**A SURVEY OF HEAT SINK
CAPACITY OF MAJOR STREAMS
WITHIN THE U.S.**

JANUARY 1969

**AEC RESEARCH &
DEVELOPMENT REPORT**

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A SURVEY OF HEAT SINK CAPACITY OF MAJOR STREAMS
WITHIN THE U.S.

By

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ABSTRACT

The supply of cooling water has always been an important consideration in the selection of sites for power plants. As power requirements increase, the availability of cooling water is becoming an increasingly important concern in power generation forecasts. This study presents data indicative of the limitations of the cooling water supply in the nation. As an index of cooling potential for each major stream, heat input for a one degree F temperature rise, with the minimum monthly average flow recorded in a ten year period, is used.

Based on this characteristic of the streams in the U.S. we have attempted to identify, on a regional basis, where alternate solutions to once-through cooling can be anticipated first. Water quality standards will also affect cooling water availability and we also attempt to identify the potential impact of these standards.

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STATEMENT OF THE PROBLEM

Some portion of the heat used in generating electricity must be rejected from the generating system. In present power plants this heat is rejected in condensing the steam leaving the turbine. Historically, most thermal power plants in the U.S. have been able to use once-through cooling with fresh water to condense this steam. Discharging heated water to our rivers is one way we have been utilizing a natural resource to meet a need of our society. Using once-through cooling has been a logical way to supply the needed cooling since adequate water was available and the power costs using this method were the lowest.

For the future it is not clear to what extent the continued use of our water resources for this purpose is desirable. As the population grows and the per capita use of power also increases we need to examine how our water resources will be affected by their continued use as cooling water. It is necessary to find the ecological effects of a given stream temperature rise and to estimate the temperature rise to be expected with the continued use of once-through cooling for future power plants.

SCOPE OF STUDY

This study is an initial gross evaluation of continued use of stream water for once-through power plant cooling. For this purpose, some characteristic of the streams examined needed to be chosen as indicative of the cooling capacity of each stream. The minimum monthly average flow recorded in a ten year period was selected. Using this flow, rather than, say, the average low month flow, yields a more conservative estimate of the cooling capacity for the stream. For some streams, low flows such as those tabulated may occur nearly every year. Other streams will have greater fluctuations in their annual minimum monthly average flows. For comparison purposes, the annual low month average flows for the three major rivers are shown (Figure 1). The river flow tabulated in this study occurs about 1% (30/3650) of the time.

There will be a difference between cooling capacity as determined in an overall survey and that which would be found if the situation for each stream were examined in detail. A more rigorous treatment than is appropriate for a broad study such as this would be needed to precisely determine each stream's ultimate cooling capacity. Plant operating schedules, reservoirs, specific plant locations, and evaporation would need to be examined. Evaporation will increase the cooling capacity of a stream considerably, particularly when the water temperature is fairly high. Alternate methods of supplying cooling water for some part of the year would also make available a larger once-through cooling capacity than a first

FIGURE I ANNUAL LOW MONTH AVERAGE STREAM FLOW

examination might reveal. This study does, however, supply some perspective on the future national and regional situation. Although an allowance was made for evaporation effects in streams, the results are conservative estimates of the available cooling capacity in that they neglect the other factors. However, they do permit some general observations to be made as to the future need to consider alternatives to once-through cooling.

This study has not been directed at any near term siting situations, and attempts only to assess the constraints to be anticipated in meeting future power demands.

Alternate systems presently available to supply cooling include: cooling ponds, spray ponds, induced or forced draft evaporative cooling towers, natural draft evaporative cooling towers and dry cooling towers. Each of these systems has advantages and disadvantages and the most attractive choice depends on a large number of characteristics of the power plant location. We have not attempted to evaluate any of these systems, only to identify where their use is most likely to become necessary.

WATER QUALITY STANDARDS

The federal government, realizing in the last few years that the waste absorbing capacity of our environment is not limitless, has started on a program to improve the way we use our environment. The federal efforts

yielded air and water quality legislation which has generally encouraged state governments to pass control legislation meeting federal guidelines. Since many of the rivers flow between states or form state boundaries, the federal government has required federal approval of water quality standards for these interstate waters. Coastal waters also come under federal jurisdiction. The federal guidelines for state water quality standards form Appendix II of this report.

State water quality standards typically specify both a maximum stream temperature and a maximum allowable temperature increase. The temperatures selected depend on the biological community living in the stream as well as the anticipated human use. If the stream supports a cold water fishery, the regulations are generally quite restrictive, permitting maximum temperatures on the order of 65-70 °F. If the stream has only warm water fish, the temperatures permitted are on the order of 90 °F. Various classes of streams range between these extremes. These maximum permitted stream temperatures generally approach the stream temperatures already occurring for some portion of the year.

Of the state regulations examined, some have general statements which may be even more restrictive. The federal regulations for interstate waters also have these general statements, that is, requiring that no pollution which could be eliminated will be permitted and no degradation of water quality below the present level will be accepted. Standards also

typically require all technically available and reasonable methods of treatment. It has not been determined how such general statements will pertain to temperature increase when the standards are applied by the states and federal government.

The temperature restrictions in water quality standards are based on the knowledge that temperatures above that to which a given species is acclimated will not be beneficial unless the new temperature is nearer the optimum for the species. Each species has an optimum temperature and a change in temperature can be expected to lead to a decline in one species in favor of another. The changes can be rapid or can occur over fairly long intervals affecting the species by subtle ways such as decreasing the ability to reproduce. Water quality standards presently tend to be restrictive due to the desire to eliminate trends which could alter the existing aquatic communities.

At this writing, most states have completed federally acceptable water quality standards; the remainder are in the final stages of finishing the standards or obtaining federal approval.

