	0	0	0	0	0	3	5
ASC39-1R	Transect 1 - right	3	5	7	10	10	11	11	4	3	0	0	0	64
ASC39-2C	Transect 2 - center	1	0	0	0	0	3	4	0	0	0	0	0	8
ASC39-2L	Transect 2 - left	3	2	0	0	0	0	0	0	0	0	0	0	5
ASC39-2R	Transect 2 - right	1	1	5	8	10	12	12	12	10	6	2	0	79
ASC39-3C	Transect 3 - center	3	1	0	0	0	0	0	0	0	0	0	1	5
ASC39	**Average %**	**71%**	**26%**	**21%**	**26%**	**35%**	**39%**	**32%**	**19%**	**19%**	**11%**	**6%**	**19%**	***27%***
ASC40-1	Transect 1	2	0	0	0	0	0	0	0	0	0	2	3	7
ASC40-2	Transect 2	3	5	6	0	0	0	0	0	0	0	5	3	22
ASC40-3	Transect 3	3	2	0	0	0	0	0	0	0	0	4	3	12
ASC40	**Average %**	**89%**	**47%**	**25%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**73%**	**100%**	***28%***
ASC44-1C	Transect 1 - center	1	0	0	0	0	0	0	0	0	0	0	1	2
ASC44-1L	Transect 1 - left	1	0	0	0	0	0	0	0	0	1	5	3	10
ASC44-1R	Transect 1 - right	2	5	6	0	4	2	1	7	1	0	0	1	29
ASC44-2C	Transect 2 - center	2	4	4	0	0	0	0	0	0	0	0	1	11
ASC44-2L	Transect 2 - left	0	1	0	0	0	0	0	0	0	0	0	1	2
ASC44-2R	Transect 2 - right	3	5	6	0	0	0	0	0	0	0	0	2	16
ASC44	**Average %**	**50%**	**50%**	**33%**	**0%**	**6%**	**3%**	**1%**	**10%**	**2%**	**2%**	**17%**	**50%**	***19%***

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
WFR1-1C	Transect 1 - center	3	3	0	0	0	0	0	0	0	0	1	3	10
WFR1-1L	Transect 1 - left	2	4	6	9	4	0	0	0	0	0	0	1	26
WFR1-1R	Transect 1 - right	2	0	0	0	0	0	0	0	8	2	1	3	16
WFR1-2C	Transect 2 - center	3	2	0	0	0	0	0	0	0	0	2	3	10
WFR1-2L	Transect 2 - left	2	3	8	8	1	0	0	0	0	0	0	2	24
WFR1-2R	Transect 2 - right	2	0	0	1	12	12	11	6	10	7	4	3	68
WFR1-3C	Transect 3 - center	3	5	0	0	0	0	0	0	0	0	4	3	15
WFR1-3L	Transect 3 - left	3	5	1	1	0	0	0	0	0	0	4	3	17
WFR1-3R	Transect 3 - right	3	1	0	1	11	11	10	10	8	7	5	3	70
WFR1	**Average %**	**85%**	**51%**	**21%**	**22%**	**26%**	**21%**	**19%**	**15%**	**29%**	**22%**	**47%**	**89%**	**37%**
WFR13-1C	Transect 1 - center	3	5	6	4	0	0	0	0	8	7	5	3	41
WFR13-1L	Transect 1 - left	3	5	8	10	11	1	0	0	4	4	5	3	54
WFR13-1R	Transect 1 - right	3	4	5	1	0	0	0	11	7	8	5	3	47
WFR13-2C	Transect 2 - center	3	5	7	9	7	0	0	0	0	4	5	3	43
WFR13-2L	Transect 2 - left	3	5	8	9	7	8	0	0	0	3	5	3	51
WFR13-2R	Transect 2 - right	3	3	3	1	0	0	0	0	5	6	5	3	29
WFR13-3C	Transect 3 - center	3	4	1	8	11	1	0	0	0	3	4	3	38
WFR13-3L	Transect 3 - left	3	5	6	5	11	11	0	0	0	2	3	3	49
WFR13-3R	Transect 3 - right	3	4	1	9	7	0	0	0	0	3	5	3	35
WFR13	**Average %**	**100%**	**89%**	**63%**	**62%**	**50%**	**19%**	**0%**	**10%**	**27%**	**56%**	**93%**	**100%**	**56%**
WFR15-1C	Transect 1 - center	3	4	3	0	0	0	0	6	9	8	5	3	41
WFR15-1L	Transect 1 - left	3	5	7	10	10	0	0	0	7	7	5	3	57
WFR15-1R	Transect 1 - right	3	5	0	0	0	10	12	12	5	8	5	3	63

