5. EFFECTS OF ALTERNATIVES SUBMITTED TO THE CORPS FOR CONSIDERATION

5.1 INTRODUCTION

This chapter presents the hydrologic, water quality, sedimentation and erosion, ice, economic, and environmental effects of the alternatives submitted by several entities to the Corps for consideration as the Corps moves through the process of determining what the future water control plan should be for the Mainstem Reservoir System. Table 5.1-1 lists the entities and the corresponding names of the alternatives to be discussed in this chapter of the RDEIS. The American Rivers (AR), and the Missouri River Natural Resources Committee (MRNRC) submittals had many similarities, including spring rises downstream from Fort Peck and Gavins Point Dams and a split navigation season on the Lower River. After discussions with both entities, the Corps combined these two submittals into a single alternative that was identified as the ARNRC alternative. Most of the components of the AR alternative were combined with some specific components identified in the submittal for the MRNRC alternative. This left six alternatives to the current Water Control Plan (CWCP) for consideration. Detailed information on the components of these alternatives is included in Chapter 4.

For this chapter, the effects of these six alternatives are compared primarily to those of the CWCP, with limited comparison of the impacts of the alternatives with each other. The effects are presented in a variety of ways from average annual data to annual data. In some cases, more detailed data is presented to provide the reader with data that more closely match the areas of concern that have been expressed throughout the study process in general, and more specifically during the preparation of the RDEIS.

Because of the distinct differences and unique combination of components in each alternative, delineation of the component of each plan that may be causing the differences among the alternatives is sometimes difficult to identify. With some of the more detailed data presented in this chapter, one will be able to get a general feeling for these differences. The reader is encouraged to place more emphasis on the relative difference in values among the alternatives than on the absolute value for each alternative. The modeling techniques used in the Study were developed to measure the effects of changing the CWCP and not to forecast the future. Many factors that will influence future economic and environmental performance were not modeled.

Each section of this chapter includes one or more tables that include data broken down by river reaches. In some instances, the data for the individual reaches do not add up to the total value included in the table. This occurs because the numbers were rounded off after the totals were computed.

Finally, data specific to many of the basin Tribes will be presented. This effort was incorporated into this chapter as the Corps strives to better fulfill its Trust responsibilities to the American Indian Tribes in the Missouri River basin.

Table 5.1-1. Alternatives submitted to the Corps for consideration.

Entity Submitting Alternative	Alternative Name
Missouri Levee and Drainage District Association	MLDDA
Missouri River Basin Association	MRBA
American Rivers and Missouri River Natural Resources Committee	ARNRC
Missouri Department of Conservation	MODC
U.S. Fish and Wildlife Service – 1994 Biological Opinion Alternative	BIOP
U.S. Fish and Wildlife Service – 30-kcfs Spring Rise Alternative	FWS30

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5.2 MAINSTEM RESERVOIR SYSTEM HYDROLOGY

This section of Chapter 5 will focus on the hydrologic variation that would result from the operation of the Mainstem Reservoir System under the CWCP and the alternatives submitted for Corps consideration. Total storage, individual lake elevations, and river flows in all of the reaches will vary among the alternatives because they feature a variety of drought conservation and service flows.

5.2.1 Mainstem Reservoir System Storage and Lake Elevations

In the hydrologic modeling process, lake levels and total system storage stand out as two hydrologic features that those whose livelihoods and responsibilities are associated with one or more of the mainstem lakes are most interested in.

Table 5.2-1 displays the minimum system storage levels and minimum lake levels for the upper three lakes for the CWCP and the alternatives. Minimum levels are presented for each of the three major droughts experienced during the 100-year period of record as well as for the period of actual historic operation from 1967 to 1997. The system storage represents the minimum daily total of the combined contents of the six mainstem lakes during each drought period: the 1930 to 1941 drought, the 1954 to 1961 drought, and the 1987 to 1993 drought. Minimum daily lake levels for the upper three lakes (Fort Peck Lake, Lake Sakakawea, and Lake Oahe) during each drought period are also presented. Minimum lake elevations for the other three mainstem lakes (Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake) are not provided. These lakes are much smaller than the upper three, representing only 12 percent of the total storage, and therefore, their operation and lake levels do not vary significantly with the different alternatives.

For all alternatives except the Missouri Levee and Drainage District Association (MLDDA) alternative, minimum storage levels modeled during the three droughts are higher than those modeled under the CWCP. Indeed, one of the primary objectives of the MRBA, ARNRC, BIOP, and FWS30 alternatives was to limit drawdown in the upper three lakes during times of drought.

The MRBA alternative resulted in a minimum storage of 27.2 MAF during the 1930 to 1941 drought. The basic objectives of this alternative were to limit the minimum storage in the 1987 to 1993 drought to about 43 MAF and to limit the minimum storage to about 28 MAF in the 1930 to 1941 drought. The primary way the MRBA alternative achieves this higher storage is through reduced service to navigation (typically a 7.1-month season and 3-kcfs reduction in navigation flow support during drought years). The MODC, BIOP, and FWS30 alternatives were based on the same minimum storage objectives as the MRBA alternative. The MODC alternative is very similar to the MRBA alternative except that it has a flat Gavins Point release until mid-September. As a result, the MODC alternative has slightly higher minimum storage levels than the MRBA alternative. The MRBA alternative was also used as the basis for the two alternatives proposed by the U.S. Fish and Wildlife Service (USFWS). Both the BIOP and FWS30 alternatives added a spring rise at Fort Peck Dam and a spring rise and low summer flows from Gavins Point Dam to the MRBA alternative. Thus, minimum system storage levels are well above those specified in the CWCP and relatively close to the MRBA alternative.

The ARNRC alternative went even further than the MRBA-based alternatives in limiting the amount of drawdown during drought periods. The objective of the ARNRC alternative was to limit drawdown to 44 MAF during droughts such as the 1954 to

Table 5.2-1. Minimum system storage (MAF) and lake levels for the upper three lakes (feet).