RESULTS

We have accumulated stream flow and temperature data for all rivers in the U.S. with minimum monthly average flows greater than 1000 cfs (cubic feet per second). In Appendix I, we have tabulated the minimum monthly average stream flows recorded in a ten-year period for each month of the year (1, 2, 3, 4). Where available, the maximum monthly average temperature

recorded is included. These two figures do not necessarily correspond to the same month in the ten year period. We have also converted stream flow to megawatts of heat required for a one degree F temperature rise. In accumulating totals for each region of the country (Table I), when the maximum temperature and minimum stream flow occurred at greatly different parts of the year a stream flow corresponding to the high temperature was used when it appeared to be more indicative of a limiting condition.

River data were accumulated for the gauging station nearest the river mouth. For some rivers, the flows from a gauging station upstream and its tributaries were combined. The regions selected were based on USGS river basins to help eliminate problems in deciding which region a river was in. The Mississippi is the only river which flows between regions. In this case, part of the flow is credited to the upper region; the major tributaries all are credited to the region in which they are found; and the flow credited to the lower Mississippi is the difference between the total flow at the mouth and the flows credited to other rivers. The flow for the lower Mississippi does not include the contribution from the Upper Mississippi.

The limiting condition on permissible heat input obtained by combining the tabulated figures (Appendix I) with maximum permitted temperatures is not the actual way the limit will be realized. The effect

of a power plant will be a local temperature increase which will diminish with distance downstream. Evaporation will occur and tend to increase cooling capacity over that suggested by the data in Appendix I. The effect of evaporation will decrease with distance downstream due to the decreased temperature difference between the stream and the air. The contribution which has not been eliminated when combined with the contribution from the other plants downstream is the condition which will have the most important effect on the stream. Only a detailed analysis, such as found in the system being used at Battelle-Northwest^(5, 6), could predict the combined effect of the many variables. However, in the absence of results of such a study for all major streams, an estimated four-fold increase in cooling capacity for a given stream temperature rise has been assumed. The factor of 4 was obtained by considering an example stream as a series of fully mixed cooling ponds.

Our general conclusion, from observing stream data and projected power requirements, is that evaporative cooling of some type will be needed for many future power plants. The availability of makeup water, the meteorological conditions, and the tradeoff between capital and operating costs will decide which type of cooling system is best suited for a particular application. The use of evaporative cooling will introduce some siting flexibility as a factor to help reduce the cost of the cooling facilities.

There does not appear to be a major difference, among regions, in the time of year at which a critical situation occurs for cooling water supply. Early fall appears to be the critical time when the high temperature-low flow combination occurs. Some rivers have lower flows at other times, but with low water temperatures.

REGIONAL OBSERVATIONS

Some regions of the country are more limited by cooling water availability than others. For a regional examination of cooling water availability the country has been divided into nine sections as shown on Figure 2. These regions are based on the USGS watershed divisions of the country. An approximate maximum temperature as well as an index of cooling water availability is included in Table I. The index of cooling water availability is based on the low monthly average flow recorded in a ten year period. The index is obtained by converting the stream flow to the amount of heat which is required to raise the stream temperature 1 °F. No evaporative dissipation was assumed. Only streams with minimum monthly average flows greater than 1000 cfs are considered.

Dividing the heat rejection required to meet the power demand, Table II, by the cooling potential index and allowing for the effect of evaporation for each region would yield a temperature rise value. This value gives some impression of the cooling water supply in a region. One should realize, however, that some of the streams are not close to load centers or may be unsuitable power plant sites for other reasons. Since

FIGURE 2

REGIONAL DIVISIONS

TABLE I

REGIONAL SUMMARY OF STREAM CHARACTERISTICS

<u>Region</u>	<u>Heat Addition to Raise Water Temperature 1 °F*, Assuming No Dissipation to Atmosphere Gigawatts_t</u>	<u>Heat Addition to Raise Water Temperature 1 °F Assuming 4-Fold Capacity Increase Due to Dissipation to the Atmosphere Gigawatts_t</u>	<u>Indicated Stream Temperature, Change, Between 1965 and 1980 Assuming Dissipation to Atmosphere** °F</u>	<u>Range Of*** Existing Maximum Stream Temperature °F</u>
1	6.91	27.64	1.4	60-75
2	1.45	5.80	12	70-85
3	2.74	10.96	2.4	80-85
4	6.09	24.36	3	85-90
5	1.14	4.56	10.5	70-80
6	2.15	8.60	13	80-85
7	1.92	7.68	11	75-85
8	1.59	6.36	12	70-85
9	15.12	60.48	0.5	70-75

* Based on minimum monthly average stream flow recorded in a ten-year period.

** (1980 Peak Load-1965 Peak Load) Heat Rejection Divided by Heat Addition per degree F, assuming dissipation to atmosphere.

*** Maximum monthly average temperatures, range found in various streams of the region.

TABLE II
REGIONAL SUMMARY OF POWER GENERATION FORECASTS

<u>Region</u>	<u>1965 Peak Load*</u> <u>(Gigawatts_e)</u>	<u>1980 Peak Load*</u> <u>(Gigawatts_e)</u>	<u>Additional Heat Rejection</u> <u>Due to Load Increase</u> <u>Between 1965 and 1980**</u> <u>(Gigawatts_t)</u>
1	13	34	39
2	22	59	69
3	10	24	26
4	23	63	74
5	18	44	48
6	43	102	110
7	23	69	85
8	31	71	74
9	14	32	33

* Based on Federal Power Commission National Power Survey, 1964 (7).

** Assumes system efficiency of 35%.

the future power demand appears to greatly outweigh the potentially available cooling water, these qualitative regional forecast observations can be made with confidence.