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
WFR15-2C	Transect 2 - center	2	5	8	8	0	0	0	0	1	7	5	3	39
WFR15-2L	Transect 2 - left	3	4	8	10	12	0	0	0	0	8	5	3	53
WFR15-2R	Transect 2 - right	3	5	8	2	0	0	0	0	6	8	5	3	40
WFR15-3C	Transect 3 - center	3	5	6	0	0	0	0	2	4	6	5	3	34
WFR15-3L	Transect 3 - left	3	5	8	10	5	0	0	0	0	5	5	3	44
WFR15-3R	Transect 3 - right	2	4	0	0	0	5	10	2	2	7	5	3	40
WFR15	**Average %**	**93%**	**93%**	**67%**	**44%**	**25%**	**14%**	**20%**	**20%**	**38%**	**89%**	**100%**	**100%**	**59%**
WFR17-1C	Transect 1 - center	0	0	0	0	0	0	0	4	9	7	5	3	28
WFR17-1L	Transect 1 - left	0	0	0	0	0	0	0	0	0	5	5	3	13
WFR17-1R	Transect 1 - right	0	0	0	0	0	0	0	10	9	8	5	3	35
WFR17-2C	Transect 2 - center	0	0	0	0	0	0	0	0	0	6	5	3	14
WFR17-2L	Transect 2 - left	3	0	0	0	0	0	0	0	0	6	5	3	17
WFR17-2R	Transect 2 - right	0	0	0	0	0	0	0	0	4	8	5	3	20
WFR17-3C	Transect 3 - center	3	0	0	0	0	0	0	0	1	6	5	3	18
WFR17-3L	Transect 3 - left	1	2	0	0	0	0	0	0	0	3	5	3	14
WFR17-3R	Transect 3 - right	2	0	0	0	0	0	0	0	3	6	5	3	19
WFR17	**Average %**	**33%**	**4%**	**0%**	**0%**	**0%**	**0%**	**0%**	**13%**	**29%**	**76%**	**100%**	**100%**	**30%**
WFR21-1C	Transect 1 - center	0	0	1	1	0	0	0	0	0	0	5	3	10
WFR21-1L	Transect 1 - left	1	4	8	4	10	0	0	0	0	0	1	3	31
WFR21-1R	Transect 1 - right	0	0	0	0	0	0	0	0	1	8	4	3	16
WFR21-2C	Transect 2 - center	3	5	4	0	0	0	0	0	3	8	5	3	31
WFR21-2L	Transect 2 - left	3	5	5	0	0	0	0	0	0	0	4	3	20
WFR21-2R	Transect 2 - right	3	3	0	0	0	0	0	0	0	8	5	3	22
WFR21-3C	Transect 3 - center	3	1	0	0	0	0	0	0	0	0	0	1	5
WFR21-3L	Transect 3 - left	3	0	0	6	10	2	0	0	0	0	0	2	23
WFR21-3R	Transect 3 - right	3	2	0	0	0	0	0	0	0	0	0	3	8
WFR21	**Average %**	**70%**	**44%**	**25%**	**12%**	**19%**	**2%**	**0%**	**0%**	**4%**	**33%**	**53%**	**89%**	**29%**
WFR27-1C	Transect 1 - center	3	2	0	0	0	0	0	0	10	7	5	2	29
WFR27-1L	Transect 1 - left	3	5	8	8	0	0	0	0	4	8	4	0	40
WFR27-1R	Transect 1 - right	2	0	0	0	0	0	0	8	10	7	5	3	35
WFR27-2C	Transect 2 - center	3	4	4	0	0	0	0	0	6	2	5	3	27
WFR27-2L	Transect 2 - left	3	5	0	0	0	0	0	0	1	5	2	3	19
WFR27-2R	Transect 2 - right	3	1	3	0	0	0	0	0	5	8	4	3	27
WFR27-3C	Transect 3 - center	3	2	0	0	0	0	10	0	3	7	4	3	32
WFR27-3L	Transect 3 - left	3	0	0	0	0	11	5	5	5	7	4	3	43
WFR27-3R	Transect 3 - right	3	5	8	10	6	0	0	1	0	8	2	2	45
WFR27	**Average %**	**96%**	**53%**	**32%**	**20%**	**6%**	**10%**	**14%**	**13%**	**49%**	**82%**	**78%**	**81%**	**45%**
WFR29-1C	Transect 1 - center	2	0	0	0	0	0	0	0	0	0	0	0	2
WFR29-1L	Transect 1 - left	3	5	7	4	0	0	0	0	0	0	0	0	19
WFR29-1R	Transect 1 - right	1	0	0	0	0	0	0	0	0	0	0	3	4
WFR29-2C	Transect 2 - center	1	0	0	0	0	0	0	0	0	0	0	0	1
WFR29-2L	Transect 2 - left	3	5	7	5	6	3	0	0	0	0	0	0	29
WFR29-2R	Transect 2 - right	1	0	0	0	0	0	0	0	0	1	5	2	9
WFR29-3C	Transect 3 - center	0	0	0	0	0	0	0	0	0	0	0	0	0
WFR29-3L	Transect 3 - left	0	0	0	1	2	1	0	0	7	7	4	1	23
WFR29-3R	Transect 3 - right	0	0	0	0	0	0	0	0	0	0	0	0	0
WFR29	**Average %**	**41%**	**22%**	**19%**	**11%**	**7%**	**4%**	**0%**	**0%**	**8%**	**11%**	**20%**	**22%**	**14%**
WFR32-1C	Transect 1 - center	2	0	0	0	0	0	0	0	0	0	0	3	5

