APPENDIX I TEMPERATURE HEAT LOADS

Calculated head 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 head loads EPA calculated using mean monthly river flows during the critical period of July – 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 each of the 15 target sites on the Columbia and lower Snake Rivers for July – 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).

Table I-1 Calculated loading capacities in the Columbia and lower Snake Rivers (July – 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	July	August	Sept	Oct	July	August	Sept	Oct	July	August	Sept	Oct.
COLUMBIA RIVER													
Grand Coulee	16.3	146	111	61	57	5,806	4,434	2,417	2,270	107	82	44	42
Chief Joseph	17.8	150	117	65	63	6,541	5,117	2,826	2,732	110	86	48	46
Wells	17.8	161	112	63	60	7,019	4,873	2,730	2,628	118	82	46	44
Rocky Reach	17.8	162	121	67	65	7,071	5,251	2,930	2,838	119	89	49	48
Rock Island	17.8	166	124	69	70	7,234	5,404	3,002	3,048	122	91	51	51
Wanapum	17.8	168	119	70	76	7,328	5,198	3,057	3,303	123	88	52	56
Priest Rapids	17.8	171	120	72	86	7,452	5,205	3,150	3,761	126	88	53	63
McNary	20.3	229	165	96	95	11,383	8,203	4,762	4,695	168	121	70	69
John Day	20.3	221	154	92	89	10,986	7,656	4,592	4,436	162	113	68	66
Dalles	20.3	171	134	89	93	8,496	6,641	4,439	4,602	126	98	66	68
Bonneville	20.3	228	161	104	106	11,333	7,983	5,172	5,246	167	118	76	78
	13.3	--	--	--	106	-	-	-	3,437	-	-	-	78
SNAKE RIVER													
Lower Granite	20.3	46	27	22	19	2,307	1,322	1,099	960	34	20	16	14
Little Goose	20.3	45	27	20	18	2,256	1,340	1,018	906	33	20	15	13
L Monumental	20.3	46	27	21	19	2,278	1,327	1,044	931	34	20	15	14
Ice Harbor	20.3	48	28	21	19	2,381	1,379	1,038	954	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 July — 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)			
	July	August	Sept	Oct	July	August	Sept	Oct
Columbia River								
Grand Coulee	146	111	61	57	36	27	15	14
Chief Joseph	150	117	65	63	37	29	16	15
Wells	161	112	63	60	39	27	15	15
Rocky Reach	162	121	67	65	40	30	16	16
Rock Island	166	124	69	70	41	30	17	17
Wanapum	168	119	70	76	41	29	17	19
Priest Rapids	171	120	72	86	42	29	18	21
McNary	229	165	96	95	56	40	23	23
John Day	221	154	92	89	54	38	23	22
Dalles	171	134	89	93	42	33	22	23
Bonneville	228	161	104	106	56	39	25	26
Snake River								
Lower Granite	46	27	22	19	11	7	5	5
Little Goose	45	27	20	18	11	7	5	4
Lower Monumental	46	27	21	19	11	7	5	5
Ice Harbor	48	28	21	19	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 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	July	August	Sept.	October	July	August	Sept.	October
Columbia River									
Kettle, WA	706	3,454	750	363	603	4.2	0.9	0.4	0.7
Colville, WA	700	218	110	99	130	0.3	0.1	0.1	0.2
Spokane, WA	639	3,661	1,848	1,849	2,717	4.5	2.3	2.3	3.3
Okanogan, WA	534	5,040	1,642	1,075	1,306	6.2	2.0	1.3	1.6
Methow, WA	524	2,317	719	458	585	2.8	0.9	0.6	0.7
Chelan, WA	503	3,290	1,660	1,647	2,446	4.0	2.0	2.0	3.0
Entiat, WA	484	627	206	110	154	0.8	0.3	0.1	0.2
Wenatchee, WA	468	4,309	1,334	731	1,662	5.3	1.6	0.9	2.0
Crab Creek, WA	411	58	68	66	58	0.1	0.1	0.1	0.1
Yakima, WA	335	1,869	1,514	1,813	2,417	2.3	1.9	2.2	3.0
Walla Walla, WA	315	68	27	45	90	0.1	0.0	0.1	0.1
Umatilla, OR	289	87	93	137	232	0.1	0.1	0.2	0.3
John Day, OR	218	560	129	92	300	0.7	0.2	0.1	0.4
Deschutes, OR	204	4,848	4,592	4,516	5,017	5.9	5.6	5.5	6.1
Klickitat, WA	180	1,218	867	769	932	1.5	1.1	0.9	1.1
Hood, OR	169	492	344	336	633	0.6	0.4	0.4	0.8
Sandy, OR	121	726	452	457	1,354	0.9	0.6	0.6	1.7
Willamette, OR	102	8,220	7,135	8,810	15,375	10.1	8.7	10.8	18.8
Lewis, WA	87	1,957	1,405	1,565	3,543	2.4	1.7	1.9	4.3
Kalama, WA	73	492	344	336	574	0.6	0.4	0.4	0.7
Cowlitz, WA	69	5,422	4,248	4,301	6,607	6.6	5.2	5.3	8.1
Snake River									
Tucannon, WA	62	88	65	71	89	0.1	0.1	0.1	0.1
Palouse, WA	60	83	32	34	68	0.1	0.0	0.0	0.1