Region 1

Nearly all streams in the Pacific Northwest support populations of trout or salmon. Because these fish seem to live in relatively low water temperatures, maximums of 68 °F have been established in the water quality standards in Oregon, Washington, and Idaho. Oregon standards permit a 2 °F temperature rise as long as the resulting temperature is below 68 °F from the total of all the sources on the river. Washington has a sliding scale; the permitted increase by all sources is $t = 110 / (T - 15)$ where T represents the resulting water temperature. Many streams in this area presently exceed this maximum temperature during part of the year. Some limited once-through cooling in the near term can be anticipated for this region. Plant operation with a shutdown for refueling coinciding with high water temperatures may be used for some plants. Only a small portion of the physically or economically limited cooling capacity of the streams in this region will probably be used because of the effect it might have on the other uses of the rivers. This region has many miles of seacoast and some plants using salt water can be expected. Compared to most regions of the country, this area is well supplied with cooling water because of the seacoast in proximity to load centers.

Region 2

The Pacific Southwest has already found uses for most of the readily available water for irrigation, domestic uses, and industry. Some streams in the area are already being stored and directed to the parts of the region where needed through diversion systems. Power plants in this area can be expected to use coastal sites wherever possible. Due to the generally unfavorable terrain, seismic conditions, and high population pressure for land use along the coast, power plant siting will probably become difficult in this region. Warm water irrigation may be an appealing dual use for some of the water supply. Desalination plants could be expected to help better utilize the waste heat as well as supplying some water needs if improvements are made on the cost of these plants.

Region 3

Region 3 has low estimated power demands as well as less restrictive water quality legislation (based on the water quality standards of North and South Dakota which limit maximum water temperature to 90 °F). Power production installed in this area probably will use once-through cooling for longer than other regions. The supply is limited, however, and it is the low estimated demand rather than a large supply which makes this region less in need of alternate cooling means than other areas.

Region 4

The only adequate size surface water supply is in four small rivers and the Mississippi. Since the aquatic life is of a warm water variety,

use of the surface water cooling capacity can be expected. When the location of the water supply is compared to the power demand some alternate cooling methods will probably be used.

Ground water presently fills a large part of the water requirements in this region. In Texas, for example, 54 percent of the total water use is now met with ground water.⁽⁸⁾ Use of ground water for makeup water would give some siting flexibility. Water from the Gulf of Mexico may also be used in meeting cooling requirements. Since the available surface water is in the eastern part of the region, the future cooling needs of the western and southern parts will have to be met by salt water or evaporative cooling.

Region 5

The proximity of this region to the Great Lakes makes prediction of water use trends more uncertain. The river waters in this region presently become quite warm in summer months and in order to supply the cooling capacity required, in all but the near term, the use of evaporative systems will probably be required. This region will import some power, as it now does, from power plants utilizing water from the Great Lakes, either as once-through cooling or makeup water.

Region 6

This region, being rich in coal, will have a large use of mine-mouth coal fired plants. These plants generally have cooling water problems

since the plant site is decided by the fuel source and siting near a water supply must be secondary. Mine-mouth plants are already using evaporative cooling methods and their problem becomes one of finding a sufficient makeup water supply nearby. Evaporative cooling can be expected to be used extensively in this region. What cooling capacity is available will be utilized up to the legal limits, but the economics of the mine-mouth plant introduces evaporative cooling sooner than when required solely to satisfy water quality standards.

Region 7

The power demands in this region are growing faster than in other regions. This region has 10 streams, but all of relatively small size. The combination of growing power requirements and limited cooling, as throughout the country, will influence power suppliers in this region to consider evaporative cooling. Coastal sites may provide some cooling capacity, but other uses of coastal areas may limit the use of sea water.

Region 8

In region 8, the Eastern Seaboard, siting of power plants will become relatively difficult due to population pressures along the sea coast where cooling water is available. One third of the fresh water credited to this region is in Maine, away from the load centers. The fresh water in the remainder of the region is nearly fully utilized and alternate cooling methods are to be expected in the not too distant future. The

cold winters and humid climate in this region, depending on plant siting, may require the conservative design of evaporative cooling facilities to minimize fog problems from large power plants. This region of the country, due to population density and present utilization of the waters would appear to require the use of alternate methods to once-through cooling for most of the future power production facilities.

Region 9

Region 9, which includes the Great Lakes and the Saint Lawrence River, can be expected to export power to the surrounding industrial regions, since the cooling capacity of these waters is very large. Use of the Great Lakes and the St. Lawrence river falls under the Federal Water Pollution Control Administration jurisdiction, since these are international waters. How the laws are interpreted with respect to localized thermal effects will determine how extensively the capacity of these lakes can be used for cooling purposes. The effect a given plant will have on a lake is complex and dependent on currents and outfall design as well as temperatures and meteorological conditions. Some of the lakes presently have a pollution problem and a considerable amount of effort is being expended to define the problem and determine required abatement practices. In addition, strong efforts are being made to reintroduce salmon and other cold water fish into some of the Great Lakes. The index for stream flow is not in itself an adequate indication of heat rejection capability in this region, because of the presence of the lakes, which were not taken into account in this survey.

DISCUSSION

The river data accumulated has permitted some qualitative observations to be made concerning the future availability of once-through cooling water. In accumulating and summarizing the data some additional points of interest have become apparent:

1. River data, particularly temperature data, are minimal for meeting data needs for future studies.
2. The effect of heat addition on lakes and the oceans, and heated water plume behavior in these bodies of water will become increasingly important in the future.
3. A mathematical model, as has been developed by BNW^(5, 6), needs to be applied on a watershed basis to suggest power plant sites which will best utilize the available resources. This watershed wide analysis would determine more qualitatively the magnitude of the resources available, and provide guidance for specific site evaluations.