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
WFR32-1L	Transect 1 - left	1	0	0	0	0	0	0	0	0	0	0	2	3
WFR32-1R	Transect 1 - right	1	0	1	0	0	0	0	0	9	7	5	3	26
WFR32-2C	Transect 2 - center	3	0	0	0	0	0	0	0	0	0	4	3	10
WFR32-2L	Transect 2 - left	3	5	0	0	0	0	0	0	0	0	0	2	10
WFR32-2R	Transect 2 - right	1	0	0	0	0	0	0	0	0	5	5	3	14
WFR32-3C	Transect 3 - center	3	1	0	0	0	0	0	0	0	0	2	3	9
WFR32-3L	Transect 3 - left	2	5	4	0	0	0	0	0	0	0	0	1	12
WFR32-3R	Transect 3 - right	2	0	0	0	0	0	0	0	4	8	5	3	22
WFR32	**Average %**	**67%**	**24%**	**7%**	**0%**	**0%**	**0%**	**0%**	**0%**	**14%**	**28%**	**47%**	**85%**	**23%**

ATTACHMENT EC – SOLAR PATHFINDER SUPPLEMENTAL FIELD DATA

Temperature Data Logger Site	Reach	GIS Riparian Vegetation Reach Type	Site Description	Average Daily Shade	GIS Reach Scale Aspect	Azimuth			Bankfull Width (Feet)			Average Bankfull Width (Feet)	Wetted Width (Feet)			Average Wetted Width (Feet)
						1	2	3	1	2	3		1	2	3	
ASHL-02	ASC4	Forested	Dense shrubs with cottonwoods and conifers at potential shade conditions. Minor road encroachment along river left to the north.	80%	-45	320	120	60		22.0	25.4	24		19.4	16.5	18
ASHL-03	ASC10	Open/Pasture	Likely straightened reach with fields on both sides and tall grass along the channel margin.	18%	0	170	170	170	15.0	17.2	16.3	16	14.4	16.1	13.5	15
none	ASC16	Forested	Somewhat meandering with alders and conifers, grazing may have led to slight channel overwidening.	78%	-45	100	10	40	23.7	24.8	29.0	26	19.6	19.7	24.9	21
none	ASC17	Open/Pasture	Meadow area upstream of lake, cattails and grasses. Probably close to potential, though there were signs of grazing.	7%	-45	190		100	31.0	27.3	28.0	29	21.5	22.2	24.7	23
ASHL-06	ASC22	Forested	Dense shrubs with cottonwoods and conifers at potential shade conditions.	78%	45	20	10	335	18.5	23.3	19.1	20	13.8	17.8	14.1	15
none	ASC31	Open/Pasture	Through fields, downstream of lake outlet, with tall grass along the channel margin and grazing along river left.	4%	0	0	10	10	28	31	35	31	24	25	31	27
ASHL-13	ASC33	Low/Moderate Riparian	Grass and shrubs along overwidened reach with historic and on-ongoing semi-urban impacts.	19%	45	100	90	140	43	45	39	42	23	28	32	28
ASHL-15	ASC35	Dense Riparian	Dense shrubs with cottonwoods and conifers, as well as topographic shading from hillslope.	64%	45	140	140	160	41	29	27	32	23	24	21	23
none	ASC36	Low/Moderate Riparian	Lawns extend to channel margin, along with riprap. Dispersed large deciduous trees.	30%	45	180	160	160	23	22	26	24	15	18	21	18
none	ASC39	Low/Moderate Riparian	Entrenched reach in urban setting with shrubs and grass.	27%	-45	100	100	100	36	30	27	31	30	26	19	25
none	ASC40	Low/Moderate Riparian	Entrenched reach in urban/rural residential setting with shrubs and grass. Downstream of USGS gage.	28%	0	20	340	60	32	25	23	26	29	22	19	23
ASHL-20	ASC44	Low/Moderate Riparian	Dense shrubs and deciduous trees along right bank and field along left bank. Slough-like channel conditions.	19%	90	140	140		*97*	*90*		*94*	*67*	*66*		*67*

Italics denote width estimates made using GIS.

Temperature Data Logger Site	Reach	GIS Riparian Vegetation Reach Type	Site Description	Average Daily Shade	GIS Reach Scale Aspect	Azimuth			Bankfull Width (Feet)			Average Bankfull Width (Feet)	Wetted Width (Feet)			Average Wetted Width (Feet)
						1	2	3	1	2	3		1	2	3	
WHTF-02	WFR1	Dense Riparian	Entrenched channel with dense deciduous trees along both banks.	37%	-45	80	80	80	80.2	72.5	70.5	74	70.5	61.6	59.1	64
WHTF-06	WFR13	Dense Riparian	Conifers and shrubs. Likely at potential.	56%	-45	20	20	20	51.1	65.3	72.2	63	48.6	58.2	51.1	53
WHTF-07	WFR15	Low/Moderate Riparian	Conifers and large deciduous trees, with understory shrubs. Likely at potential. Single band of trees along river left provide excellent shade.	59%	0	30	30	30	64.5	72.0	92.7	76	59.1	56.9	72.7	63
WHTF-08	WFR17	Low/Moderate Riparian	Conifers and shrubs with hillslope/topographic shading along river right.	30%	0	50	40	30	68.6	71.4	99.1	80	61.8	69.6	76.7	69
WHTF-09	WFR21	Low/Moderate Riparian	Conifers and shrubs, with interspersed cottonwoods. Perhaps historic loss of sinuosity.	29%	0	10		350	92.3	54.4	66.2	71	76.1	50.5	55.5	61
WHTF-10	WFR27	Low/Moderate Riparian	Conifers, deciduous trees and shrubs in residential setting.	45%	-45		60	60	65	70	68	68	61	60	62	61
none	WFR29	Open/Pasture	Shrubs and grass. Residential and horse pasture.	14%	-45	320	320	300	65	70	66	67	59	61	62	61
WHTF-11	WFR32	Low/Moderate Riparian	Shrubs and sparse deciduous trees in urban setting.	23%	90	60	60	40	63	60	59	61	49	53	53	52

