The Annual Flows of the Mississippi River

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INTRODUCTION
The establishment of European civilization in North America may be looked upon as a long march across the continent as the people established settlements, clearings and highways, and undertook utilization of the natural resources. This process can be divided into three large undertakings which resulted in actual change of the physical landscape. The first task was the clearing of the impenetrable eastern forest which was then crossed only by Indian trails. This magnificent area of climax forest was not felled by the lumbermen; instead it was cut and burned piecemeal to make clearings for the settlers. West of the Mississippi River, settlements involved the plowing of the prairie and the killing of the buffalo. These processes brought about destruction of both the tall and short grass prairies. The introduction of livestock and the activities of farming insured the prolonged destruction of the prairies.

Another vast change introduced by the white man has been his attempts to control the preeminent central Mississippi River which drains much of the lower United States and part of Canada. The river and its appurtenances comprise geographic and geological factors. As such, it is difficult to control and, in fact, cannot be controlled except within very definite narrow limits. Thus, unlike the biotic provinces conquered and partially obliterated by man, the Mississippi gives the impression of fighting back at encroachments upon its domain. Obviously, if mankind is to control the river, even to a small extent, we must know as much as possible about it. Herein the writer analyzes to some extent the characteristics of the annual flow. At the end of the present year, 1979, we shall have a time series of only 80 years of adequate data dating from 1900 to consider. Variations in previous flows are considered where they are known.

BACKGROUND INFORMATION
The Mississippi River watershed is exceeded in area on Earth only by the watersheds of the Amazon and the Congo. It drains two thirds of the lower United States (some
The river begins in Minnesota and flows southward within its alluvial plain between the escarpments of its valley. In a few places it touches these escarpments as at the bluffs of Vicksburg and Natchez.

The river has a natural levee all along its floodplain which consists of fine, alluvial soil that forms from sand and silt deposits when the river overflows its banks during high-water periods. Essentially the load is deposited quickly as the current speed falls after it leaves the channel. This levee slopes away from the river, at the rate of about seven feet to a mile, to the low-lying swamps on either side. This natural levee system was the finest land available when the first white man came into the country, and it was better drained than any other land of the area.

High water comes every year between December–January and June–July. A flood ensues when the river overflows its natural levees. The area which is subject to flooding under natural conditions consists of 34,600 square miles or 22.1 million acres south of Cairo, Illinois, including 18,000 square miles of deltaic plain. Floods occur about every three years under natural conditions, but nowadays they are largely restrained by man-made levees.

The fine arable land along the river which remained high and dry after the spring floods had gone down, in contrast to the swampy areas back away from the river, led to extensive settlement up and down the river banks, beginning when New Orleans was first settled in 1717.

The river was the great travel connection from the days of the pirogues and canoes of the Indians and early explorers, to the time of the flatboats and steamboats and today the powerful diesel-motor towboats, with their huge strings of barges, and the ocean-going freighters. The fact that the river was the great avenue of travel and commerce, reinforced the tendency of the Europeans to settle along its banks. The only alternative was for the settlers to go beyond the swamps to the edges of the valley itself, that is to the escarpments, which were sometimes as much as 50 miles away.

The river did not overflow and discommodate the settlers every year but rather about once every three years, and even so, the floods were not very high in the beginning, although they filled in the back waters at times and went to the very edges of the valley, being commonly 50 miles wide along the lower river and even 80 miles in the widest place. But the vast areas of swamps lying alongside the river acted as overflow basins for floods and when the white man first came to live along the river, low levees or banquettes, three feet high around the Vieux Carré or Old Square, sufficed to protect the settlement of Nouvelle Orleans.