In setting pollution standards it is usually not possible for the regulating body to clearly see the sensitivity of cost (to the public) to the level of regulation. A detailed modeling of river systems will help in finding the approximate sensitivity of power cost to permitted temperature levels.

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APPENDIX A

STREAM FLOW - TEMPERATURE DATA

APPENDIX A

REGION 1

Columbia River
 (minus major tributaries)
Columbia River (total)
Cowlitz River

Deschutes River
Kootenai River
Pend Oreille River

Rogue River
Skagit River
Snake River

Snohomish River
Spokane River
Willamette River

Yakima River

REGION 2

Colorado River
Klamath River
Sacramento River

REGION 3

Missouri River

REGION 4

Arkansas River
Mississippi River
 (minus major tributaries)
Mississippi River (total)

Red River
White River
Yazoo River

REGION 5

Chippewa River
Illinois River
Mississippi River (upper)

Rock River
St. Croix River
Wisconsin River

REGION 6

Cumberland River
Ohio River
Tennessee River

Wabash River

REGION 7

Alabama River
Altamaha River
Apalachicola River

Choctawhatchee River
Congaree River
Pearl River

Pee Dee River
Savannah River
Suwannee River

Roanoke River

REGION 8

Androscoggin River
Connecticut River
Delaware River

Hudson River
Kennebec River
Merrimack River

Penobscot River
Potomac River
St. John River

Susquehanna River

REGION 9

Black River
Manistee River
Menominee River

Oswego River
St. Joseph River
St. Lawrence River

ALASKA

Copper River
Kuskokwin River
Newhalen River

Nuyakuk River
Yukon River

REGION 1

COLUMBIA RIVER

@ Mouth, minus major tributaries

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	46,110	3,034
November	39,660	2,610
December	41,270	2,716
January	66,780	4,395
February	82,830	5,451
March	88,670	5,836
April	86,030	5,662
May	63,710	4,193
June	237,090	15,605
July	144,680	9,523
August	89,770	5,908
September	61,990	4,080

COLUMBIA RIVER

@ Mouth - Total

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	100,960	6,645	62
November	99,410	6,542	53
December	116,060	7,638	46
January	149,590	9,846	41
February	171,260	11,272	45
March	182,660	12,022	45
April	214,660	14,128	51
May	280,080	18,434	57
June	457,450	30,108	63
July	227,910	15,000	69
August	139,770	9,199	72
September	112,350	7,395	68

COWLITZ RIVER

Castle Rock, Washington

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,360	89	54
November	1,300	85	47
December	3,590	236	44
January	5,780	380	43
February	7,390	486	45
March	7,110	467	46
April	8,630	567	49
May	11,880	782	53
June	7,220	475	59
July	3,380	222	69
August	2,240	147	70
September	1,690	111	63

DESCHUTES RIVER

Biggs, Oregon

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	4,470	294	55
November	4,830	318	50
December	4,920	324	45
January	5,010	329	44
February	5,520	363	48
March	5,330	350	49
April	5,500	362	54
May	5,420	356	62
June	4,970	327	65
July	4,490	295	69
August	4,340	286	67
September	4,230	278	63

KOOTENAI RIVER

Porthill, Idaho

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	5,200	342
November	3,950	260
December	3,370	222
January	3,000	197
February	3,570	235
March	3,770	248
April	7,842	516
May	31,270	2,058
June	35,220	2,318
July	15,820	1,041
August	7,920	521
September	5,470	360

PEND OREILLE RIVER

Metaline Falls, Washington

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	12,440	818
November	19,620	1,291
December	16,260	1,070
January	13,760	905
February	13,830	910
March	16,280	1,071
April	17,400	1,145
May	37,890	2,493
June	50,080	3,296
July	20,030	1,318
August	8,620	567
September	10,650	701

ROGUE RIVER

@ Mouth, Oregon

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,660	109	55
November	1,770	116	50
December	2,300	151	45
January	4,300	283	44
February	8,350	549	48
March	6,470	425	49
April	6,120	402	54
May	4,420	290	59
June	2,380	156	67
July	1,290	85	74
August	1,040	68	76
September	1,020	67	70

SKAGIT RIVER

Mount Vernon, Washington

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	6,900	454
November	7,250	477
December	8,420	554
January	9,540	628
February	10,500	691
March	9,190	605
April	11,600	763
May	17,250	1,135
June	18,810	1,238
July	14,240	937
August	7,680	505
September	6,640	437

SNAKE RIVER

Clarkston, Washington

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	22,110	1,455	60
November	20,670	1,360	60
December	22,200	1,461	43
January	22,050	1,451	39
February	20,780	1,367	41
March	23,330	1,535	46
April	51,980	3,421	53
May	94,560	6,223	55
June	102,500	6,746	64
July	29,530	1,943	74
August	19,210	1,264	75
September	20,070	1,321	70

SNOHOMISH RIVER

Snohomish, Washington

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,090	71
November	1,450	95
December	4,020	264
January	2,960	195
February	4,150	272
March	4,100	269
April	7,870	518
May	10,840	713
June	7,100	467
July	2,400	158
August	1,280	84
September	1,360	89

SPOKANE RIVER

Longlake, Washington

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	2,580	169
November	2,980	196
December	3,270	215
January	5,110	336
February	4,660	307
March	4,690	308
April	8,760	576
May	17,800	1,171
June	7,540	496
July	2,660	175
August	1,650	108
September	1,770	116

WILLAMETTE RIVER

@ Mouth, Oregon

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	4,720	310	57
November	4,540	299	51
December	19,500	1,283	47
January	25,980	1,710	45
February	30,240	1,990	47
March	31,610	2,080	48
April	26,520	1,745	53
May	14,300	941	62
June	10,220	673	66
July	6,080	400	71
August	4,590	302	68
September	4,720	310	65