ATTACHMENT ED – QUAL2K MODEL CALIBRATION INPUTS

ASHLEY CREEK MODEL CALIBRATION INPUTS

1. **QUAL2K**
   - 15 days, August 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

2. **Headwater**
   - Temperatures and flow for ASHL-01 used to simulate outflow from lake
   - Rating curve coefficients based on mean velocity and mean depth measurements with an exponent of zero based on measurements in ASHL-01

3. **Downstream**
   - No prescribed downstream boundary

4. **Reach**
   - 46 reaches based on vegetation and aspect derived from GIS analysis of aerial imagery
   - Three reaches flow through lakes: 14, 18 and 29
   - Rating curve coefficients based on mean velocity and mean depth measurements with an exponent of zero, applied to each reach based on data from measured site within reach, extrapolated to un-assessed reaches based on proximal measurement and review of aerial imagery
   - Depth and velocity coefficients for reaches that flow through lakes were estimated based on measured values in slow moving slough-like conditions
   - Depth coefficients were manipulated in the application of the water use scenario and the natural condition scenario in order to keep the width constant for the majority of the reaches

5. **Reach Rates**
   - N/A

6. **Air Temperature**
   - Averaged over 15 days from AgriMet Creston station

7. **Due Point Temperature**
   - Averaged over 15 days from AgriMet Creston station
   - Increased relative humidity data by 15% based on Big Hole assessment

8. **Wind Speed**
   - Averaged over 15 days from AgriMet Creston station

9. **Cloud Cover**
   - Averaged over 15 days from NCDC station at Kalispell Glacier Park International Airport

10. **Shade**
    - Solar pathfinder measurements were assigned to the reach in which they were located

- Average solar pathfinder values were assigned to reaches in which no measurement was performed, averages based on vegetation type as assessed in GIS: forested, dense riparian, low/moderate riparian, open/pasture
- 0% shade was assigned for the three “lake” reaches – 14, 18, 29

11. Rates

- No adjustment to standard model assumptions

12. Light and Heat

- Utilized sediment thermal thickness of 10 cm and sediment thermal diffusivity of 0.005 cm^2/s

13. Diffuse Sources

- Irrigation loss at six sites based on observed agriculture and decrease in streamflow between temperature data logger sites
- Loss due to groundwater aquifer or evapotranspiration at one site where no agriculture was observed, based on decrease in streamflow between temperature data logger sites
- Hydro balance performed at each streamflow measurement site and above/below each lake
- Appears that lowermost portion of creek is a backwater slough of the Flathead River and there may be extensive hyporheic interactions which were not accounted for in the model

14. Point Sources

- 22 identified tributaries based on 1:100,000 NHD layer, 2 with flow measurements (tribs 8 and 20), 5 flows estimated based on hydro balance (tribs 1, 5, 17, 18, 22), no flow assigned to 15 tribs, some noted as dry during field visits
- Tributary temperatures based on Spring Creek measurement (ASHL-16) since Porter Creek (ASHL-07) had cool water and actually appeared to be a spring creek
- 3 temperature measurements on tributary streams, ASHL-09 discarded since no flow measurement performed and hydro balance did not indicate an increase in streamflow
- Baseline Kalispell WWTP discharge based on average flow (0.119 m^3/s or 4.2 cfs)/temperature (20.1°C or 68.18°F) for August 2008
- Discharge for Kalispell WWTP when discharging at the naturally occurring stream temperature based on average flow for August 2003 – 2012 (0.116 m^3/s or 4.1 cfs).

15. Hydraulics Data

- 9 streamflow measurements, discarded additional flow measurement of 11.9 cfs from ASHL-11, also discarded the two lowermost streamflow measurements from sites ASHL-19 and ASHL-20

16. Temperature Data

- 16 temperature measurements on Ashley Creek, averaged over 15 days

WHITEFISH RIVER MODEL CALIBRATION INPUTS

1. QUAL2K
- 2 days, August 17-18

2. Headwater
- Temperatures and flow for WHTF-01 used to simulate outflow from lake
- Rating curve coefficients based on mean velocity and mean depth measurements from 5 sites measured in 2008, raised to the 0 exponent

3. Downstream
- No prescribed downstream boundary

4. Reach
- 32 reaches based on vegetation and aspect derived from GIS analysis of aerial imagery
- Rating curve coefficients based on mean velocity and mean depth measurements from 5 sites measured in 2008, raised to the 0 exponent

5. Reach Rates
- N/A

6. Air Temperature
- Averaged over 2 days from AgriMet Creston station

7. Due Point Temperature
- Averaged over 2 days from AgriMet Creston station
- Increased relative humidity data by 15% based on Big Hole measurements

8. Wind Speed
- Averaged over 2 days from AgriMet Creston station

9. Cloud Cover
- Averaged over 2 days from NCDC station at Kalispell Glacier Park International Airport

10. Shade
- Solar pathfinder measurements were assigned to the reach in which they were located
- Average solar pathfinder values were assigned to reaches in which no measurement was performed, averages based on vegetation type as assessed in GIS: dense riparian, low/moderate riparian, open/pasture