In brief, it may be said that various situations and conditions constrained the white man to settle in areas which were naturally part of the river's overflow area and which was subject to flooding. Circumstances which were not even recognized and of which the future portent was not foreseen, set the European settler upon the course of opposing and fighting the river rather than trying to live with it. Living with the river would have entailed building human dwellings and other structures on pilings or earthen banks about three feet high. However, it was easier to build a low embankment around the town of New Orleans and this was first completed in 1721. In effect, the colonials built a ring levee. This was a rather innocent beginning, but as settlers moved up and down the river they were forced for their own protection, and later by law, to build levees and the river was cut off more and more from its natural overflow areas. As this took place, the floods and in turn the levees became higher so that now they are up to 40 feet. This situation was aggravated along the lower river by the closure of former distributaries, Bayou Manchac to the east just below Baton Rouge, and both Bayou Plaquemine and Bayou Lafourche lower down on the west bank.

This situation was reviewed and summarized by Gunter (1952, p. 123) in the following words:

"Levees grew ever higher as the river was cut from its flood basins and so did floods. Today levees at some points are thirty-five feet high. In addition many tributary streams were leveed and they in turn were cut off from their flood basins. Maps of the present system show a bewildering tracery of levees, quite difficult to describe in detail, which however is unnecessary for our purposes. It is sufficient to say that the total levee system was around 991 miles long in 1880 and 2,130 miles long in 1935.

Up to 1885 the effects of levees were not so great as they have become since. According to Elliott (1932, p. 83) the flood of 1882 may be taken as typical of a major flood prior to extensive levee construction. 'Comparison of succeeding flood crests with this flood gives a definite indication of the increase in flood heights.' He gave figures taken at the Carrollton (New Orleans) gauge showing that the crest was at 14.95'feet in 1882, 16 feet in 1890 and 21 feet in 1912. The Red River Landing gauge registered 48.50 feet in 1882, 53.20 feet in 1912 and 57.45 feet in 1927. The greatest flood of all was in 1927 when numerous crevasses modified flood heights on the lower river, making them useless for comparison. At the Cairo, Illinois gauge the 1927 high water crest was at 56.4 feet. The highest previous crest was at 54.69 feet in 1913. At the time of the 1912 flood the gauge stood at 54.0 feet.

In summary, levee construction started in 1717, 235 years ago, at New Orleans and was a gradual
process up until about 1880. From that time the rate was accelerated, until the nineteen-thirties when the whole system was greatly extended and more or less stabilized, following the disastrous flood of 1927. Flood heights became higher as the levee system increased.”

Viosca (1927) discussed the developments that would have come about along the river if the white man had not elected to fight it in the beginning and he and Gunter (1956, 1957) discussed the changes which have taken place within the great valley. Gunter (1952) has also discussed some general changes which have taken place around the river’s mouth.

At the present time about three fourths of the 35,000-square-mile floodplain area has been cut off from the river by levees. It appears that devegetation of the land also has tended to increase the peaking of annual floods, which means an increase in flood heights. The most disastrous flood of all time came in 1927. Efforts at flood control became coordinated and administered by the Corps of Engineers, U.S. Army, following the 1927 catastrophe.

RIVER FLOW AND MAJOR FLOODS

The Atchafalaya Problem

Table 1 gives the measured flows of the Mississippi River for each year of the twentieth century in terms of mean flow per second for each year. These figures were furnished by the New Orleans District of the Corps of Engineers. Data before 1900 are unavailable or unreliable.

Today the Mississippi River has two large natural distributaries, the main river and the Atchafalaya. The flows of the two distributaries are given in the same terms. According to Elliott (1932) the Atchafalaya in 1858 carried 77,061 cfs of water during high-water stages. Insofar as the flood or high-water flow is at least around 700,000 cfs in the main river, the Atchafalaya had 10% or maybe even less of the flow in 1858. Since that time the Atchafalaya has grown greatly. This growth has been common knowledge and has been written up in the New Orleans newspapers many times. It was known to early writers such as Mark Twain. In the early 1930s the writer talked to old people who had seen footbridges across the original Atchafalaya Bayou (Gunter 1952) in antebellum days. Apparently, it is an old main channel of the river of a thousand years or so ago, which changed to the left of the direction of flow and is now trying to change back again.