YAKIMA RIVER

Kiona, Washington

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,980	130	57
November	1,840	121	48
December	1,680	110	42
January	2,120	139	40
February	2,430	160	46
March	1,880	123	49
April	2,000	131	56
May	3,250	213	62
June	2,610	171	71
July	1,220	80	78
August	1,440	94	76
September	1,760	116	68

REGION 2

COLORADO RIVER

Imperial Dam. California - Arizona

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	7,790	512	74
November	5,770	379	65
December	4,430	291	55
January	4,190	276	53
February	5,650	372	60
March	8,460	556	61
April	10,860	714	69
May	9,450	622	78
June	10,930	719	80
July	12,240	805	85
August	11,660	767	86
September	9,810	645	82

KLAMATH RIVER

Klamath, California

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. Of Stream 1 °F - MW_t</u>
October	3,150	207
November	3,500	230
December	4,140	272
January	7,620	501
February	12,100	796
March	11,420	751
April	14,930	982
May	13,570	893
June	7,480	492
July	3,910	257
August	2,580	169
September	2,490	164

SACRAMENTO RIVER

Sacramento, California

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	7,910	520	64
November	7,340	483	56
December	7,210	474	52
January	11,090	729	49
February	17,860	1,175	53
March	15,110	994	55
April	13,650	898	62
May	11,410	751	65
June	8,020	527	73
July	8,100	533	73
August	8,740	575	73
September	9,650	635	70

REGION 3

MISSOURI RIVER

Hermann, Missouri

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	32,990	2,171	67
November	20,900	1,375	50
December	15,650	1,030	39
January	16,070	1,057	39
February	18,870	1,242	40
March	28,140	1,852	44
April	36,490	2,401	61
May	42,840	2,819	71
June	42,830	2,819	82
July	41,680	2,743	85
August	43,050	2,833	82
September	36,020	2,370	77

REGION 4

ARKANSAS RIVER

Little Rock, Arkansas

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,170	76	70
November	1,760	115	58
December	3,890	256	49
January	5,480	360	43
February	13,950	918	51
March	6,830	449	57
April	9,240	608	67
May	14,370	945	80
June	8,830	581	84
July	4,030	265	87
August	2,790	183	86
September	1,360	89	79

MISSISSIPPI RIVER

@ Mouth, minus major tributaries

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	55,390	3,645
November	52,940	3,484
December	54,540	3,589
January	18,560	1,221
February	160,240	10,547
March	57,470	3,782
April	66,730	4,392
May	268,160	17,649
June	167,810	11,045
July	148,260	9,758
August	80,100	5,272
September	59,410	3,910

MISSISSIPPI RIVER

@ Mouth, total

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	146,400	9,636	75
November	143,400	9,438	63
December	175,800	11,571	53
January	156,300	10,287	46
February	430,400	28,328	48
March	384,400	25,300	52
April	424,700	27,953	62
May	565,800	37,240	74
June	386,500	25,439	81
July	305,500	20,107	87
August	217,800	14,335	87
September	167,400	11,018	83

RED RIVER

Alexandria, Louisiana

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,600	105	78
November	1,620	106	70
December	3,280	216	59
January	6,230	409	54
February	24,780	1,631	58
March	11,320	745	60
April	15,850	1,043	67
May	20,210	1,330	81
June	6,460	425	84
July	3,040	200	87
August	2,330	153	87
September	1,850	122	82

WHITE RIVER

DeValls Bluff, Arkansas

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	3,720	244	69
November	3,830	252	58
December	5,260	346	51
January	7,820	514	44
February	12,410	816	50
March	14,050	924	56
April	16,310	1,073	66
May	18,180	1,196	75
June	11,380	749	80
July	7,820	514	84
August	7,110	468	84
September	4,280	281	78

YA200 RIVER

Greenwood, Mississippi

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	900	59
November	1,090	71
December	1,640	108
January	2,830	186
February	7,130	469
March	7,550	496
April	4,600	303
May	6,180	406
June	6,300	414
July	3,050	200
August	2,010	132
September	1,620	106

REGION 5

CHIPPEWA RIVER

Durand, Wisconsin

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	2,760	181
November	2,800	184
December	3,100	203
January	2,900	190
February	3,220	212
March	4,180	275
April	6,570	432
May	4,710	310
June	4,420	290
July	4,520	297
August	3,750	247
September	3,930	259

ILLINOIS RIVER

Meredosia, Illinois

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	4,520	297
November	5,520	363
December	6,940	456
January	6,470	426
February	8,750	576
March	12,380	814
April	10,010	658
May	11,930	785
June	15,640	1,029
July	9,560	629
August	8,030	528
September	6,180	406

MISSISSIPPI RIVER

St. Paul, Minnesota

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	3,270	215	63
November	3,770	248	46
December	2,870	188	40
January	2,250	148	37
February	1,980	130	38
March	3,120	205	41
April	4,610	303	50
May	7,410	487	62
June	7,260	478	72
July	6,030	396	79
August	3,300	217	82
September	4,750	312	73

ROCK RIVER

Joslin, Illinois

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,380	90	61
November	1,860	122	45
December	1,520	100	36
January	1,260	82	35
February	2,270	149	35
March	2,800	184	42
April	4,470	294	53
May	2,030	133	66
June	2,700	177	76
July	2,540	167	80
August	1,350	88	78
September	1,080	71	70

ST. CROIX RIVER

St. Croix Falls, Wisconsin

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	2,460	162
November	2,290	150
December	1,900	125
January	1,700	111
February	1,650	108
March	2,100	138
April	2,900	191
May	3,130	206
June	3,870	254
July	2,360	155
August	2,070	136
September	2,490	163

