APPENDIX I TEMPERATURE HEAT LOADS

Calculated heat loads for loading capacity and allocations

In the TMDL, loading capacity and nonpoint source load allocations are expressed as temperature, and point source wasteload allocations are expressed as heat loads. Temperature and heat load can both be used to understand the loading capacity of a system and develop allocations for a TMDL.

EPA chose to present point source wasteload allocations as heat loads in the TMDL because many facilities can manage effluent flow to reduce the impact of their discharge on the receiving water. Expressing wasteload allocations as heat loads provides point sources with flexibility to manage temperature and/or effluent flow to achieve their wasteload allocations. By contrast, nonpoint sources of heat in the watershed are subject to the ebb and flow of the system, which includes more than 900 river miles, and which can be affected by a variety of factors that may change on a seasonal, annual or decadal basis. Use of temperature as the metric for nonpoint source load allocations provides a practical target for water resource managers to work toward and is consistent with the water quality standards at issue in this system—numeric temperature criteria.

For completeness and transparency, this appendix presents heat loads EPA calculated using mean monthly river flows during the critical period of June – October in 2011-2016, but that are not presented in the TMDL. Heat loads are calculated as the product of temperature, flow and a conversion factor and are expressed in kilocalories per day (kcal/day) using the following equation:

$HL_w = T_w \times Q_w \times c$

where,

HL_w = Heat Load (kcal/day)
T_w = Water temperature (°C).
Q_w = River Flow (thousand cubic feet per second (kcfs))
c = Conversion factor = 2.446×10^9 kcal-s/°C-ft^3-day

Calculated heat loads for the following are included in this appendix:

- Loading capacity in the Columbia and lower Snake Rivers
- Load allocations for each source group: point sources, tributaries, and dams
- Refined tributary load allocations

Loading Capacity

In Table I-1, EPA provides the total and 0.3°C portion of the loading capacities expressed as kcal/day at target sites on the Columbia and lower Snake Rivers for June – October, using average monthly flow data from 2011-2016. These loading capacities are calculated using measured monthly mean flows from the DART sites and the target temperatures (temperature criteria values + 0.3°C). The Lake Roosevelt target site is not included, because it is located within the reservoir and no flow information is available for the load calculation.

Table I-1 Calculated loading capacities in the Columbia and lower Snake Rivers (June – October; 2011-2016)

Location	Target	Mean Monthly Flow 2011-2016 (kcfs)					Total Loading Capacity (kcal/day x 10^9)					0.3°C Portion of the Loading Capacity (kcal/day x 10^9)				
	°C	June	July	Aug	Sept	Oct	June	July	Aug	Sept	Oct	June	July	Aug	Sept	Oct
COLUMBIA RIVER																
Grand Coulee	16.3	153	146	111	61	57	6,106	5,806	4,434	2,417	2,270	112	107	82	44	42
Chief Joseph	17.8	158	150	117	65	63	6,861	6,541	5,117	2,826	2,732	116	110	86	48	46
Wells	17.8	173	161	116	63	59	7,546	7,019	5,060	2,730	2,587	127	118	85	46	44
Rocky Reach	17.8	178	162	121	67	65	7,737	7,071	5,251	2,930	2,838	130	119	89	49	48
Rock Island	17.8	184	166	124	69	70	8,009	7,234	5,404	3,002	3,048	135	122	91	51	51
Wanapum	17.8	193	168	119	70	77	8,393	7,328	5,198	3,057	3,358	141	123	88	52	57
Priest Rapids	17.8	196	171	120	72	82	8,517	7,452	5,205	3,150	3,591	144	126	88	53	61
McNary	20.3	283	229	165	96	95	14,062	11,383	8,203	4,762	4,726	208	168	121	70	70
John Day	20.3	278	221	154	92	90	13,791	10,986	7,656	4,592	4,457	204	162	113	68	66
Dalles	20.3	265	208	145	94	92	13,140	10,348	7,179	4,649	4,574	194	153	106	69	68
Bonneville	20.3	285	228	161	104	107	14,176	11,333	7,983	5,172	5,298	209	167	118	76	78
	13.3	--	--	--	--	107		-	-	-	3,471	-	-	-	-	78
SNAKE RIVER																
Lower Granite	20.3	83	46	27	22	19	4,127	2,307	1,322	1,099	962	61	34	20	16	14
Little Goose	20.3	80	45	27	20	18	3,959	2,256	1,340	1,018	908	59	33	20	15	13
Lower Monumental	20.3	81	46	27	21	19	4,046	2,278	1,327	1,044	936	60	34	20	15	14
Ice Harbor	20.3	84	48	28	21	19	4,189	2,381	1,379	1,038	959	62	35	20	15	14

Allocations for each source group: point sources, tributaries, and dams

EPA has divided the 0.3°C portion of the loading capacity from Table I-1 into equal 0.1°C allocations for point sources, tributaries and dams. These 0.1°C allocations are presented in Table I-2 for each of the 15 target sites on the Columbia and lower Snake Rivers for June — October, and are functionally a 0.1°C allocation above the WQC. For tributaries and point sources, the allocations in Table I-2 apply to the tributary and point sources located upstream of the target site.