According to Comeaux (1970) a raft in the upper Atchafalaya began to grow sometime between 1500 and 1778, but with Shreve’s cutoff, which removed a large oxbow in the main river, the Atchafalaya was virtually bypassed and it decreased in size until 1839, when raft removal was first attempted. In 1861, the process was completed and the Atchafalaya began to grow rapidly. Floods decreased along the lower Mississippi and increased on the Atchafalaya until all farming along that stream came to an end.

### Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Mississippi River at Red River Landing</th>
<th>Atchafalaya River at Simmesport</th>
<th>Combined Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>432</td>
<td>64.7</td>
<td>497</td>
</tr>
<tr>
<td>1901</td>
<td>377</td>
<td>55.4</td>
<td>432</td>
</tr>
<tr>
<td>1902</td>
<td>461</td>
<td>70.2</td>
<td>531</td>
</tr>
<tr>
<td>1903</td>
<td>639</td>
<td>136</td>
<td>775</td>
</tr>
<tr>
<td>1904</td>
<td>465</td>
<td>76.8</td>
<td>542</td>
</tr>
<tr>
<td>1905</td>
<td>576</td>
<td>104</td>
<td>680</td>
</tr>
<tr>
<td>1906</td>
<td>592</td>
<td>103</td>
<td>695</td>
</tr>
<tr>
<td>1907</td>
<td>676</td>
<td>134</td>
<td>810</td>
</tr>
<tr>
<td>1908</td>
<td>667</td>
<td>146</td>
<td>813</td>
</tr>
<tr>
<td>1909</td>
<td>581</td>
<td>105</td>
<td>686</td>
</tr>
<tr>
<td>1910</td>
<td>473</td>
<td>73.7</td>
<td>547</td>
</tr>
<tr>
<td>1911</td>
<td>419</td>
<td>70.6</td>
<td>530</td>
</tr>
<tr>
<td>1912</td>
<td>646</td>
<td>138</td>
<td>784</td>
</tr>
<tr>
<td>1913</td>
<td>584</td>
<td>122</td>
<td>706</td>
</tr>
<tr>
<td>1914</td>
<td>409</td>
<td>69.7</td>
<td>479</td>
</tr>
<tr>
<td>1915</td>
<td>653</td>
<td>126</td>
<td>779</td>
</tr>
<tr>
<td>1916</td>
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<td>1917</td>
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<td>604</td>
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<tr>
<td>1918</td>
<td>400</td>
<td>61.9</td>
<td>462</td>
</tr>
<tr>
<td>1919</td>
<td>602</td>
<td>120</td>
<td>722</td>
</tr>
<tr>
<td>1920</td>
<td>657</td>
<td>145</td>
<td>802</td>
</tr>
<tr>
<td>1921</td>
<td>527</td>
<td>95.4</td>
<td>622</td>
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<tr>
<td>1922</td>
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<td>125</td>
<td>691</td>
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<tr>
<td>1923</td>
<td>590</td>
<td>116</td>
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<td>1924</td>
<td>548</td>
<td>98.3</td>
<td>646</td>
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<td>1925</td>
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<td>1928</td>
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<td>1929</td>
<td>643</td>
<td>177</td>
<td>820</td>
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<tr>
<td>1930</td>
<td>419</td>
<td>99.8</td>
<td>519</td>
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<tr>
<td>1931</td>
<td>283</td>
<td>57.8</td>
<td>341</td>
</tr>
<tr>
<td>1932</td>
<td>516</td>
<td>139</td>
<td>655</td>
</tr>
<tr>
<td>1933</td>
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<td>667</td>
</tr>
<tr>
<td>1934</td>
<td>292</td>
<td>71.8</td>
<td>364</td>
</tr>
<tr>
<td>1935</td>
<td>574</td>
<td>177</td>
<td>751</td>
</tr>
<tr>
<td>1936</td>
<td>346</td>
<td>85.5</td>
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<tr>
<td>1937</td>
<td>514</td>
<td>158</td>
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<td>1938</td>
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<td>588</td>
</tr>
<tr>
<td>1940</td>
<td>313</td>
<td>94.9</td>
<td>408</td>
</tr>
<tr>
<td>1941</td>
<td>376</td>
<td>114</td>
<td>490</td>
</tr>
<tr>
<td>1942</td>
<td>499</td>
<td>157</td>
<td>656</td>
</tr>
<tr>
<td>1943</td>
<td>520</td>
<td>165</td>
<td>685</td>
</tr>
<tr>
<td>1944</td>
<td>475</td>
<td>159</td>
<td>634</td>
</tr>
<tr>
<td>1945</td>
<td>683</td>
<td>264</td>
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<tr>
<td>1946</td>
<td>509</td>
<td>202</td>
<td>711</td>
</tr>
<tr>
<td>1947</td>
<td>426</td>
<td>165</td>
<td>591</td>
</tr>
<tr>
<td>1948</td>
<td>448</td>
<td>173</td>
<td>621</td>
</tr>
<tr>
<td>1949</td>
<td>555</td>
<td>226</td>
<td>781</td>
</tr>
</tbody>
</table>
In the first decade of the present century the Mississippi proper carried 84.5% of the river flow while the Atchafalaya River carried 15.4%. From 1970 to 1978, inclusive, the Atchafalaya carried 32.9% of the total flow and the Mississippi carried 66.1%. The change in the partition of flow has been approximately an 18% decline in 78 years in the Mississippi flow as shown by Table 2, with a commensurate increase in the Atchafalaya. If the present tendency continues, the Atchafalaya River will carry as much water as the Mississippi in about 49 years from the present (1979) or circa year 2038. Apparently, aggrandizement by the Atchafalaya still continues in spite of attempts by the Corps of Engineers to stop it.