11. Rates
- No adjustment to standard model assumptions

12. Light and Heat
- Utilized sediment thermal thickness of 10 cm and sediment thermal diffusivity of 0.005 cm^2/s

13. Diffuse Sources

- Surface water inputs within 2 reaches (14 and 16-29) based on hydro balance, modeled at 17.25 °C based on mean temperature of WHTF-04 (Walker Creek)

14. Point Sources

- 7 tributaries, 2 with flow measurements, 5 flows estimated based on hydro balance
- Tributary temperatures all based on measurement from WHTF-04 (Walker Creek)
- 1 WWTP discharge based on average flow (0.0372 m^3/s or 1.3 cfs)/temperature (22.2°C or 71.96°F) for August 2008

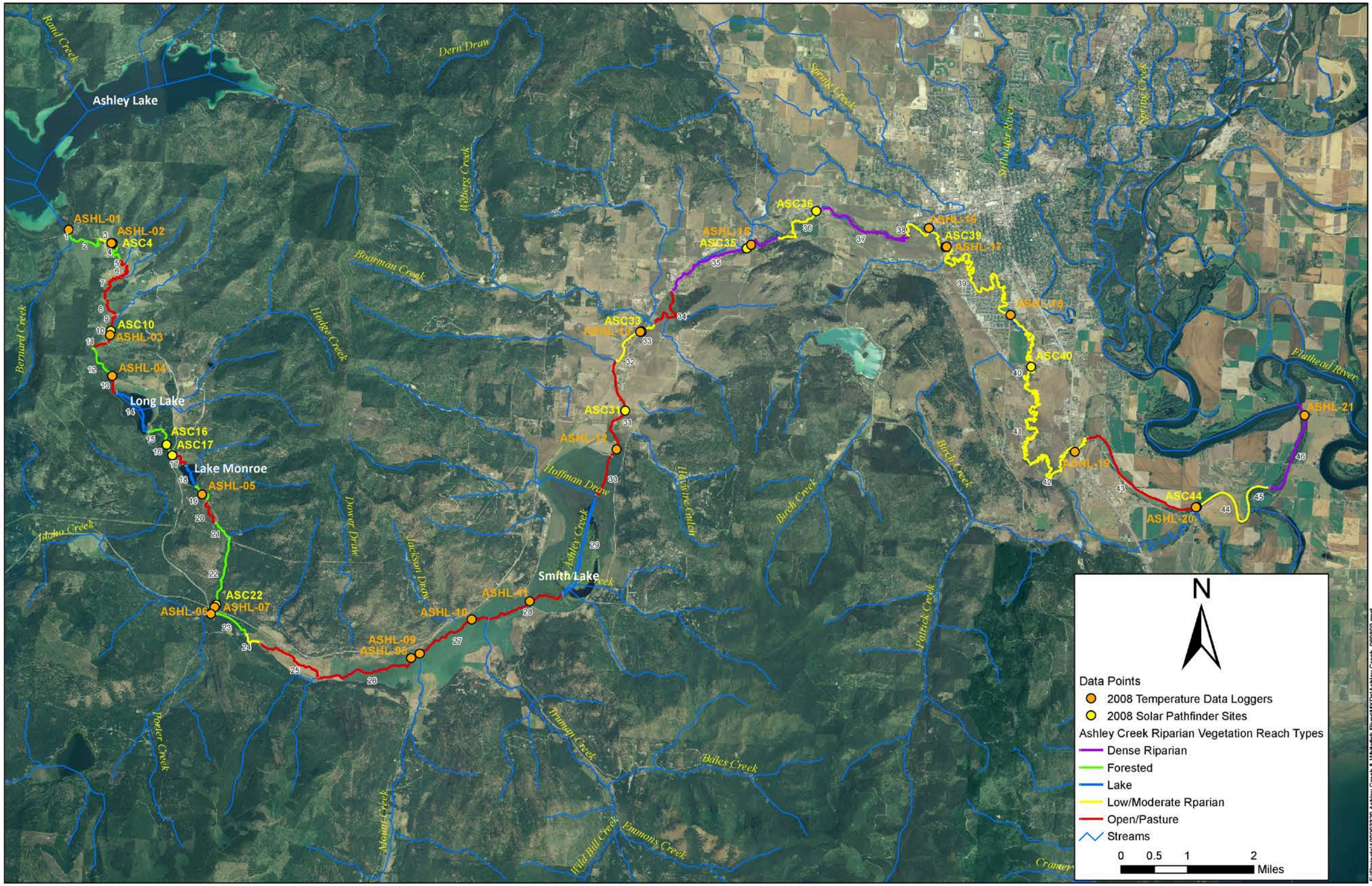
15. Hydraulics Data

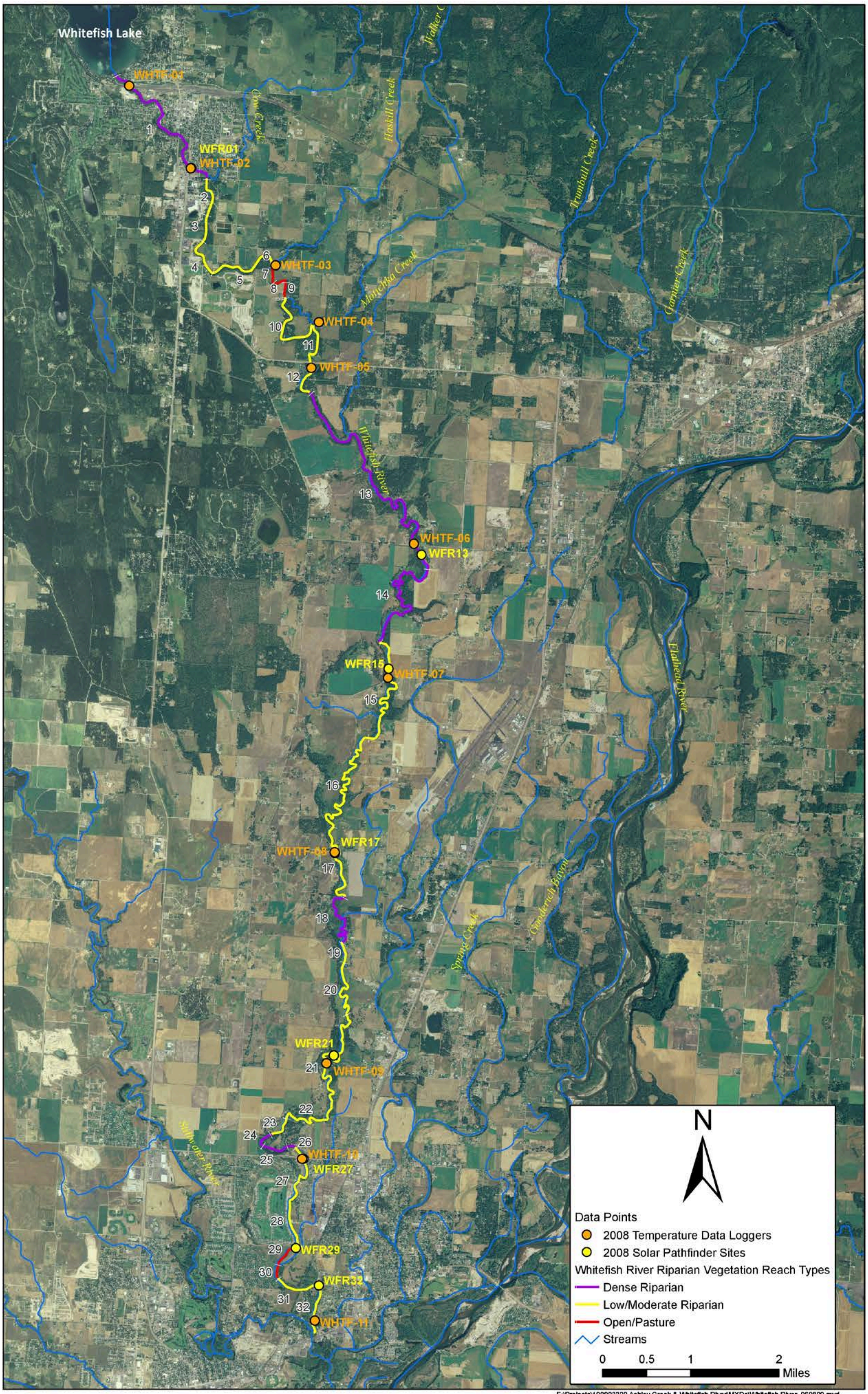
- 4 streamflow measurements, discarded additional measurement of 145 cfs from WHTF-08

16. Temperature Data

