# APPENDIX F – DAILY LOADS

## F1.0 OVERVIEW

In this appendix the TMDL is expressed using daily loads to satisfy an additional EPA required TMDL element. Daily loads should not be considered absolute limits for a given day and may be refined in the future as part of the adaptive management process. The TMDLs may not be feasible at all locations within the watershed but if the allocations are followed, pollutant loads are expected to be reduced to a degree that the targets are met and beneficial uses are no longer impaired. It is not expected that daily loads will drive implementation activities.

In this appendix, daily loads are presented for sediment and temperature. Given the nature of nutrient analysis, targets, and loading, daily loads for nutrients are inherently described via the TMDLs in **Section 7.0** of the main document.

## F2.0 SEDIMENT DAILY LOAD

The preferred approach for calculating daily sediment loads is to use a nearby water quality gage with a long-term dataset for flow and suspended sediment. Within the Boulder River watershed, there are only two long-term gage stations: Boulder River near Boulder (06033000) and Cataract Creek near Basin (06031950). Neither of these gage stations have a record of suspended sediment data.

Although no suspended sediment data is associated with these gages, the average daily hydrograph can be used to infer an estimated daily sediment load. A daily sediment load was determined using the means of daily mean values for discharge in cfs per day from a USGS gage station on the Boulder River. The USGS station Boulder River near Boulder (06033000) was selected to represent the daily variability in flows in the Boulder River watershed. It is assumed in this representation that the sediment loads will generally follow the hydrograph, as increased flows often reflect increased runoff that carries sediment from upland erosion and is more likely to influence bank erosion. Therefore, the percentage of the mean of daily mean value for discharge, in relation to the sum of the mean of daily mean discharge values can be derived and applied to the sediment loads for a watershed of interest.

The mean of daily mean values for discharge, in cfs, was calculated based on approximately 70 years of record (October 1, 1928 – September 30, 2012) from the Boulder River USGS station (**Table F-1**). **Figure F-1** visually represents the average daily percentage of the total yearly discharge for each day of the calendar year.

To conserve resources, this appendix only provides the base data from the USGS stream gage, and the daily percentages of the total annual load. For specific streams, all daily TMDLs may be derived by using the daily percentages in **Table F-2** and the TMDLs expressed as an average annual load, which are discussed in **Section 5.6** of the main document. For example, the total allowable annual sediment load for Basin Creek was estimated to be 523 tons. To determine the TMDL for Basin Creek on January 1, this value is multiplied by 0.062% which provides a daily load of 0.3 tons.