In fact, Table 3 shows, in terms of the mean flows for each month, that during the flood year of 1973, the Atchafalaya took over 37% of the flow. Nevertheless, the Old River Control is operated by the Corps to retain approximately the same distribution of flow as would have been obtained under natural river conditions of 1950.

The Larger Floods

Measurements of river flow were not as accurate in the 1800s as they are today, but there are indications (cf. Elliott 1932) that the 1882 flood was about equivalent to those of 1927 and 1973. Thus these three floods are roughly equivalent to 50-year floods.

The 1927 flood is rated as the most destructive of all time because there were more and greater crevasses in the lower floodplain and no doubt there were greater areas of flooding. In part this is due to the fact that levees were not as good then as they are today. It is also partly because a major portion of the flood control system, consisting of reservoirs on the upper river, the Bonnet Carre Spillway, and the major floodways of the Atchafalaya River, did not exist at that time. Even so the 1973 flood put 13 million acres of the 22-million-acre floodplain under water at one time. Actually about one fourth of the floodplain today is left free and not cut off from the river by levees.

Final data on the combined daily flow of the Mississippi and Atchafalaya rivers, as shown in Table 4, give a lower total flow for 1973 than 1927. Table 4 shows the daily mean flows for each month. It should be noted, too, that the greater flow of the river fell in the first six months during 1973, while in 1927 flood waters lasted for seven months through July.