WISCONSIN RIVER

Muscoda, Wisconsin

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	3,520	231
November	4,010	263
December	4,120	271
January	4,190	275
February	4,470	294
March	6,090	400
April	6,520	429
May	5,650	372
June	5,440	358
July	4,550	299
August	3,320	218
September	3,590	236

REGION 6

CUMBERLAND RIVER

Dover, Tennessee

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	2,610	172	68
November	3,260	214	56
December	9,540	628	50
January	13,700	901	44
February	24,280	1,598	48
March	21,020	1,383	50
April	26,100	1,717	58
May	13,060	859	70
June	9,430	620	77
July	4,340	285	81
August	3,880	255	81
September	3,390	223	76

OHIO RIVER

Evansville, Indiana

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	7,520	495	68
November	9,630	634	57
December	24,130	1,588	46
January	32,350	2,129	41
February	66,180	4,355	43
March	144,100	9,484	47
April	158,900	10,458	58
May	105,800	6,963	73
June	50,670	3,335	79
July	28,610	1,883	84
August	20,140	1,325	82
September	10,830	712	78

TENNESSEE RIVER

Paducah, Kentucky

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	20,020	1,317	69
November	25,410	1,672	57
December	34,450	2,267	48
January	30,800	2,027	42
February	73,850	4,860	51
March	54,610	3,594	51
April	35,940	2,365	59
May	30,890	2,033	71
June	33,850	2,228	79
July	31,270	2,058	83
August	31,090	2,046	84
September	23,580	1,552	79

WABASH RIVER

Mount Carmel, Illinois

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	2,560	168	66
November	2,700	177	52
December	2,970	195	46
January	3,740	246	41
February	6,360	418	43
March	8,640	568	52
April	19,450	1,280	61
May	11,240	739	69
June	9,600	631	75
July	3,840	252	80
August	3,460	227	82
September	3,030	199	74

REGION 7

ALABAMA RIVER

Claiborne, Florida

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	6,130	403
November	6,820	448
December	7,980	525
January	9,110	599
February	33,720	2,219
March	30,330	1,996
April	33,460	2,202
May	16,710	1,099
June	11,140	733
July	7,740	509
August	7,690	506
September	7,060	464

ALTAMAHA RIVER

Doctortown, Georgia

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,750	115
November	1,790	117
December	2,690	177
January	4,050	266
February	10,350	681
March	7,030	463
April	9,870	649
May	5,330	350
June	3,620	238
July	2,690	177
August	2,400	158
September	2,150	141

APALACHICOLA RIVER

Chattahoochee, Florida

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	5,320	350
November	5,910	389
December	7,990	526
January	7,260	478
February	13,210	869
March	12,780	841
April	19,330	1,272
May	12,210	803
June	7,890	519
July	9,270	610
August	7,010	461
September	6,090	401

CHOCTAWHATCHEE RIVER

Bruce, Florida

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,580	104
November	1,740	114
December	1,940	128
January	2,340	154
February	3,900	256
March	2,530	166
April	4,770	313
May	2,780	183
June	2,490	164
July	2,350	155
August	1,860	122
September	1,670	109

CONGAREE RIVER

Columbia, South Carolina

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,960	129
November	2,460	162
December	1,940	128
January	2,970	195
February	4,290	282
March	4,070	268
April	4,830	317
May	3,620	238
June	2,590	170
July	2,570	169
August	2,970	195
September	2,200	145

PEARL RIVER

Bogalusa, Louisiana

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,190	78
November	1,320	87
December	1,710	112
January	2,170	143
February	7,270	478
March	5,270	347
April	7,220	475
May	4,410	290
June	2,270	149
July	1,770	116
August	1,510	99
September	1,250	82

PEE DEE RIVER

Peedee, South Carolina

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	2,120	139	66
November	2,240	147	56
December	3,790	249	48
January	3,270	215	41
February	6,530	429	40
March	8,220	541	46
April	8,180	538	56
May	5,540	364	68
June	3,390	223	77
July	2,900	190	81
August	1,980	130	82
September	1,380	90	76

SAVANNAH RIVER

Clyo, Georgia

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	4,210	276	71
November	5,330	350	67
December	5,260	346	57
January	5,850	385	54
February	7,320	481	58
March	7,050	464	58
April	9,750	641	66
May	6,770	445	73
June	5,840	384	77
July	4,640	305	81
August	4,790	315	80
September	4,210	277	79

SUWANNEE RIVER

Wilcox, Florida

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	4,240	279
November	3,720	244
December	3,580	235
January	3,610	237
February	3,600	237
March	3,800	249
April	4,630	304
May	4,420	291
June	4,170	274
July	4,100	270
August	3,960	260
September	4,120	271

ROANOKE RIVER

Scotland Neck, North Carolina

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,730	113	66
November	2,450	161	59
December	4,400	289	52
January	5,100	335	43
February	4,410	290	47
March	6,340	417	51
April	7,470	491	60
May	5,520	363	69
June	2,960	195	74
July	2,350	154	81
August	3,350	220	81
September	2,000	131	78

REGION 8ANDROSCOGGIN RIVER

Auburn, Maine

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	2,120	139
November	1,900	125
December	2,320	153
January	3,030	199
February	3,330	219
March	3,320	218
April	7,660	504
May	5,420	356
June	3,130	206
July	2,620	172
August	2,270	149
September	2,280	150

CONNECTICUT RIVER

Thompsonville, Connecticut

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	3,740	246
November	5,620	370
December	9,520	626
January	8,020	528
February	9,690	638
March	12,420	817
April	24,820	1,633
May	14,240	937
June	6,860	451
July	3,540	233
August	3,230	212
September	2,800	184