	System Storage		Fort Peck Lake		Lake Sakakawea		Lake Oahe	
Alternative	**Date**	**Level**	**Date**	**Level**	**Date**	**Level**	**Date**	**Level**
1930-1942 Drought								
CWCP	Sep-41	18.7	Jun-41	2157	Feb-37	1773	May-41	1537
MLDDA	Feb-38	20.1	Feb-38	2162	Mar-38	1775	Feb-38	1540
MRBA	Feb-40	27.2	Mar-40	2181	Mar-40	1793	Feb-40	1559
ARNRC	Feb-35	30.6	Mar-35	2190	Mar-35	1800	Feb-35	1566
MODC	Feb-41	29.0	Mar-41	2182	Jan-41	1795	Jul-39	1563
BIOP	Feb-41	25.8	Mar-40	2178	Mar-40	1790	Feb-40	1557
FWS30	Mar-35	27.3	Mar-37	2181	Mar-35	1793	Mar-35	1560
1954-1962 Drought								
CWCP	Dec-61	40.1	Mar-62	2206	Feb-62	1813	Aug-61	1586
MLDDA	Dec-61	39.8	Mar-62	2206	Feb-62	1812	Aug-61	1586
MRBA	Dec-61	42.1	Mar-62	2209	Feb-62	1817	Aug-55	1586
ARNRC	Dec-61	46.3	Jan-62	2207	May-57	1824	Sep-55	1591
MODC	Dec-61	43.4	Mar-62	2211	Feb-62	1818	Oct-55	1578
BIOP	Dec-61	44.6	Aug-61	2212	Mar-62	1821	Aug-58	1589
FWS30	Dec-61	44.4	Aug-61	2212	Mar-62	1820	Aug-55	1588
1987-1993 Drought								
CWCP	Jan-93	40.2	Apr-91	2206	Mar-93	1813	Aug-90	1585
MLDDA	Jan-93	39.1	Mar-93	2204	Mar-93	1812	Aug-90	1583
MRBA	Jan-93	42.7	Mar-93	2209	Feb-91	1818	Aug-90	1586
ARNRC	Jan-91	45.5	Feb-93	2200	Mar-91	1822	Dec-91	1595
MODC	Jan-93	43.2	Mar-93	2210	Feb-91	1818	Aug-90	1587
BIOP	Jan-93	43.3	Mar-93	2206	Mar-93	1819	Aug-92	1590
FWS30	Jan-93	43.1	Mar-93	2206	Mar-93	1818	Aug-92	1589
Historic Minimums								
1967-1997	Jan-91	40.8	Apr-91	2209	May-91	1815	Nov-89	1581

1961 drought and the 1987 to 1993 drought. In more severe droughts, such as the 1930 to 1941 drought, system storage was targeted at 31 MAF.

In contrast, the MLDDA alternative was very similar to the CWCP except that it increased the amount of storage available for flood control by lowering the base of the annual flood control zone by 2 MAF. Thus, the resulting minimum system storages were very near those modeled using the CWCP. During the 1930 to 1941 drought, the MLDDA alternative resulted in slightly higher minimum system storage due to the fact that navigation was suspended 3 years using the MLDDA criteria rather than just 1 year with the CWCP criteria. During the other two drought periods, the system storage was slightly below that modeled for the CWCP less water was available in the carryover and multiple use zone and because of the adjusted base of the annual flood control and multiple use zone.

Comparing the alternatives submitted for consideration to the actual historic operation during the period of record, which only includes the 1987 to 1993 drought, we see that all of the alternatives except MLDDA would have resulted in a higher minimum system storage than actually occurred during the latest drought. The MLDDA alternative would have resulted in a system storage that was 1.7 MAF lower than the actual historic operation.

Variations in the lake elevations of the upper three lakes are similar to the total system storage because the storage in the three lakes makes up the bulk of the system storage. There are minor variations due to the unique operating objectives of the individual lakes, such as unbalancing and the Fort Peck spring rise that can affect the timing and distribution of storage in the system. In general, the MRBA alternative and the alternatives that used the MRBA alternative as a base, namely the MODC, BIOP, and FWS30 alternatives, result in higher lake levels than the CWCP. This, of course, is due to the fact that these alternatives were designed to provide a higher minimum storage level (27.2 MAF) than the CWCP (18.7 MAF). The ARNRC alternative generally provides the highest minimum lake levels for Lake Sakakawea and Lake Oahe. This is because of the higher drought conservation measures. At Fort Peck Lake, the ARNRC alternative provides the highest minimum pool during the 1930 to 1941 drought, but provides lower lake levels compared to other alternatives during the 1954 to 1961 and 1987 to 1993 droughts. The MLDDA alternative results in the same or slightly lower lake elevations during the 1954 to 1961 and 1987 to 1993 droughts, and slightly higher levels during the 1930 to 1941 drought for the same reasons given earlier in the discussion about system storage.

In summary, all of the alternatives except the MLDDA result in generally higher minimum system storage and lake levels during the three drought periods. The differences between the alternatives based on the MRBA alternative (MRBA, MODC, BIOP, and FWS30) are generally small, averaging 1 to 3 feet. The ARNRC alternative provides the highest minimum system storage and lake levels, while the MLDDA generally provides the lowest.

5.2.2 Fort Peck Release

A spring rise out of Fort Peck for the benefit of native fish species was included in several of the alternatives submitted to the Corps for consideration. In particular, the ARNRC, FWS30, BIOP, and MODC alternatives were modeled with a spring rise from Fort Peck during the May/June timeframe. The modeling results for the various alternatives are presented on Figures 5.2-1 through 5.2-3 as a derivative of a flow duration-type analysis. The figures presented indicate the percent of years that a given discharge, either 18 or 23 kcfs, is equaled or is exceeded for various durations during the months of May and June. Increased releases of 23 kcfs for 3 weeks from Fort Peck Dam in the mid-May through June timeframe approximately every third year were recommended as a starting point in the USFWS 1994 BiOp. Although the USFWS goal was to release 23 kcfs for 3 weeks, some benefit is derived even if the goal is not fully met; therefore, a release of 18 kcfs was also included in the analysis of model results.