The 1973 data and the flood data for 1927 were used to calculate the fact that during 1927 the river put 13 million acres of the 22-million-acre floodplain under water at one time. Actually about one fourth of the floodplain today is left free and not cut off from the river by levees.
Mean Min.
Day Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1 935 822 759 1093 1357 1216 703 367 247 222 394 599
2 936 842 722 1112 1393 1191 643 439 232 241 374 656
3 938 854 868 1154 1327 1159 627 403 239 219 376 700
4 914 863 654 1181 1329 1126 614 408 239 231 346 740
5 888 867 620 1205 1403 1070 596 407 238 231 350 576
6 885 873 594 1241 1388 1090 572 399 237 235 375 587
7 892 875 580 1273 1373 1045 550 388 234 271 374 798
8 897 881 565 1292 1322 1054 535 374 232 207 394 828
9 900 872 559 1291 1447 1029 511 355 230 336 402 844
10 902 861 563 1268 1392 1037 494 353 228 359 403 861
11 904 846 582 1254 1310 1012 467 313 229 377 406 861
12 908 839 591 1352 1428 1014 447 294 232 394 386 892
13 909 842 618 1296 1418 992 441 279 235 348 794 896
14 908 858 660 1342 1426 978 433 269 231 415 362 933
15 911 868 709 1335 1428 983 430 263 227 418 349 946
16 892 873 745 1387 1498 1003 421 260 223 423 342 954
17 882 875 780 1359 1441 979 414 255 220 427 334 962
18 867 880 800 1440 1414 957 404 254 218 430 328 968
19 848 885 814 1323 1402 975 396 260 222 427 321 950
20 819 876 833 1368 1426 964 384 267 216 425 318 954
21 816 863 877 1323 1409 931 355 246 245 430 311 925
22 765 866 886 1286 1392 910 361 283 218 435 302 886
23 742 860 887 1298 1370 878 350 285 213 439 299 834
24 708 856 945 1279 1361 856 339 299 209 437 305 805
25 698 849 983 1285 1299 856 328 296 207 437 314 801
26 699 839 995 1244 1372 850 319 296 210 439 327 791
27 709 819 1005 1280 1299 819 300 297 208 434 355 774
28 727 789 1021 1260 1352 811 293 283 209 430 407 724
29 751 1041 1360 1297 744 294 268 212 427 454 717
30 767 1054 1433 1220 76 308 260 218 420 530 715
31 792 1072 1207 336 256 411 720

Mean 842 857 779 1284 1373 977 441 311 224 372 362 826
Max. 938 885 1072 1433 1498 1216 703 408 247 439 530 968
Min. 698 789 559 1093 1207 744 293 254 207 222 299 599

TABLE 4.
Monthly flow of the Mississippi and Atchafalaya rivers in terms of the mean flows computed in thousands of cubic feet per second.

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<tr>
<td>1927</td>
<td>1117</td>
<td>1311</td>
<td>1395</td>
<td>1662</td>
<td>2223</td>
<td>1818</td>
<td>1317</td>
<td>601</td>
<td>391</td>
<td>450</td>
<td>348</td>
<td>652</td>
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<tr>
<td>1973</td>
<td>1269</td>
<td>1283</td>
<td>1196</td>
<td>1924</td>
<td>2102</td>
<td>1529</td>
<td>739</td>
<td>476</td>
<td>350</td>
<td>560</td>
<td>554</td>
<td>1199</td>
</tr>
</tbody>
</table>

The Periods and Times of Great Floods

De la Vega, the chronicler of De Soto’s explorations, recorded a flood that began on March 10, 1543, which was said to have crested 40 days later, and lasted about 80 days. It was said to cover the valley for 20 leagues on each side of the river. In terms of the old Spanish league, this would be a distance of about 105 miles and the flood must have touched both escarpments of the valley. This distance seems to be excessive, but in any case, this was clearly a very large flood 436 years ago. We have nothing to compare it to afterwards. The location was thought to be at Helena, Arkansas.

La Salle recorded another flood in 1664. The French settlers at New Orleans encountered a flood in 1717 and again in 1718 before levees were constructed. The city was flooded by crevasses at least eight times up to 1849. From 1717 to 1816, there were 17 floods recorded on the river...
according to the summary given by Elliott (1932, pp. 105–113), but between 1817 and 1916, there were 37 recorded floods. Thus, it would appear that levees brought more floods by raising flood heights, if the flood occurrences were reliably reported. However, Elliott says that they were not well recorded before 1799. As he pointed out, the hydraulics of the river have become much more efficient throughout the years so that the river could accommodate banks it carried only 1,000,000 cfs.