DELAWARE RIVER

Trenton, New Jersey

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	2,410	158	62
November	3,900	257	53
December	7,740	509	42
January	7,520	494	38
February	8,880	584	39
March	8,780	578	43
April	13,110	863	59
May	6,460	425	68
June	4,300	282	83
July	2,080	137	85
August	1,830	120	82
September	2,250	148	77

HUDSON RIVER

Green Island, New York

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	4,500	296	60
November	4,840	318	48
December	9,500	625	36
January	9,600	631	33
February	8,400	552	33
March	12,660	833	37
April	15,730	1,035	47
May	9,700	638	62
June	5,360	353	73
July	4,090	269	75
August	3,800	250	76
September	3,990	263	69

KENNEBEC RIVER

Waterville, Maine

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	3,190	210
November	2,800	184
December	4,700	309
January	4,130	271
February	4,880	321
March	5,880	386
April	12,000	789
May	8,840	582
June	4,270	280
July	3,310	217
August	3,680	242
September	3,060	201

MERRIMACK RIVER

Lowell, Massachusetts

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,290	84
November	2,140	140
December	4,420	290
January	4,260	280
February	4,490	295
March	7,500	493
April	9,410	619
May	4,790	315
June	2,390	157
July	1,710	112
August	1,200	78
September	900	59

PENOBSCOT RIVER

Passadumkeag, Maine

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	4,270	281
November	4,990	328
December	6,290	414
January	6,510	428
February	5,660	372
March	5,850	384
April	17,860	1,175
May	13,060	859
June	6,000	395
July	4,850	319
August	4,510	297
September	4,410	290

POTOMAC RIVER

Washington, D.C.

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,230	81	64
November	1,790	118	51
December	2,240	147	41
January	2,530	166	35
February	4,540	298	40
March	8,950	589	46
April	8,570	564	56
May	7,200	473	71
June	5,810	382	79
July	2,040	134	84
August	1,160	76	82
September	1,320	87	77

ST. JOHN RIVER

Fort Kent, Maine

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,410	92
November	2,080	136
December	1,230	81
January	1,370	90
February	1,030	67
March	880	58
April	9,570	630
May	18,890	1,243
June	5,370	353
July	2,930	192
August	1,040	68
September	1,100	72

SUSQUEHANA RIVER

Marietta, Pennsylvania

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	3,680	242	61
November	7,960	523	48
December	19,440	1,279	40
January	14,120	929	35
February	23,260	1,531	38
March	28,120	1,850	42
April	43,010	2,831	51
May	21,020	1,383	68
June	12,420	817	76
July	5,520	363	78
August	4,570	300	78
September	4,100	269	72

REGION 9BLACK RIVER

Watertown, New York

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,510	99	55
November	1,940	127	43
December	2,530	166	37
January	1,470	96	35
February	1,390	91	34
March	2,620	172	35
April	5,490	361	45
May	2,820	185	57
June	1,780	117	71
July	1,350	89	75
August	1,160	76	72
September	1,250	82	65

MANISTEE RIVER

Manistee, Michigan

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,530	100	51
November	1,610	106	42
December	1,640	108	36
January	1,620	107	34
February	1,610	106	34
March	1,770	116	43
April	2,050	135	51
May	1,530	100	61
June	1,510	99	67
July	1,460	96	70
August	1,340	88	67
September	1,470	97	59

MENOMINEE RIVER

McAllister, Wisconsin

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,550	101
November	1,780	117
December	1,840	120
January	1,730	113
February	1,600	105
March	1,900	124
April	4,530	298
May	2,610	171
June	2,270	149
July	1,620	106
August	1,380	90
September	1,420	93

OSWEGO RIVER

Oswego, New York

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	1,500	98	57
November	1,790	117	46
December	5,120	337	38
January	3,070	201	34
February	5,490	361	35
March	8,710	573	39
April	7,920	521	48
May	2,790	183	62
June	2,190	144	73
July	1,730	114	75
August	1,450	95	74
September	1,580	103	68

ST. JOSEPH RIVER

Berrien Springs, Michigan

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	1,460	96
November	1,620	106
December	1,810	119
January	1,800	118
February	3,120	205
March	4,140	272
April	3,710	244
May	3,440	226
June	2,220	146
July	1,680	110
August	1,880	124
September	1,460	96

ST. LAWRENCE RIVER

Ogdensburg, New York

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>	<u>Maximum Monthly Average Stream Temp. - °F</u>
October	209,000	13,756	61
November	207,000	13,624	51
December	209,000	13,756	40
January	178,000	11,715	34
February	190,000	12,505	32
March	203,000	13,361	32
April	230,000	15,138	39
May	229,000	15,072	50
June	230,000	15,138	61
July	227,000	14,941	67
August	223,000	14,677	71
September	219,000	14,414	66

ALASKA

COPPER RIVER

Chitina, Alaska

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	14,200	934
November	6,000	394
December	4,400	289
January	2,700	177
February	2,300	151
March	2,000	131
April	3,000	197
May	21,780	1,433
June	58,350	3,840
July	98,480	6,481
August	82,630	5,438
September	42,130	2,773

KUSKOKWIM RIVER

Crooked Creek, Alaska

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	29,570	1,946
November	14,000	921
December	10,000	658
January	9,300	612
February	9,600	631
March	7,600	500
April	8,600	566
May	28,550	1,879
June	33,880	2,230
July	44,060	2,900
August	41,840	2,753
September	49,100	3,231

NEWHALEN RIVER

Iliamna, Alaska

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	8,670	571
November	3,400	223
December	1,800	118
January	1,200	79
February	1,000	65
March	1,000	65
April	1,200	79
May	2,980	196
June	10,130	666
July	16,050	1,056
August	17,240	1,134
September	13,760	905