For example, Figure 5.2-1 indicates that for a 10-day period during the months of May and June under the CWCP, a release of 18 kcfs can be expected to be equaled or exceeded in about 10 percent of the years, and a release of 23 kcfs can be expected to be equaled or exceeded on average in about 7 percent of the years. Likewise, under the ARNRC alternative for a 10-day duration, Fort Peck's release should equal or exceed 18 kcfs about 23 percent of the years and 23 kcfs about 20 percent of the years.

In Figure 5.2-1, the CWCP is compared to the MLDDA and ARNRC alternatives. Neither the CWCP nor the MLDDA have a Fort Peck spring rise, so the contrast between them and the ARNRC alternative is quite obvious. Figure 5.2-2 compares the MRBA alternative to the two alternatives provided by the USFWS. The MRBA alternative does not include the Fort Peck spring rise, but it does provide more opportunities for higher releases than the CWCP due in part to the unbalancing feature of the MRBA alternative. The two USFWS alternatives include a spring rise but, as Figure 5.2-2 indicates, the BIOP provides a better chance for a 2-week spring rise than the FWS30 alternative. Furthermore, both USFWS alternatives are more effective at providing a spring rise than the ARNRC alternative. The MODC alternative, shown in Figure 5.2-3, actually outperforms all other alternatives in providing an effective spring rise out of Fort Peck with 25 percent of the years having 2 weeks of releases above 18 kcfs.

5.2.3 Lake Sakakawea Elevations

The State of North Dakota has indicated that it has water quality concerns at Lake Sakakawea when the pool is drawn down below elevation 1,825 feet. To facilitate the water quality analysis for Lake Sakakawea, Figures 5.2-4 through 5.2-6 were developed to compare the number of days that Lake Sakakawea was below 1,825 feet elevation during the three historic drought periods in the Missouri River basin under the various operating scenarios.

For background purposes, the carryover-multiple use zone under the current operating criteria (CWCP) extends from 1,775 feet to 1,837.5 elevation feet. The actual historic minimum pool level at lake Sakakawea during the 1987 to 1993 drought was 1,815 feet.

As simulated using the Daily Routing Model (DRM), Lake Sakakawea was drawn down below 1,825 feet elevation for a period of many years under all of the operating alternatives during the 1930 to 1941 drought. As shown in Figure 5.2-4, Lake Sakakawea was drawn down the longest under the CWCP, nearly 12 consecutive years. The MLDDA alternative was only slightly better, recovering from the drought just a little quicker. All of the alternatives that impose a higher minimum system storage result in fewer days spent below 1,825 feet elevation, although the difference is not as pronounced during the 1930 to 1941 drought as it is in the less severe droughts. During the 1930 to 1941 drought, Lake Sakakawea first fell below elevation 1,825 feet during 1931 under all of the alternatives. Under the alternatives with higher minimum storage requirements the pool spent at least part of the year above 1,825 feet elevation until 1934. Figure 5.2-4 demonstrates that the pool was refilled quicker under the alternatives with higher minimum pools. The least time the pool spent below 1,825 feet elevation was with the ARNRC alternative.

Figures 5.2-5, representing the 1954 to 1961 drought, and 5.2-6, representing the 1987 to 1993 drought, show considerable difference between the various alternatives. During both droughts, the MLDDA, with its 2 MAF reduction in carryover-multiple use storage, results in the most number of days spent below 1,825 feet elevation. The CWCP is only slightly better. The MRBA alternative, and the other three plans that use the MRBA alternative as a base condition, namely the MODC, BIOP, and FWS30, all show a significant improvement over the CWCP due to the higher minimum storage goals. The ARNRC alternative, with its even higher minimum pool levels, performs the best in this aspect, virtually eliminating the time spent below 1,825 feet elevation in the 1954 to 1961 drought and greatly reducing the duration in the 1987 to 1993 drought.

5.2.4 Bismarck Flow Duration

A flow duration-type analysis was done using the DRM results at Bismarck. In the analysis, the number of days during the April to June timeframe when flows at Bismarck exceed 55 kcfs were totaled for each year in the 100-year period of record. A duration-type analysis was also performed. Flood damages in the Bismarck area begin when the flows exceed the 55- to 60-kcfs range. Figures 5.2-7 through 5.2-9 compare the results of the analysis for the CWCP and the alternatives submitted to the Corps for consideration.

In Figure 5.2-7, comparing the CWCP with the MLDDA and ARNRC alternatives, the effect of the Gavins Point Dam spring rise in the ARNRC alternative can be noted. In order to support a spring rise from Gavins Point Dam, higher releases need to be passed down through the system. The result is a slight increase in the number of days that flows at Bismarck exceed 55 kcfs during the April through June period. In most years there is no difference between the alternatives; however, in 10 percent of the years the ARNRC alternative results in approximately 8 days with flows at the Bismarck gage above 55 kcfs during the April to June timeframe. This compares to 5 days with the CWCP. The MLDDA alternative reduces the number of days with flow above 55 kcfs at Bismarck, with only 1 to 2 days in ten percent of the years.

Figure 5.2-8 compares the MRBA alternative with the two alternatives provided by the USFWS (BIOP and FWS30). The BIOP and FWS30 alternatives, both of which contain a Gavins Point Dam spring rise, result in a slight increase in the frequency of flows exceeding 55 kcfs at Bismarck.

Figure 5.2-9 compares the MRBA and MODC alternatives to the CWCP. The MRBA and MODC alternatives result in a slight increase in the number of days Bismarck is above 55 kcfs due to the movement of water between the lakes for the Fort Peck Dam spring rise and unbalanced storage in the upper three lakes.

5.2.5 Gavins Point Dam Release

The alternatives presented for the Corps' consideration contain widely varying Gavins Point Dam releases depending on time of year, navigation support level, whether or not the spring rise and low summer flows are part of the plan, as well as other factors. In order to allow the differences between the alternatives to be displayed and understood, release duration plots were developed for each month, January through December, using average monthly Gavins Point Dam releases for the period of record for the CWCP and the alternatives. The results are 12 monthly figures each displaying seven duration curves, one for each alternative.