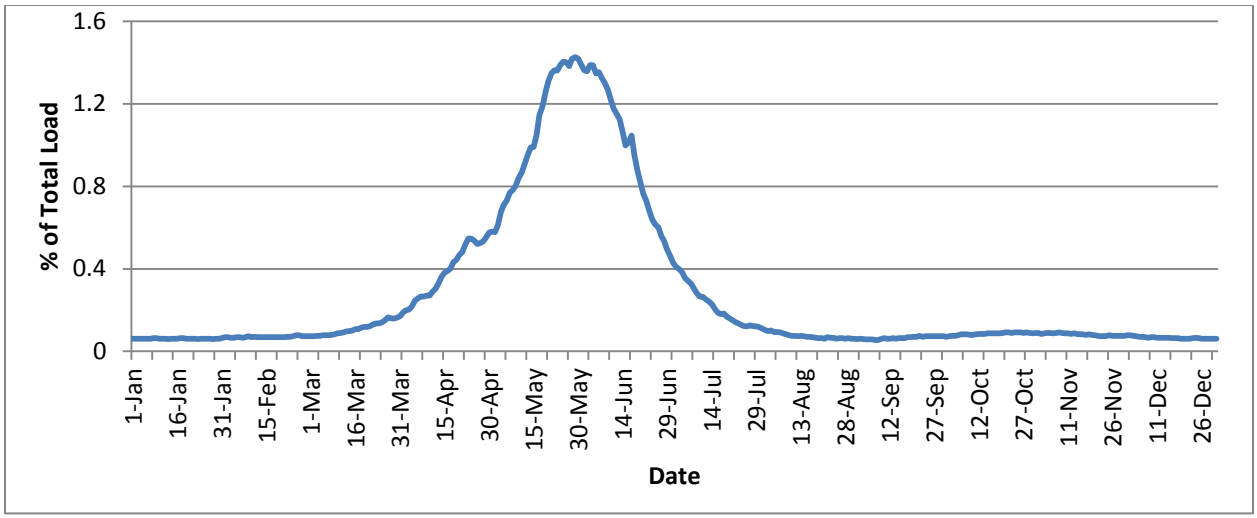


**Figure F-1. Average daily percentage of the total mean yearly discharge**

**Figure F-1** illustrates the shape of the average hydrograph for the Boulder River, driven by climate and precipitation, and typical of many western Montana streams. In general, it appears that flows (and thereby increased sediment loads) increase in the spring as winter snowpack in the high elevations melts and drains to the waterways below. Peak flows typically occur in the month of May, followed by a declining hydrograph into August where flows near baseflow levels. The small rise in flow in late September through October likely represents the end of irrigation season and a slight increase in flow levels due to the discontinuation of water withdrawals and/or recharge from groundwater inputs.

The approach outlined above provides a simple approximation for a reasonable portioning of the total annual load among days throughout the year. It is acknowledged that a direct linear relationship between sediment load and the hydrograph may not exist. Sediment loading is frequently episodic and dependent on many differing physical, climatological, and anthropogenic factors. However, the approach for daily loads in this context does provide us with insight into those times of the year where sediment loading is most likely to occur, and thereby gives us a guide for assessment and management of sediment loading in the watershed.

## F3.0 TEMPERATURE DAILY LOAD

Because of the dynamic temperature conditions throughout the course of a day, the temperature TMDL is the thermal load, at an instantaneous moment, associated with the stream temperature when in compliance with Montana's water quality standards. The temperature standard for the Boulder River and High Ore Creek is defined as follows: For waters classified as B-1, the maximum allowable increase over the naturally occurring temperature is 1$^{o}$ F, if the naturally occurring temperature is less than 66$^{o}$ F. Within the naturally occurring temperature range of 66$^{o}$ F to 66.5$^{o}$ F, the allowable increase cannot exceed 67$^{o}$ F. If the naturally occurring temperature is greater than 66.5$^{o}$ F, the maximum allowable increase is 0.5$^{o}$ F.

The daily load for temperature is therefore the thermal load to the stream over 24 hours that is associated with all reasonable land, soil, and water conservation practices. A total maximum daily heat load can be calculated using average daily temperature values representative of conditions where the temperature standard is met and applying them to Equation F-1 below. However, the resultant daily load is not particularly useful from a management perspective. Fish are most distressed by warm water

temperatures that typically peak during summer afternoons. Providing thermal loads based upon an average daily temperature does not necessarily identify the thermal loads that would be most detrimental to fish during the hottest periods of the day, but it does provide a value for the total thermal load allowed over the course of 24 hours as required by EPA. Daily thermal loads will be met through achievement of targets and allocations for the Boulder River and High Ore Creek temperature TMDLs.

**Equation F-1**

Total Maximum Daily Load (TMDL) = $(\Delta-32)*Q*(1.36*10^6)$

Where:

TMDL = allowed thermal load per day in kilocalories, above waters melting point
Δ = allowed average daily temperature (F)
Q = instantaneous discharge (cfs)
$1.36*10^6$ = conversion factor

**Table F-1. Mean of daily mean values for each day for 69 - 71 years of record in, cfs (Calculation Period 1928-10-01 -> 2012-09-30)**