NUYAKUK RIVER

Dillingham, Alaska

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	5,060	333
November	3,330	219
December	2,400	158
January	1,800	118
February	1,400	92
March	1,300	85
April	800	52
May	3,300	217
June	10,360	681
July	6,790	447
August	3,850	253
September	5,270	347

YUKON RIVER

Kaltag, Alaska

<u>Month</u>	<u>Low Monthly Average Flow cfs</u>	<u>Heat Required To Raise Temp. of Stream 1 °F - MW_t</u>
October	113,100	7,444
November	58,000	3,817
December	39,420	2,594
January	38,610	2,541
February	32,000	2,106
March	20,000	1,316
April	21,500	1,415
May	190,000	12,505
June	425,100	27,979
July	296,700	19,528
August	281,400	18,521
September	230,100	15,145

APPENDIX B

FEDERAL GUIDELINES FOR ESTABLISHING WATER QUALITY

STANDARDS FOR INTERSTATE WATERS

APPENDIX B

FEDERAL GUIDELINES FOR ESTABLISHING WATER QUALITY
STANDARDS FOR INTERSTATE WATERS *

"1. Water quality standards should be designed to 'enhance the quality of water.' If it is impossible to provide for prompt improvement in water quality at the time initial standards are set, the standards should be designed to prevent any increase in pollution. In no case will standards providing for less than existing water quality be acceptable.

"2. No standards of water quality will be approved which provide for the use of any stream or portion thereof for the sole or principal purpose of transporting wastes.

"3. Water quality criteria should be applied to the stream or other receiving water or portions thereof. The criteria should identify the water uses to be protected and establish limits on pollutants or effects of pollution necessary to provide for such uses. Numerical values should be stated for such quality characteristics where such values are available. Where appropriate, biological or bioassay parameters may be used. In the absence of appropriate numerical values or biological parameters, criteria should consist of verbal descriptions in sufficient detail as to show clearly the quality of water intended (e.g., 'substantially free from oil').

"4. The measure of time period and limiting values which will govern for purposes of the criteria should be defined (e.g., annual arithmetic mean concentration, single daily maximum concentration). Where appropriate, the specified recurrence and duration of the accepted design stream-flow should be defined (e.g., 25-year recurrence of minimum lowflow of 10-day duration).

"5. Water quality criteria should be accompanied by a description of present water quality and uses, together with uses expected in the future and the water quality required to make those uses possible. The water quality standards proposed by a State should provide for:

- (a) Potential and future water uses as well as the present intended use and uses;

* From: Public Hearing Information Bulletin on Proposed Water Quality Standards for Waters of Puget Sound South of the Tacoma Narrows. Washington State Pollution Control Commission. Olympia, Washington, January 5, 1967.

- (b) The upgrading and enhancement of water quality and the use or uses of streams or portions thereof that are presently affected by pollution;
- (c) The maintenance and protection of quality and use or uses of waters now of a high quality or of a quality suitable for present and potential future uses.

"6. The plan for implementing and enforcing the water quality criteria should be submitted in sufficient detail to describe the nature of the actions to be taken to achieve compliance, a time schedule for such compliance, the controls and surveillance for measuring compliance, and the enforcement authority and measures for ensuring compliance. Achievement of the purposes of the Act is paramount.

"7. The plan should include consideration of all relevant pollutional sources, such as municipal and industrial wastes, cooling water discharges, irrigation return flows, and combined sewer overflows.

"8. No standard will be approved which allows any wastes amenable to treatment or control to be discharged into any interstate water without treatment or control regardless of the water quality criteria and water use or uses adopted. Further, no standard will be approved which does not require all wastes, prior to discharge into any interstate water, to receive the best practicable treatment or control unless it can be demonstrated that a lesser degree of treatment or control will provide for water quality enhancement commensurate with proposed present and future water uses.

"9. Public hearings are required to be held by States establishing standards in accordance with the provisions of the Act.

"A summary of each public hearing, accompanied by certification as to notice and conduct of such public hearing in conformity with procedures provided therefor, should be provided the Secretary. The summary should adequately advise him of:

- (a) The waters which were the subject of the public hearing;
- (b) The interests and interest groups represented, including those in downstream or adjacent States which would be affected by the standards;
- (c) The views expressed on water quality and water uses by the various interests and interest groups;
- (d) Statistical data, reports and other information submitted in support of statements, views and positions expressed at the hearing, including those provided by the State or States holding the hearing.

"When necessary to the Secretary's determination that the State criteria and plan are consistent with the purposes of the Act, a full transcript of the hearing and supporting data will be requested.

"In the review of the hearing record to determine whether the State criteria and plan are consistent with the purposes of the Act, attention will be given to the extent to which there was expression of views by conservation, civic, recreation, agricultural, industrial and planning interests, as well as by Federal, State, interstate and local agencies. Particular attention will be given to the extent to which there was opportunity for participation by interests downstream or adjacent States which would be affected by the standards.

"10. State standards will be reviewed in terms of their consistency and comparability with those for affected waters of downstream or adjacent States. Coordination is encouraged among States to assure such consistency.

"11. The use or uses of the waters concerned, the water quality criteria to provide for such use or uses, and the plan for implementing the water quality criteria should be in conformity with any comprehensive water pollution control program developed pursuant to Section 3 of the Federal Water Pollution Control Act, as amended; should encompass any remedial program recommended by the Secretary as a result of an enforcement action taken under Section 10 of the Act; and should be revised to reflect any recommendations resulting as such programs and actions develop.

"12. To meet the goals established by the Act, water quality standards must be adequate to protect and upgrade water quality in the face of population and industrial growth, urbanization, and technological change. In accordance with the provisions of the Act, it is anticipated that after the initial setting of standards, periodic review and revision will be required to take into account changing technology of waste production and waste removal and advances in knowledge of water quality requirements developed through research."

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