Under any given operating alternative, Gavins Point Dam releases vary widely throughout the year; therefore, it is beneficial to examine the model results on a month-by-month basis. Figures 5.2-10 through 5.2-21 allow a month-by-month comparison of the alternatives. The discussion here, however, is limited to pointing out the major differences among the plans. Many of the alternatives presented require the shifting of water from one season to another. For example, a spring rise followed by low summer flows may require higher flows in the fall months in order to evacuate storage accumulated in the flood control pools of the upper three lakes. The navigation season also ends later for these alternatives.

The spring rise is the primary reason for differences between the alternatives. Between January and March, Figures 5.2-10 through 5.2-12, the duration curves for the various alternatives are, for the most part, quite similar in the range and frequency of Gavins Point Dam release.

Figure 5.2-13 shows a significant dichotomy in the duration curves in April. Alternatives with a spring rise and low summer flows are sometimes forced to release extra water during April in wet years due to the release restrictions imposed later in the summer. As a result, the ARNRC, BIOP, and FWS30 alternatives indicate much higher releases than the CWCP and the other three alternatives, namely the MLDDA, MRBA, and MODC alternatives.

This trend continues into May due to the spring rise, as shown in Figure 5.2-14, with the FWS30 resulting in the highest releases, followed closely by the ARNRC and BIOP alternatives. The remaining four alternatives without a spring rise result in much lower releases. Releases in June, as shown on Figure 5.2-15, appear to show little difference between the spring rise and the non-spring rise alternatives. The difference between the alternatives is masked by the use of average monthly flows. The spring rise alternatives had higher Gavins Point Dam releases from May 15 to June 15 followed by lower releases during the latter half of June, causing the average monthly flows for June to average near the non-spring rise alternatives. If the first and second halves of June were analyzed separately, the first half would show results similar to May and the second half would be similar to July.

In July and August, releases modeled with the two USFWS alternatives (BIOP and FWS30) and the ARNRC alternative are dramatically affected by the low summer flow criteria and the duration curves for these alternatives drop well below the CWCP and other non-spring rise alternatives as seen in Figures 5.2-16 and 5.2-17.

After the low summer flows in the ARNRC, BIOP, and FWS30 alternatives, Gavins Point Dam releases are increased in order to evacuate the remaining excess water in the system storage between September and November, Figures 5.2-18 through 5.2-20. Once again the release duration curves for these alternatives are significantly higher than the other alternatives. The November release duration curve also indicates the shortened navigation season required in 30 to 35 percent of the years under the MRBA and MODC alternatives.

December's duration curves for the CWCP and the other alternatives, Figure 5.2-21, are once again quite similar, although there is some variation in the Gavins Point Dam release at end of the navigation season. The minimum winter release, 12 kcfs, is consistent across the range of alternatives.

5.2.6 Nebraska City Flow Duration

Along the Lower River below the Mainstem Reservoir System, the magnitude, timing, and duration of high flows may affect landowners through direct flooding, high ground water, and/or interior drainage flooding. Because the duration of high flows is a significant factor, the modeling results for the various alternatives are presented on Figures 5.2-22 through 5.2-24 as a derivative of a flow duration-type analysis. In the analysis, the number of days during the April to July time frame when flows at Nebraska City exceed 55 kcfs was totaled for each year in the 100-year period of record and a duration-type analysis was performed. Landowners in the Nebraska City area begin to experience interior drainage problems when flows n the Missouri River approach 55 kcfs. The differences among the alternatives follow a similar pattern because the flows at Nebraska City are highly influenced by the Gavins Point Dam releases.

Figure 5.2-22 shows while the MLDDA alternative is nearly identical to the CWCP, the ARNRC alternative would result in more days with flows above the 55-kcfs level during the period of April through July due to the spring rise. Likewise, Figure 5.2-23 shows as the magnitude of the spring rise increases, as one would expect, the frequency and duration of flows above 55 kcfs at Nebraska City also increase. The BIOP alternative results in greater flows than the MRBA alternative, which does not include a spring rise, and the FWS30 alternative, which has a higher spring rise than the BIOP alternative, results in even more days spent above 55 kcfs.

Figure 5.2-24 shows that there is relatively little difference between the CWCP and the MRBA or MODC alternatives because neither of these two alternatives includes a spring rise.

5.2.7 Boonville Flow Duration

A similar analysis was performed for flows at Boonville, Missouri. Figures 5.2-25 through 5.2-27 show a duration-type analysis of the number of days during the May through June time frame that the flows at the Boonville gage exceed 90 kcfs. Long duration, high flows on this part of the Lower River can restrict releases from tributary lakes. Releases from the Kansas River tributaries begin to be restricted when flows at Waverly, Missouri are greater than 90 kcfs. Waverly is not a control point in the DRM; however, Boonville is the next downstream control point.

For the May through June period, Figure 5.2-25 shows essentially no difference between the CWCP and the MLDDA alternative in the number of days with flow above 90 kcfs at Boonville. The ARNRC alternative, with its spring rise, results in generally 5 to 10 more days with flows above 90 kcfs during the May to June time frame than the CWCP or MLDDA alternative.

The MRBA, BIOP, and FWS30 alternatives are compared in Figure 5.2-26. The MRBA alternative, with no spring rise out of Gavins Point Dam, results in the fewest days with flows above 90 kcfs at Boonville. The BIOP alternative, with its 17.5-kcfs spring rise, and the FWS30 alternative, with its 30-kcfs spring rise, result in an increasingly higher number of days with flow above 90 kcfs.

The MRBA and MODC alternatives are compared to the CWCP in Figure 5.2-27. Neither of these alternatives involve a spring rise from Gavins Point Dam. There is very little difference in the likelihood of high flows at Boonville.