- 9 temperature measurements, averaged over 2 days

Attachment EE – Monitoring Site and Riparian Vegetation Reach Type Maps


Ashley Lake
Long Lake
Lake Monroe
Smith Lake
Rand Creek
Dern Draw
Bernard Creek
Weberg Creek
Boarman Creek
Hodge Creek
Idaho Creek
Dover Draw
Jackson Draw
Porter Creek
Hoffman Draw
Ashley Creek
Truman Creek
Bales Creek
Mount Creek
Wild Bill Creek
Emmons Creek
Spring Creek
Stillwater River
Birch Creek
Patrick Creek
Flathead River
ASHL-01
ASHL-02
ASC4
ASC10
ASHL-03
ASHL-04
ASC16
ASC17
ASHL-05
ASC22
ASHL-07
ASHL-06
ASHL-09
ASHL-08
ASHL-10
ASHL-11
ASHL-12
ASC31
ASC33
ASHL-13
ASC35
ASHL-15
ASC36
ASHL-16
ASC39
ASHL-17
ASHL-18
ASC40
ASHL-19
ASC44
ASHL-20
ASHL-21
N
Data Points
2008 Temperature Data Loggers
2008 Solar Pathfinder Sites
Ashley Creek Riparian Vegetation Reach Types
Dense Riparian
Forested
Lake
Low/Moderate Rparian
Open/Pasture
Streams
0 0.5 1 2
Miles