Table I-2 0.1°C portion of allocation for each source group: point sources, tributaries and dams

Target Site	Mean Monthly Flow 2011 – 2016 (kcfs)					0.1°C Portion of Allocation (kcal/day x 10^9)				
	June	July	Aug	Sept	Oct	June	July	Aug	Sept	Oct
Columbia River										
Grand Coulee	153	146	111	61	57	37	36	27	15	14
Chief Joseph	158	150	117	65	63	39	37	29	16	15
Wells	173	161	116	63	59	42	39	28	15	15
Rocky Reach	178	162	121	67	65	43	40	30	16	16
Rock Island	184	166	124	69	70	45	41	30	17	17
Wanapum	193	168	119	70	77	47	41	29	17	19
Priest Rapids	196	171	120	72	82	48	42	29	18	20
McNary	283	229	165	96	95	69	56	40	23	23
John Day	278	221	154	92	90	68	54	38	23	22
Dalles	265	208	145	94	92	65	51	35	23	23
Bonneville	285	228	161	104	107	70	56	39	25	26
Snake River										
Lower Granite	83	46	27	22	19	20	11	7	5	5
Little Goose	80	45	27	20	18	20	11	7	5	4
Lower Monumental	81	46	27	21	19	20	11	7	5	5
Ice Harbor	84	48	28	21	19	21	12	7	5	5

For dams, the load allocations in Table I-2 do not require further refinement because the dams release the flow of the mainstems at each target site and have a cumulative impact on heating or cooling that is not readily attributable to individual dams. EPA has further refined tributary and point source allocations, however, to specify the loads for each tributary and for each point source effluent discharge to the mainstems. EPA used the RBM10 model to estimate these allowable heat loadings. The refined tributary-specific loadings are discussed below. Wasteload allocations for NPDES-permitted point sources, expressed as heat loads, are provided in the TMDL and are not replicated in this appendix.

Refined Tributary Allocations

EPA used the RBM10 model to estimate the effect of temperature changes at the mouths of the tributaries on the temperature of the mainstem Columbia and Snake rivers. Through trial-and-error, model results indicated that a uniform tributary reduction of 0.5°C below current temperatures, at the confluence with the mainstem, results in a maximum cumulative temperature change in the mainstem

approximately equal to the 0.1°C temperature allocation. In Table I-3, EPA provides the individual load allocations for tributaries for the months of June, July, August, September, and October. These loadings are calculated for each tributary using measured mean monthly flow and the allowable temperature impact for tributaries determined from the modeling assessment, 0.5°C at the mouth.

Table I-3 Refined load allocation for major tributaries

Tributary Name	Mainstem Inflow Location	Average Monthly Tributary Flow (2011 – 2016) (cfs)					Load Allocation: 0.5°C impact to each tributary at mouth kcal/day*10^9				
	RM	June	July	Aug	Sept	Oct	June	July	Aug	Sept	Oct
Columbia River											
Kettle, WA	706	10,118	3,454	750	363	603	12.4	4.2	0.9	0.4	0.7
Colville, WA	700	443	218	110	99	130	0.5	0.3	0.1	0.1	0.2
Spokane, WA	639	10,340	3,661	1,848	1,849	2,717	12.6	4.5	2.3	2.3	3.3
Okanogan, WA	534	10,051	5,040	1,642	1,075	1,306	12.3	6.2	2.0	1.3	1.6
Methow, WA	524	5,445	2,317	719	458	585	6.7	2.8	0.9	0.6	0.7
Chelan, WA	503	3,276	3,290	1,660	1,647	2,446	4.0	4.0	2.0	2.0	3.0
Entiat, WA	484	1,201	627	206	110	154	1.5	0.8	0.3	0.1	0.2
Wenatchee, WA	468	7,299	4,309	1,334	731	1,662	8.9	5.3	1.6	0.9	2.0
Crab Creek, WA	411	48	58	68	66	58	0.1	0.1	0.1	0.1	0.1
Yakima, WA	335	4,282	1,869	1,514	1,813	2,417	5.2	2.3	1.9	2.2	3.0
Walla Walla, WA	315	356	68	27	45	90	0.4	0.1	0.0	0.1	0.1
Umatilla, OR	289	368	87	93	137	232	0.5	0.1	0.1	0.2	0.3
John Day, OR	218	2,506	560	129	92	300	3.1	0.7	0.2	0.1	0.4
Deschutes, OR	204	5,344	4,848	4,592	4,516	5,017	6.5	5.9	5.6	5.5	6.1
Klickitat, WA	180	1,824	1,218	867	769	932	2.2	1.5	1.1	0.9	1.1
Hood, OR	169	761	492	344	336	633	0.9	0.6	0.4	0.4	0.8
Sandy, OR	121	1,533	726	452	457	1,354	1.9	0.9	0.6	0.6	1.7
Willamette, OR	102	14,014	8,220	7,135	8,810	15,375	17.1	10.1	8.7	10.8	18.8
Lewis, WA	87	3,177	1,957	1,405	1,565	3,543	3.9	2.4	1.7	1.9	4.3
Kalama, WA	73	761	492	344	336	574	0.9	0.6	0.4	0.4	0.7
Cowlitz, WA	69	7,982	5,422	4,248	4,301	6,607	9.8	6.6	5.2	5.3	8.1
Snake River											
Tucannon, WA	62	184	88	65	71	89	0.2	0.1	0.1	0.1	0.1
Palouse, WA	60	268	83	32	34	68	0.3	0.1	0.0	0.0	0.1