Solid line = the number of days/percent of years the release from Fort Peck Dam exceeds 23 kcfs.
Dashed line = the number of days/percent of years the release from Fort Peck Dam exceeds 18 kcfs.

Figure 5.2-1. Number of days in May/June that Fort Peck releases exceed target for CWCP, MLDDA, and ARNRC alternatives.

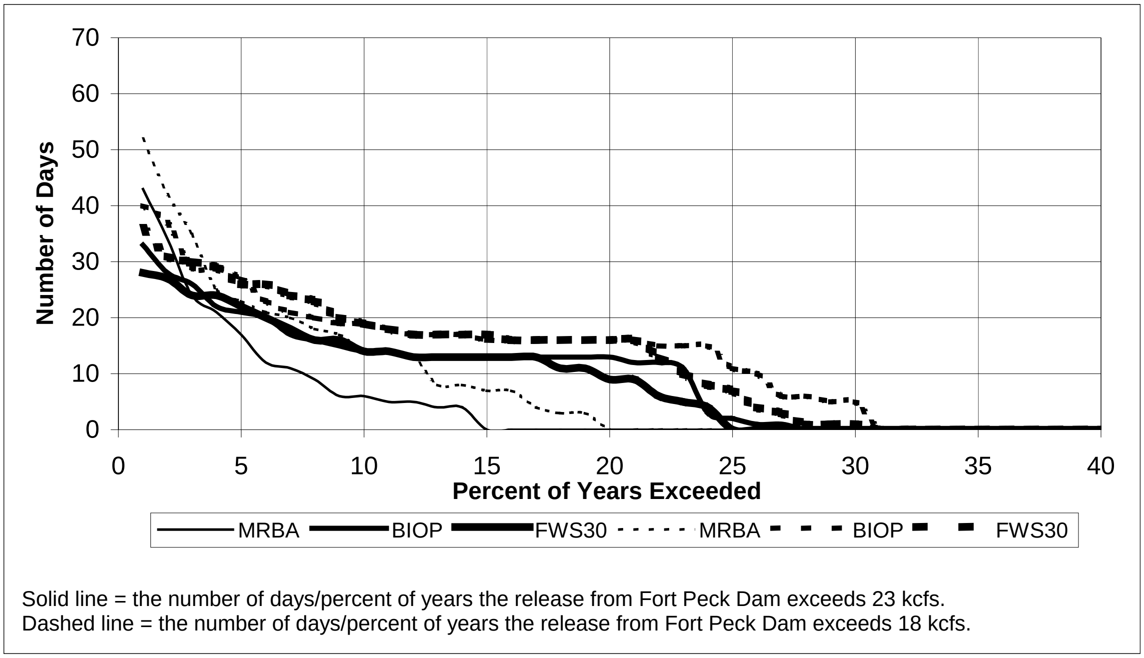

Figure 5.2-2. Number of days in May/June that Fort Peck releases exceed target for MRBA, BIOP, and FWS30 alternatives.

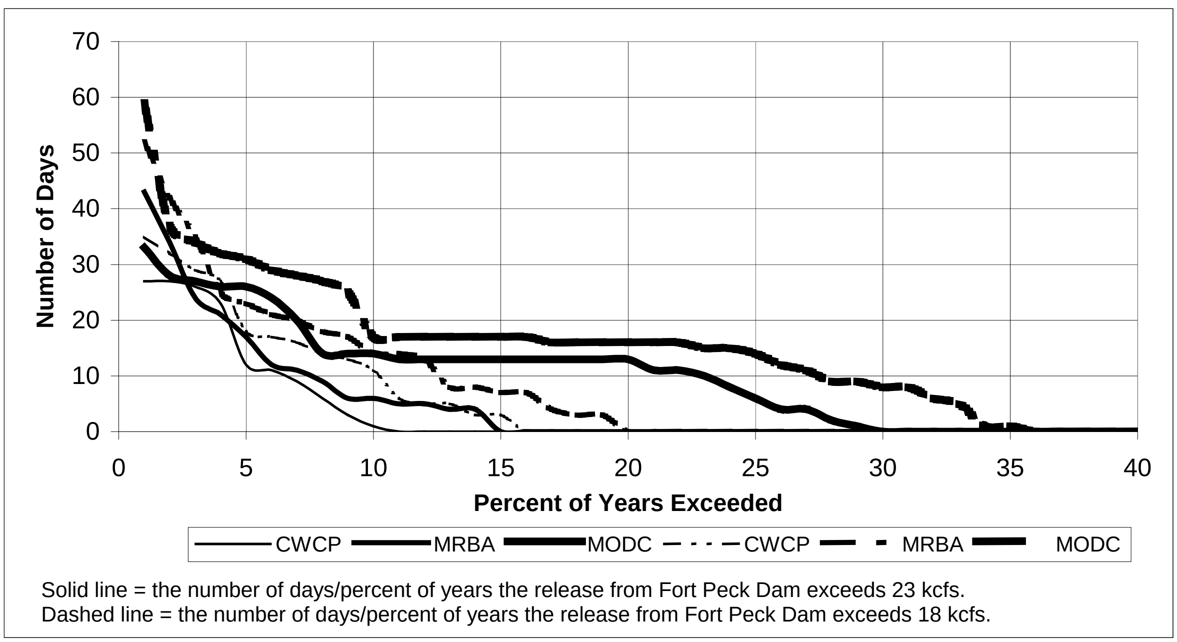

Figure 5.2-3. Number of days in May/June that Fort Peck releases exceed target for CWCP, MRBA, and MODC alternatives.