| Day of month | Mean of daily mean values for each day of record in cfs | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1 | 27 | 30 | 32 | 82 | 253 | 594 | 187 | 45 | 26 | 31 | 39 | 34 |
| 2 | 27 | 30 | 32 | 87 | 252 | 592 | 179 | 43 | 27 | 32 | 37 | 34 |
| 3 | 27 | 29 | 33 | 88 | 266 | 605 | 174 | 44 | 26 | 33 | 38 | 33 |
| 4 | 27 | 29 | 33 | 94 | 295 | 605 | 167 | 41 | 25 | 33 | 39 | 32 |
| 5 | 27 | 30 | 34 | 107 | 310 | 587 | 155 | 41 | 25 | 34 | 39 | 31 |
| 6 | 27 | 30 | 34 | 112 | 319 | 590 | 149 | 40 | 25 | 36 | 38 | 31 |
| 7 | 27 | 29 | 34 | 116 | 336 | 578 | 143 | 38 | 24 | 36 | 39 | 30 |
| 8 | 28 | 30 | 35 | 116 | 341 | 566 | 133 | 36 | 24 | 36 | 40 | 29 |
| 9 | 28 | 32 | 36 | 118 | 350 | 553 | 123 | 34 | 26 | 35 | 39 | 30 |
| 10 | 27 | 30 | 38 | 118 | 366 | 532 | 116 | 33 | 28 | 35 | 38 | 30 |
| 11 | 27 | 31 | 39 | 126 | 378 | 513 | 115 | 33 | 27 | 36 | 38 | 29 |
| 12 | 27 | 30 | 40 | 133 | 396 | 501 | 110 | 32 | 27 | 37 | 37 | 29 |
| 13 | 26 | 30 | 42 | 144 | 414 | 490 | 106 | 33 | 28 | 37 | 38 | 29 |
| 14 | 27 | 30 | 43 | 157 | 431 | 464 | 100 | 32 | 27 | 37 | 37 | 29 |
| 15 | 27 | 30 | 44 | 166 | 432 | 435 | 90 | 31 | 28 | 38 | 36 | 29 |
| 16 | 27 | 30 | 47 | 170 | 457 | 442 | 82 | 31 | 28 | 38 | 36 | 28 |
| 17 | 28 | 30 | 47 | 175 | 499 | 456 | 79 | 30 | 28 | 38 | 35 | 28 |
| 18 | 28 | 30 | 50 | 188 | 518 | 414 | 80 | 29 | 30 | 38 | 36 | 28 |
| 19 | 27 | 30 | 52 | 194 | 547 | 380 | 74 | 28 | 30 | 38 | 35 | 27 |
| 20 | 27 | 30 | 52 | 204 | 571 | 356 | 70 | 28 | 31 | 39 | 34 | 27 |
| 21 | 27 | 30 | 54 | 210 | 588 | 332 | 66 | 27 | 31 | 40 | 33 | 27 |
| 22 | 27 | 31 | 57 | 225 | 594 | 318 | 62 | 30 | 33 | 40 | 32 | 27 |
| 23 | 26 | 31 | 59 | 238 | 593 | 296 | 59 | 29 | 31 | 39 | 32 | 28 |
| 24 | 27 | 32 | 59 | 238 | 605 | 278 | 56 | 29 | 32 | 40 | 33 | 29 |
| 25 | 27 | 34 | 62 | 234 | 612 | 268 | 53 | 27 | 32 | 40 | 34 | 28 |
| 26 | 27 | 34 | 66 | 227 | 611 | 262 | 53 | 28 | 32 | 40 | 33 | 27 |
| 27 | 27 | 32 | 72 | 229 | 603 | 244 | 55 | 28 | 32 | 39 | 33 | 27 |
| 28 | 26 | 32 | 70 | 232 | 618 | 233 | 53 | 27 | 32 | 40 | 33 | 27 |
| 29 | 27 | 32 | 69 | 240 | 622 | 215 | 53 | 28 | 32 | 39 | 33 | 27 |
| 30 | 27 | | 71 | 251 | 619 | 201 | 51 | 27 | 32 | 38 | 33 | 27 |
| 31 | 28 | | 74 | | 607 | | 48 | 27 | | 39 | | 27 |