Also according to Elliott, the 1882 flood was the last typical major one before extensive levee building. In the 47 years prior to and including 1882, there were 19 floods; in the 47 years from 1883 to 1929, there were 16 floods. Thus, the floods were not increased after 1882 (Elliott 1932, p. 104) although levee and flood heights rose on all the gages.* A variant of "gage" used invariably by the Corps of Engineers.

Actually there were 37 floods in the 1800s and only 27 floods in the first 80 years of this century, counting flows of over 700,000 cfs as a flood year, including the year 1979, which is not over at this writing. There have been only nine floods in the past 30 years by the same token and 17 in the first 50 years of the century. Actually, Elliott's criteria for floods in the twentieth century presumably were gage heights, crevasses, etc., but since 1927, there have been no crevasses.

Looked at another way, from about 1775 on, it seems that considerable attention was paid to floods and in fact measurements by a gage at Natchez were attempted in 1770. From that year to 1929, inclusive, there were 53 floods listed by Elliott (1932) or a flood every 2.87 years. The annual river flow, as shown in Table 1, is generally very high in flood years, but not always. In 1922, the average flow was only 691,000 cfs but there was a flood, of which Elliott said (1932, p. 114), "The 1922 flood stages were well above previous records at all gaging stations above White River, but from that point to Carrollton they exceeded all previous records." Three crevasses occurred.

Because of the last instance, we have listed as a flood year all years in Table 1 in which the total "instantaneous" flow was above 700,000 cfs. There were 25 such years out of the 78 total during this century so far, giving an average of one every 3.00 years. The approach then seems to be fairly consistent with actual overflows in switching to high-water months are nearly always in the first six or seven months of the year, such as December 1973, and if so they contribute to flooding in the following year.

A great drought on this continent began in the early 1930s and ended in the late 1950s, so that possibly there will be more rain in the next 50 years. In fact, Price and Gunter (1943) pointed out that a change to drier weather took place in south Texas about 1870. The idea of a climatic change was laughed out of court by the scientific community at that time, but it is now recognized that a definite change to drier and warmer weather took place in about 1876 in the United States and was reversed again in the late 1950s, 1957–1958 to be precise.

Today we have high waters or "swells" in the river, as some early writers called them, without any flooding at all outside the levees. And so it is to be hoped that in the future, variations in river flow will be shown by gage heights and cfs readings rather than floods and destruction. This does not mean that all-out levee building is advocated. Rather it would seem that return to the river of the vast overflow areas between the natural levees and the escarpments of the valley should be effected wherever possible. This would permit lower levees and enrichment of the valley by its natural soils rather than their artificial waste into the sea, which prevails today.

Prior to the flood of 1882, there was not extensive levee building, but there were accounts of floods by various authorities, according to whom the greatest floods were in 1782, 1785, 1791 and 1809. During the latter year the Natchez gage was installed, and people on the lower river thought the Great Lakes were emptying southward through the river. From then on this gage registered at 48.0 feet and above in 1813, 1815, 1823 and 1828. This gage was at 47.8 in 1858 and 49.0 in 1859. It registered 45.75 in 1882. The St. Louis gage came into use in 1826 and most of the other gages in 1844. These gave more objective information on floods. The years 1840 and 1844 had major floods.

The written accounts of Elliott (1932) and the gage readings indicate that the greatest floods were 1782, 1828 and 1882. Thus 1782, 1828, 1882, 1927 and 1973 would be on 48-year intervals, the so-called 50-year floods. Possibly in 1782, 1828 or 1882 there were 100-year floods, but we have no objective data for precise comparisons. But subjectively the accounts leave little doubt that all of these would rank minimally as 50-year floods.

In 1882, the whole Mississippi floodplain, 34,600 square miles, was reported to have been flooded. The 1927 flood followed high rises on all watersheds contributing to the Mississippi River.