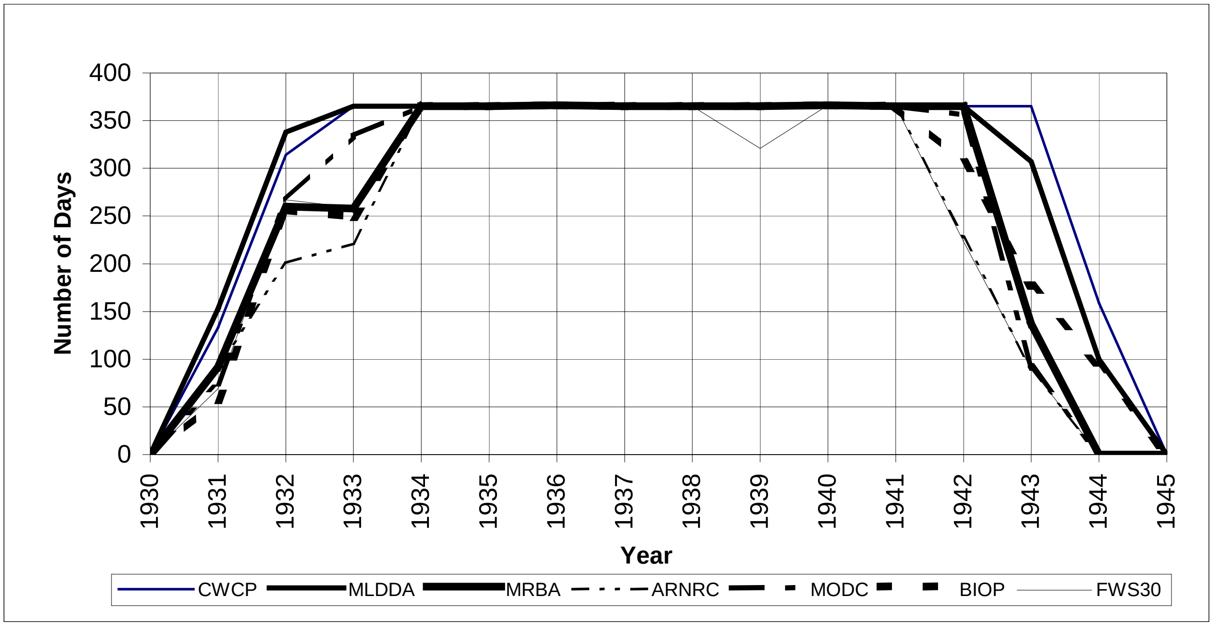

Figure 5.2-4. Lake Sakakawea number of days per year below elevation 1,825 feet, 1930 to 1941 drought.

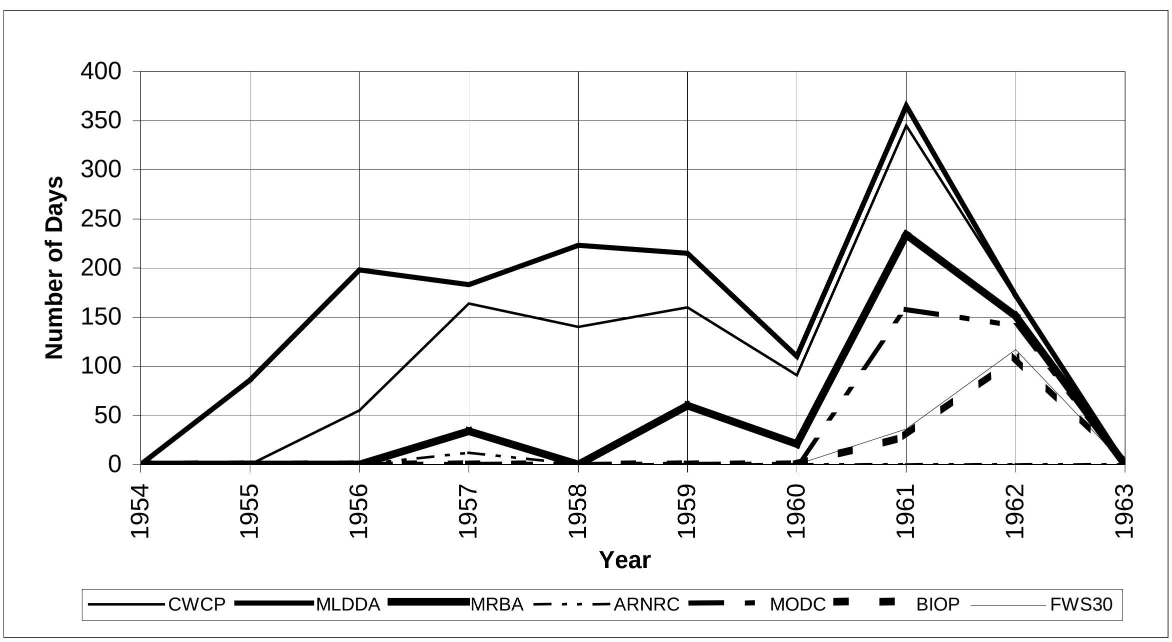

Figure 5.2-5. Lake Sakakawea number of days per year below elevation 1,825 feet, 1954 to 1961 drought.