**Table F-2. Percentage of mean of daily mean values per day based on the sum of all mean of daily mean values**

| Day of month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0.062 | 0.069 | 0.073 | 0.188 | 0.580 | 1.363 | 0.429 | 0.103 | 0.060 | 0.071 | 0.089 | 0.078 |
| **2** | 0.062 | 0.069 | 0.073 | 0.200 | 0.578 | 1.358 | 0.411 | 0.099 | 0.062 | 0.073 | 0.085 | 0.078 |
| **3** | 0.062 | 0.067 | 0.076 | 0.202 | 0.610 | 1.388 | 0.399 | 0.101 | 0.060 | 0.076 | 0.087 | 0.076 |
| **4** | 0.062 | 0.067 | 0.076 | 0.216 | 0.677 | 1.388 | 0.383 | 0.094 | 0.057 | 0.076 | 0.089 | 0.073 |
| **5** | 0.062 | 0.069 | 0.078 | 0.245 | 0.711 | 1.347 | 0.356 | 0.094 | 0.057 | 0.078 | 0.089 | 0.071 |
| **6** | 0.062 | 0.069 | 0.078 | 0.257 | 0.732 | 1.353 | 0.342 | 0.092 | 0.057 | 0.083 | 0.087 | 0.071 |
| **7** | 0.062 | 0.067 | 0.078 | 0.266 | 0.771 | 1.326 | 0.328 | 0.087 | 0.055 | 0.083 | 0.089 | 0.069 |
| **8** | 0.064 | 0.069 | 0.080 | 0.266 | 0.782 | 1.298 | 0.305 | 0.083 | 0.055 | 0.083 | 0.092 | 0.067 |
| **9** | 0.064 | 0.073 | 0.083 | 0.271 | 0.803 | 1.269 | 0.282 | 0.078 | 0.060 | 0.080 | 0.089 | 0.069 |
| **10** | 0.062 | 0.069 | 0.087 | 0.271 | 0.840 | 1.220 | 0.266 | 0.076 | 0.064 | 0.080 | 0.087 | 0.069 |
| **11** | 0.062 | 0.071 | 0.089 | 0.289 | 0.867 | 1.177 | 0.264 | 0.076 | 0.062 | 0.083 | 0.087 | 0.067 |
| **12** | 0.062 | 0.069 | 0.092 | 0.305 | 0.908 | 1.149 | 0.252 | 0.073 | 0.062 | 0.085 | 0.085 | 0.067 |
| **13** | 0.060 | 0.069 | 0.096 | 0.330 | 0.950 | 1.124 | 0.243 | 0.076 | 0.064 | 0.085 | 0.087 | 0.067 |
| **14** | 0.062 | 0.069 | 0.099 | 0.360 | 0.989 | 1.064 | 0.229 | 0.073 | 0.062 | 0.085 | 0.085 | 0.067 |
| **15** | 0.062 | 0.069 | 0.101 | 0.381 | 0.991 | 0.998 | 0.206 | 0.071 | 0.064 | 0.087 | 0.083 | 0.067 |
| **16** | 0.062 | 0.069 | 0.108 | 0.390 | 1.048 | 1.014 | 0.188 | 0.071 | 0.064 | 0.087 | 0.083 | 0.064 |
| **17** | 0.064 | 0.069 | 0.108 | 0.401 | 1.145 | 1.046 | 0.181 | 0.069 | 0.064 | 0.087 | 0.080 | 0.064 |
| **18** | 0.064 | 0.069 | 0.115 | 0.431 | 1.188 | 0.950 | 0.184 | 0.067 | 0.069 | 0.087 | 0.083 | 0.064 |
| **19** | 0.062 | 0.069 | 0.119 | 0.445 | 1.255 | 0.872 | 0.170 | 0.064 | 0.069 | 0.087 | 0.080 | 0.062 |
| **20** | 0.062 | 0.069 | 0.119 | 0.468 | 1.310 | 0.817 | 0.161 | 0.064 | 0.071 | 0.089 | 0.078 | 0.062 |
| **21** | 0.062 | 0.069 | 0.124 | 0.482 | 1.349 | 0.762 | 0.151 | 0.062 | 0.071 | 0.092 | 0.076 | 0.062 |
| **22** | 0.062 | 0.071 | 0.131 | 0.516 | 1.363 | 0.729 | 0.142 | 0.069 | 0.076 | 0.092 | 0.073 | 0.062 |
| **23** | 0.060 | 0.071 | 0.135 | 0.546 | 1.360 | 0.679 | 0.135 | 0.067 | 0.071 | 0.089 | 0.073 | 0.064 |
| **24** | 0.062 | 0.073 | 0.135 | 0.546 | 1.388 | 0.638 | 0.128 | 0.067 | 0.073 | 0.092 | 0.076 | 0.067 |
| **25** | 0.062 | 0.078 | 0.142 | 0.537 | 1.404 | 0.615 | 0.122 | 0.062 | 0.073 | 0.092 | 0.078 | 0.064 |
| **26** | 0.062 | 0.078 | 0.151 | 0.521 | 1.402 | 0.601 | 0.122 | 0.064 | 0.073 | 0.092 | 0.076 | 0.062 |
| **27** | 0.062 | 0.073 | 0.165 | 0.525 | 1.383 | 0.560 | 0.126 | 0.064 | 0.073 | 0.089 | 0.076 | 0.062 |
| **28** | 0.060 | 0.073 | 0.161 | 0.532 | 1.418 | 0.534 | 0.122 | 0.062 | 0.073 | 0.092 | 0.076 | 0.062 |
| **29** | 0.062 | 0.073 | 0.158 | 0.551 | 1.427 | 0.493 | 0.122 | 0.064 | 0.073 | 0.089 | 0.076 | 0.062 |
| **30** | 0.062 | 0.000 | 0.163 | 0.576 | 1.420 | 0.461 | 0.117 | 0.062 | 0.073 | 0.087 | 0.076 | 0.062 |
| **31** | 0.064 | 0.000 | 0.170 | 0.000 | 1.392 | 0.000 | 0.110 | 0.062 | 0.000 | 0.089 | 0.000 | 0.062 |