It scarcely seems possible that in a relatively stable geologic and climatic era that the river flow could be multiples of times what it has already been in the last few thousand years.
years. That would mean that the so-called 500- or 1,000-
year floods would possibly be less than 100% or twice dif-
ferent from the average.

In any case, we are approaching a 250-year record of the
river and there seems to be some evidence for a 50-year
cycle of great floods in which the river flows a little less
than twice the mean flow for an average year. The known
minimum annual flow is 341,000 cfs and the known high is
1,106,000 cfs, the mean being 646,000 or rather close to
flood-year flows (700,000 cfs) most of the time. The median
is 655,000 cfs. These data are all taken from Table 1. It should
be remembered that these figures are the means for the whole
year. In 1939, there was one day at Red River Landing
when the Mississippi flowed only 85,000 cfs for a day.

According to Elliott (1932, p. 95) climatic experts have
estimated that the river flow could vary up to about
3,000,000 cfs, which is 21.4% above the 2,261,000 greatest
flow which has been observed. Perhaps this would come with
a 500-year flood.

Some Statistics of Flows

The mean daily flow of the Mississippi River, as shown
by Table 1, ranged from 341,000 in 1931 to 1,106,000 cfs
in 1927. The lowest daily combined flow during this 79-year
stretch has not been determined but the highest was
2,261,000 on May 16, 1973. The reader should hold in
mind that these figures are in terms of the mean flows in
cubic feet per second for the whole 24-hour day. The lowest
instantaneous flow of the Mississippi proper has been given
as 85,000 cfs. For the combined distributaries it must have
been 100,000 cfs or a little more.

The statistical measures of the central tendency of an
array of figures, such as the Mississippi River flows, are a
powerful but simple statistical tool which is often neglected.
The mean or average annual flow has already been given as
646,304 cfs. By coincidence, this is almost precisely the
median number shows that it
annual figure for 1924. In the 1900–1978 time series,
38 years were equal to the mean or below it; 41 years
exceeded the mean.

The measurement of the median number shows that it
is 655,000 cfs.

The mode of all measurements was at 655,400 cfs, very
close to the median. It seems that the central tendency
figures are all skewed a little to the left of midpoint or a
little less than the point between the extremes. This seems
to follow from the fact that the flood and high-water
periods are generally not as long or as extensive as the low-
water periods, even in some flood years. The years 1927
and 1973 were exceptions. Similarly, Table 5 shows that
most flows were in the 500,000 and 600,000 classes, with
53 of the 79 years, or 67%, below 699,000.

In terms of dispersion, the decile annual flows seem to
be at 432,000 and 820,000 cfs, and the quartiles are at
531,000 and 748,000 cfs annually. This also shows a certain
skewness towards the low side. The standard deviation was
calculated to be 159.4 and the coefficient of variation was
0.247.

<table>
<thead>
<tr>
<th>Class Ranges</th>
<th>Annual Flows</th>
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<tbody>
<tr>
<td>300</td>
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<tr>
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</tr>
<tr>
<td>1,000</td>
<td>1</td>
</tr>
<tr>
<td>1,100</td>
<td>1</td>
</tr>
</tbody>
</table>

Inspection of Table 1 shows that high-water years were
not particularly associated. In 1903, 1912, 1913, 1916,
1920, 1929 and 1937, there were low-water years (less than
500,000 mean cfs) within the second year before or after a
flood year. In contrast, in 1907, 1922, 1950 and 1973, there
were high-water years (over 800,000 cfs mean) next to or
within the second year of the flood years. In summary, there
was continuous high water or a tendency towards several
such years together during four flood years, but in seven
flood periods the river was variable, so to speak, with high-
and low-flow years close together.

One of the lowest river flows of all time occurred in the
summer of 1976, three years after the great flood of 1973,
and three years before the 1979 flood and the Bonnet Carré
Spillway opening.