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ATTACHMENT EF – RIPARIAN VEGETATION REACH TYPES

Stream	Length (km)	Length (mi)	Reach	Existing Riparian Vegetation Type	Field Assessment Performed	Potential Riparian Vegetation Type	Currently Meeting Potential Shade Conditions	Existing Conditions Scenario (assigned based on field data and reach type averages)	Shade Scenario
upper Ashley Creek	0.31	0.19	1	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.89	0.55	2	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.19	0.12	3	low/moderate riparian	no	forested	no	25%	79%
upper Ashley Creek	0.90	0.56	4	forested	yes	forested	yes	80%	80%
upper Ashley Creek	0.23	0.14	5	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.54	0.34	6	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	1.09	0.68	7	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.56	0.35	8	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.33	0.20	9	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.43	0.27	10	open/pasture	yes	forested	no	18%	79%
upper Ashley Creek	0.40	0.25	11	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.98	0.61	12	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.47	0.29	13	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	1.39	0.86	14	lake	no			0%	0%
upper Ashley Creek	0.37	0.23	15	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.66	0.41	16	forested	yes	forested	yes	78%	78%
upper Ashley Creek	0.67	0.42	17	open/pasture	yes	open/pasture	yes	7%	7%
upper Ashley Creek	0.59	0.37	18	lake	no			0%	0%
upper Ashley Creek	0.56	0.35	19	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.75	0.47	20	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	0.52	0.32	21	forested	no	forested	yes	79%	79%
upper Ashley Creek	1.95	1.21	22	forested	yes	forested	yes	78%	78%
upper Ashley Creek	0.94	0.58	23	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.50	0.31	24	low/moderate riparian	no	forested	no	25%	79%
upper Ashley Creek	1.84	1.14	25	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	2.94	1.83	26	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	2.13	1.32	27	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	2.11	1.31	28	open/pasture	no	open/pasture	yes	10%	10%
Smith Lake	2.64	1.64	29	lake	no			0%	0%
middle Ashley Creek	1.05	0.65	30	open/pasture	no	open/pasture	yes	10%	10%
middle Ashley Creek	2.72	1.69	31	open/pasture	yes	open/pasture	no	4%	10%
middle Ashley Creek	0.54	0.34	32	low/moderate riparian	no	dense riparian	no	25%	64%
middle Ashley Creek	0.99	0.62	33	low/moderate riparian	yes	dense riparian	no	19%	64%
middle Ashley Creek	1.49	0.93	34	open/pasture	no	dense riparian	no	10%	64%
middle Ashley Creek	3.33	2.07	35	dense riparian	yes	dense riparian	yes	64%	64%
middle Ashley Creek	1.71	1.06	36	low/moderate riparian	yes	dense riparian	no	30%	64%
middle Ashley Creek	2.83	1.76	37	dense riparian	no	dense riparian	yes	64%	64%
middle Ashley Creek	0.32	0.20	38	low/moderate riparian	no	dense riparian	no	25%	64%
middle Ashley Creek	8.97	5.57	39	low/moderate riparian	yes	dense riparian	no	27%	64%
lower Ashley Creek	2.79	1.73	40	low/moderate riparian	yes	dense riparian	no	28%	64%
lower Ashley Creek	4.40	2.73	41	low/moderate riparian	no	dense riparian	no	25%	64%
lower Ashley Creek	3.81	2.36	42	low/moderate riparian	no	dense riparian	no	25%	64%
lower Ashley Creek	3.45	2.14	43	open/pasture	no	dense riparian	no	10%	64%
lower Ashley Creek	2.09	1.30	44	low/moderate riparian	yes	dense riparian	no	19%	64%
lower Ashley Creek	1.00	0.62	45	low/moderate riparian	no	dense riparian	no	25%	64%
lower Ashley Creek	2.52	1.57	46	dense riparian	no	dense riparian	yes	64%	64%

Stream	Length (km)	Length (mi)	Reach	Existing Riparian Vegetation Type	Field Assessment Performed	Potential Riparian Vegetation Type	Currently Meeting Potential Shade Conditions	Existing Conditions Scenario (assigned based on field data and reach type averages)	Shade Scenario
Whitefish River	3.09	1.92	1	dense riparian	yes	dense riparian	no	37%	47%
Whitefish River	0.73	0.45	2	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.49	0.31	3	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.76	0.48	4	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.23	0.76	5	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.24	0.15	6	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.30	0.19	7	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.26	0.16	8	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.30	0.19	9	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.93	0.58	10	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.69	0.43	11	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.57	0.97	12	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	5.28	3.28	13	dense riparian	yes	dense riparian	yes	56%	56%
Whitefish River	2.98	1.85	14	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	2.60	1.62	15	low/moderate riparian	yes	dense riparian	yes	59%	59%
Whitefish River	3.07	1.91	16	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.89	1.17	17	low/moderate riparian	yes	dense riparian	no	30%	47%
Whitefish River	1.56	0.97	18	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.37	0.23	19	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.39	0.86	20	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	3.08	1.91	21	low/moderate riparian	yes	dense riparian	no	29%	47%
Whitefish River	0.96	0.60	22	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.47	0.29	23	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.31	0.19	24	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.48	0.30	25	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.18	0.11	26	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.81	0.50	27	low/moderate riparian	yes	dense riparian	no	45%	47%
Whitefish River	1.33	0.82	28	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.50	0.31	29	open/pasture	yes	dense riparian	no	14%	47%
Whitefish River	0.27	0.17	30	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.84	0.52	31	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.93	0.58	32	low/moderate riparian	yes	dense riparian	no	23%	47%