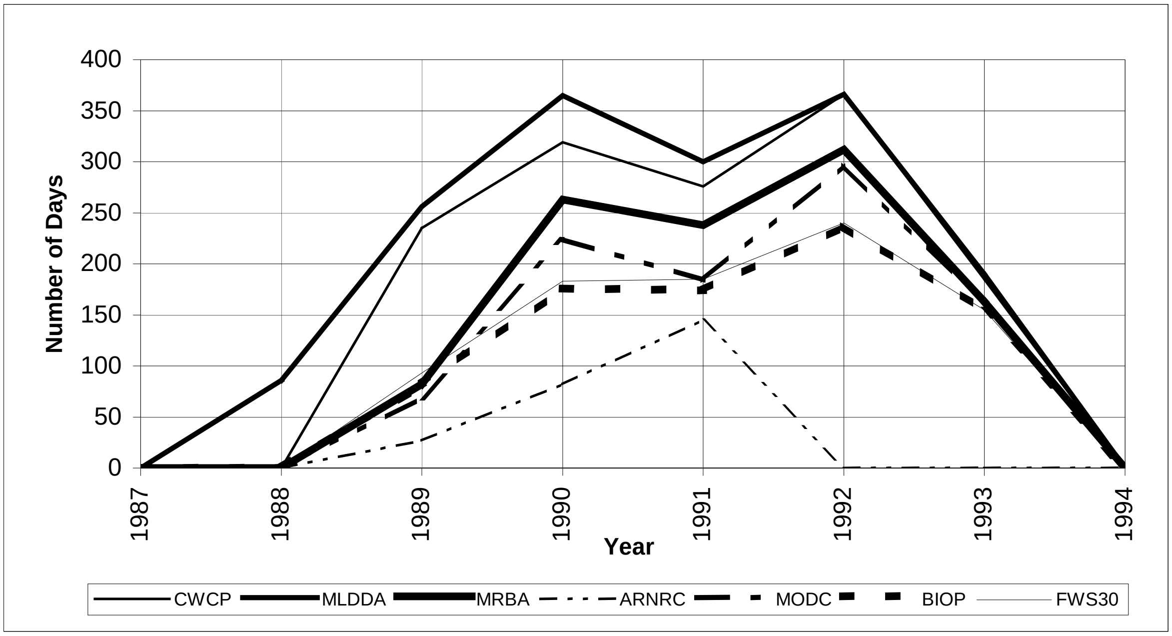

Figure 5.2-6. Lake Sakakawea, number of days per year below elevation 1,825 feet, 1987 to 1993 drought.

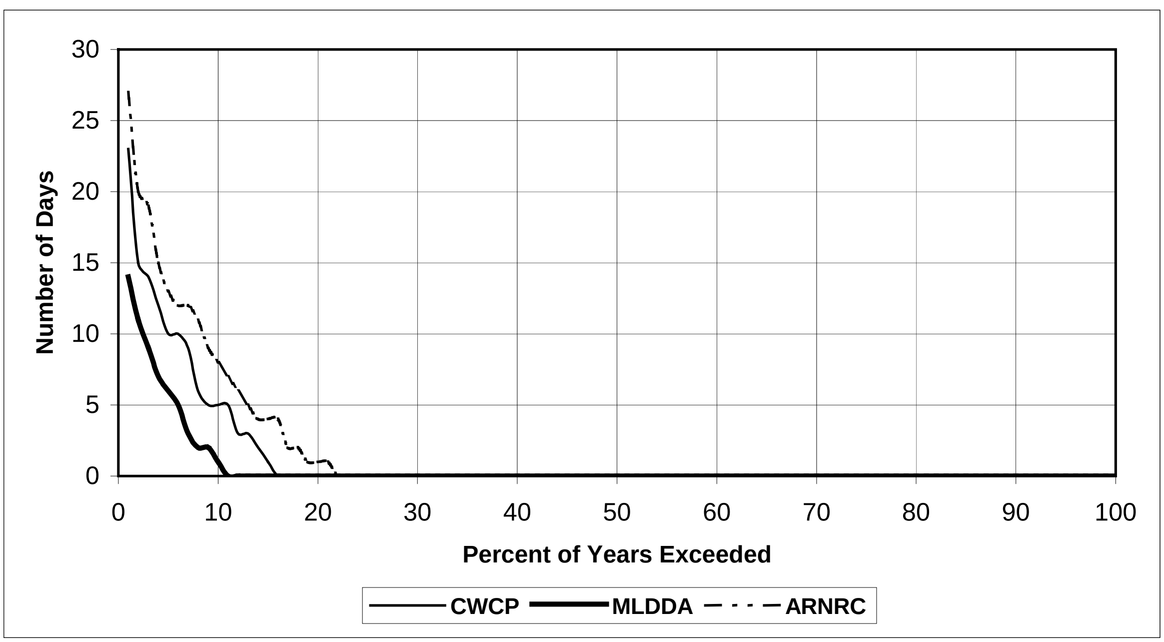

Figure 5.2-7. Missouri River at Bismarck, number of days flows exceed 55 kcfs, April through June for CWCP, MLDDA, and ARNRC alternatives.

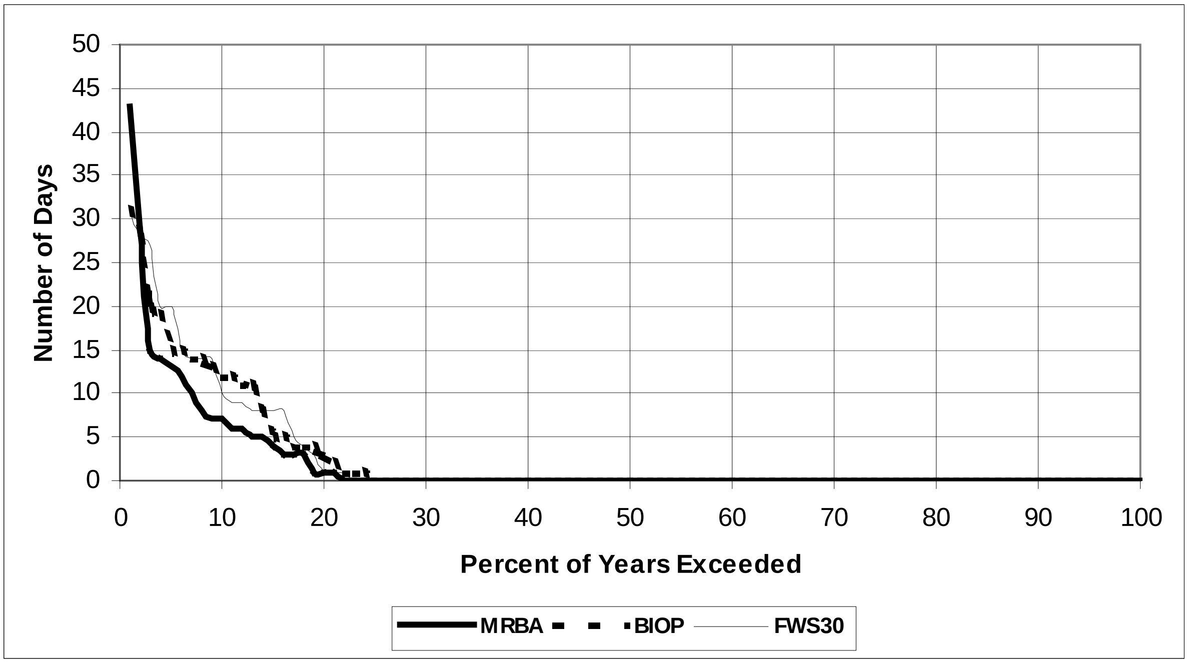

Figure 5.2-8. Missouri River at Bismarck, number of days flows exceed 55 kcfs, April through June for MRBA, BIOP, and FWS30.