Biological Importance of the River

The river brings down large amounts of nutrient salts and
cool, fresh water into the bays and estuaries of Louisiana
and Mississippi during the late winter and spring. These
factors have large effects on fisheries production of the area
but no exhaustive treatment has been presented. Biologists
know that oyster reefs are killed by floods (Gunter 1953)
and that larval brown shrimp are repelled sometimes by
walls of cold, low-salinity water as they try to enter the
estuaries during the early months of the year. But an ade-
quate treatment awaits a better and longer series of biological
data. This concerns the most productive fishery area on the
continent (Gunter 1963) and presumably the information
will be forthcoming.

Ancient Flows

According to Emiliani et al. (1976), the Mississippi River
used to flow 2 to 5 times more than at present, but this was
11,000 to 7,000 years ago when the Wisconsin ice sheet of
North America was melting. The climate at that time was nothing like that of the fairly stable present. During an earlier period of glacier melting some 18,000 years ago, a lake containing some 1,800 cubic miles of water behind an ice dam in Washington, Idaho and Montana, made its way to the Pacific some 330 miles away following melting of the dam. The flow was 10 million cubic meters per second or 345 million cfs or 10 times the combined flows of the rivers of the world (Snow 1976). It dug the Grand Coulee and cleared out the Columbia River Gorge. It was all over in 30 days. Such cataclysmic water flows are simply not characteristic of today's climate.

CONCLUSIONS AND SUMMARY

In 1900, the Corps of Engineers instituted measurements of the flow of the Mississippi and Atchafalaya rivers, the two distributaries of the Mississippi River system. These are given in cubic feet per second for the whole year as a mean or average figure. A series of 80 integers will have been collected at the end of 1979. The flow has ranged from 341,000 cfs in 1931, four years after the greatest flood, to the greatest annual flood, in record at 1,427,000 cfs in 1972 at 1,106,000 cfs. The mean annual flow has been 646,000 cfs to the end of 1978. The median is at 655,000 feet and the mode is 655,400 cfs. The decile figures are 432,000 and 820,000 cfs. The quartiles are at 531,000 and 748,000. All of these figures seem to be on the low side and cleared out the Columbia River Gorge. It was all over in 30 days. Such cataclysmic water flows are simply not characteristic of today's climate.

Since 1928, when the Corps of Engineers took over flood control, there have been virtually no crevasses and levee breaks, and floods are registered by high water, arbitrarily set here with an annual-mean flow of 700,000 cfs. Even so there have been some floods with crevasses at lower flow figures and some high-flow years in the 800,000-cfs class without floods. This comes about because floods depend also on the concentration of runoffs in given months.

The measurements of dispersion show 159,408 cfs for the standard deviation and a coefficient of variation of 0.247, none of which is particularly noteworthy.

Apparently the Atchafalaya carried about 10% of the total flow in 1858. It has grown to approximately 33% of the total flow and, during 1973, it carried 37% of the total flow.

The river's greatest measured flow, 2,261,000 cfs, has been only 6.63 times the mean of its lowest annual flow, 341,000 cfs.

The floods of 1828 and 1882, which covered the floodplain, fit well with 1927 and 1973 as 100-year floods, although the older floods may have been greater. These floods seem to come when all tributaries are contributing heavily. These seem to be the peak floods that can come under the present climatic regime. The climatologists estimated for Elliott (1932) that the maximum expected flood would be about 3,000,000 cfs. This is only 21.4% greater than the greatest high that has been experienced recently, 2,261,000 cfs, on May 16, 1973. Presumably, the 3,000,000-cfs flood would be a 500- or maybe even a 1000-year flood. With spillways, floodways, reservoirs upstream and strong levees, all operated judiciously along with some sacrifice of the floodplain, it would seem that we could hope to get by such a crisis without an overwhelming catastrophe. But such a confrontation between man and the river is certain to come and it must be met with careful planning and relentless vigilance.

REFERENCES CITED