ATTACHMENT EG – HYDROLOGIC BALANCE

Reach	Hydrologic Balance (cms)		Notes
1	0.2024	ASHL-01	outlet of Ashley Lake
	0.2024	**flow at outlet of 1**	
2	0.0895	trib 1	Bernard Creek
3			
4	0.2920	ASHL-02	
	0.2920	**flow at outlet of 4**	
5	0.0482	irrigation loss	start of irrigated agriculture, loss of 50% of decrease in flow between ASHL-02 and ASHL-03
6		trib 2	irrigated agriculture
7		trib 3	irrigated agriculture
8			irrigated agriculture
9	0.0482	irrigation loss	loss of 50% of decrease in flow between ASHL-02 and ASHL-03
10		trib 4	irrigated agriculture
	0.1955	ASHL-03	
	0.1955	**flow at outlet of 10**	
11	0.0082	irrigation loss	loss of 50% of decrease in flow between ASHL-03 and ASHL-04
12			
13	0.0082	irrigation loss	loss of 50% of decrease in flow between ASHL-03 and ASHL-04
	0.1792	ASHL-04	
	0.1792	**flow at outlet of 13**	flow into Lone Lake
14	0.0264	trib 5	Lone Lake, lake reach, Hodge Creek flows into lake
	0.2055	**flow at outlet of 14**	
15			
16			
17	**0.2055**	**flow at outlet of 17**	
18		trib 6	Monroe Lake, lake reach, unnamed streamflows into lake
	0.2055	**flow at outlet of 18**	
19	0.2055	ASHL-05	downstream of lake
	0.2055	**flow at outlet of 19**	
20	0.0639	groundwater loss	or evapotranspiration, flows through wet meadow
21			
22		trib 7	
	0.1416	ASHL-06	
	0.1416	**flow at outlet of 22**	
23	0.0827	ASHL-07, trib 8	Porter (Idaho) Creek
	0.2243	**flow at outlet of 23**	combined flow of ASHL-06 and ASHL-07
24			
25	0.0601	irrigation loss	loss of 50% of decrease in flow (0.601 cms) between combined ASHL-06/07 and ASHL-13
26		trib 9	
27		trib 10	Mount Creek, ASHL-09 identified as "ditch entering Ashley Cr", no flow measurement, data not applied
28		trib 11	Truman Creek
		ASHL-11	flow measurement discarded, slough-like conditions
	0.1643	**flow at outlet of 28**	
29		trib 12, trib 13	Smith Lake, lake reach, two un-named streams flow into lake
	0.1643	**flow at outlet of 29**	

Reach	Hydrologic Balance (cms)		Notes
30		trib 14	Hoffman Draw
31	0.0601	irrigation loss	loss of 50% of decrease in flow between combined ASHL-06/07 and ASHL-13
32		trib 15	
33	0.1042	ASHL-13	USGS gaging station 12367500 (1930-1974)
	0.1042	**flow at outlet of 33**	
34		trib 16	Boorman Creek, reported dry during site visit
	0.0067	trib 17	one half of difference in flow
	0.0067	trib 18	one half of difference in flow
	0.1175	ASHL-15	
	0.1175	**flow at outlet of 35**	
36		trib 19	
37	0.0539	irrigation loss	
38			
39	0.0670	ASHL-16, trib 20	Spring Creek
	0.1306	ASHL-17	
	0.1306	flow d/s of ASHL-17	
	0.1190		WWTP input (2.723mgd/4.214cfs)(station 21.0)
	0.2496	**flow at outlet of 39**	
40		trib 21	flow of 9.5 cfs at USGS 12367800 on 8/19/08, based on measured flow of 8.83cfs on 8/29/08
41			
42		ASHL-19	flow measurement discarded, slough-like conditions
43			
44		ASHL-20	flow measurement discarded, slough-like conditions
45	0.0270	trib 22	Patrick Creek connected or an oxbow
46	**0.2766**	**flow at mouth**	

Reach	Hydrologic Balance (cms)		Notes
1	3.2918	WHTF-01	outlet of Whitefish Lake
	3.2918	**flow at outlet of 1**	
2	0.0569	trib 1	Cow Creek, est. based on WHTF-01+03 and WHTF-06, split with Motichka Cr.
3	0.0372	WWTP	WWTP input (0.851mgd/1.317cfs)(station 35.8)
4			
5			
7	0.1004	WHTF-03, trib 2	Haskill Creek - temperature data logger did not work
	3.4863	**flow at outlet of 7**	
8			
9			
10	0.0158	WHTF-04, trib 3	Walker Creek
	3.5021	**flow at outlet of 10**	
11			
12			
13	0.0569	trib 4	Motchika, est. based on WHTF-01+03 and WHTF-06, split with Cow Cr.
	3.5590	WHTF-06	
	3.5590	**flow at outlet of 13**	
14	0.1579	surface water gain	majority of reach between WHTF-06 and WHTF-07 is irrigated agriculture, but no ditch outlets were observed in aerial imagery, so assumed to be an unidentified surface water input
15	3.7738	WHTF-07	at USGS gage mean daily flow on 8/13 was 135 cfs (3.8111 cms)
	0.0569	trib 5	unnamed small tributary, same flow as Cow/Motichka
	3.7738	**flow at outlet of 15**	
16	0.0350	surface water gain	added between reach 16 (station 18.445) and reach 29 (station 2.540)
17			
18	0.0569	trib 6	unnamed small tributary, same flow as Cow/Motichka
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30	0.0569	trib 7	unnamed small tributary, same flow as Cow/Motichka
31			
32	3.9226	WHTF-11	
	3.9226	**flow at outlet of 32**	approximately 60 yards upstream of confluence with Stillwater