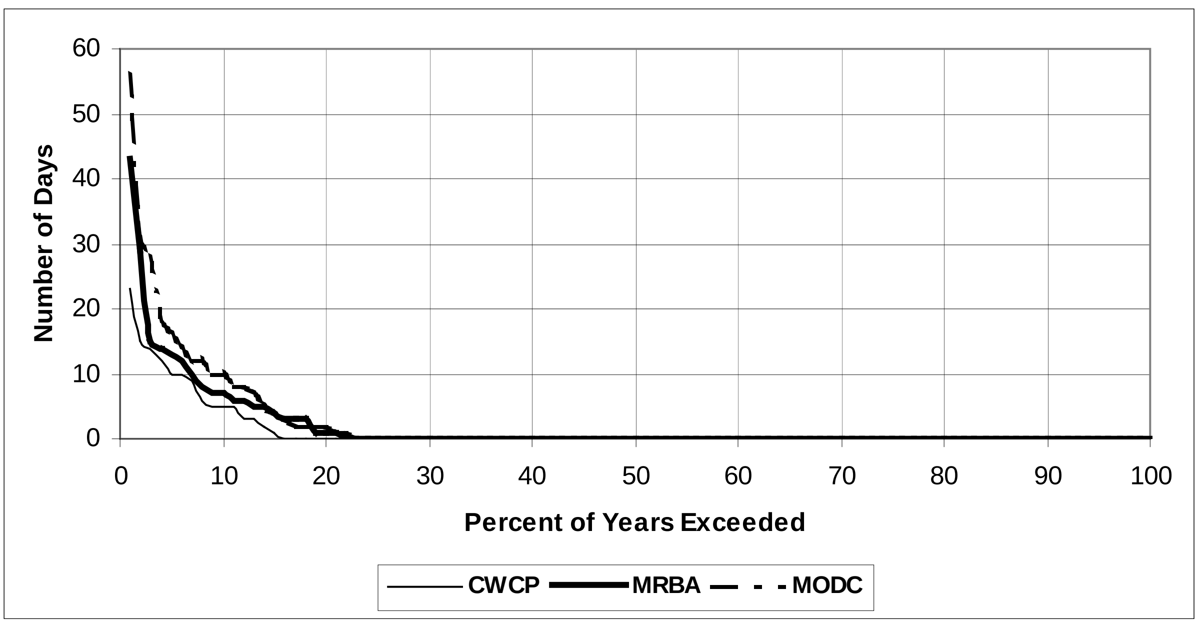

Figure 5.2-9. Missouri River at Bismarck, number of days flows exceed 55 kcfs, April through June for CWCP, MRBA, and MODC alternatives.

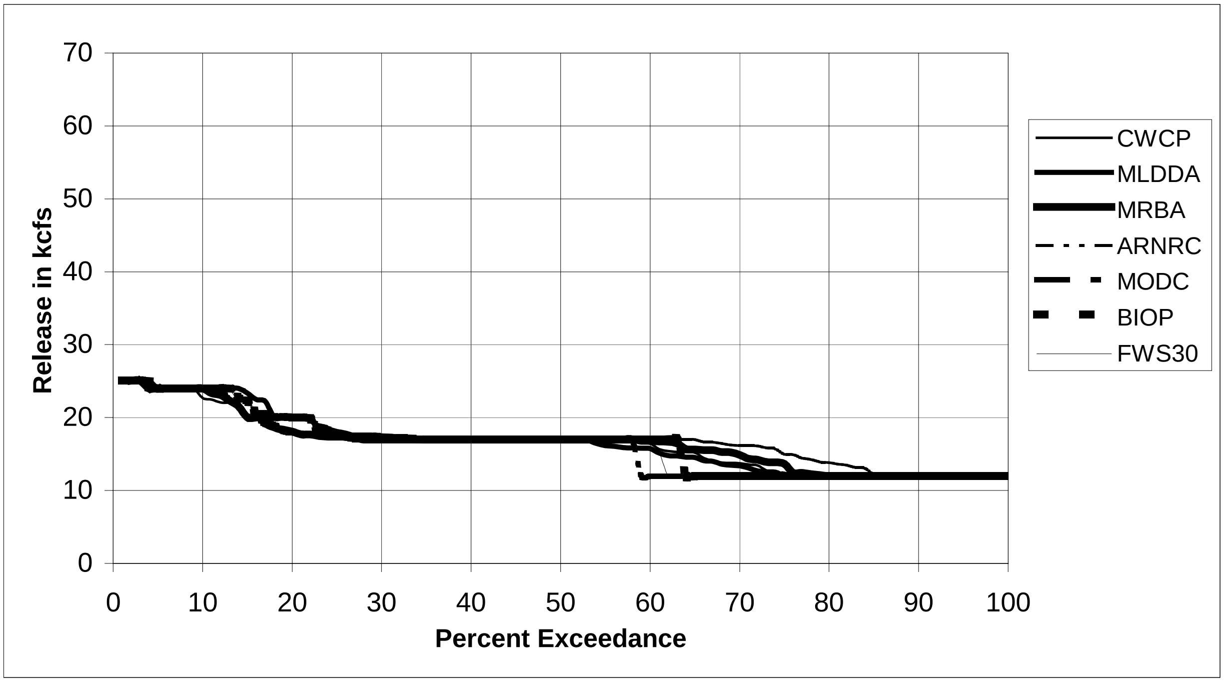

Figure 5.2-10. Gavins Point release duration, January.

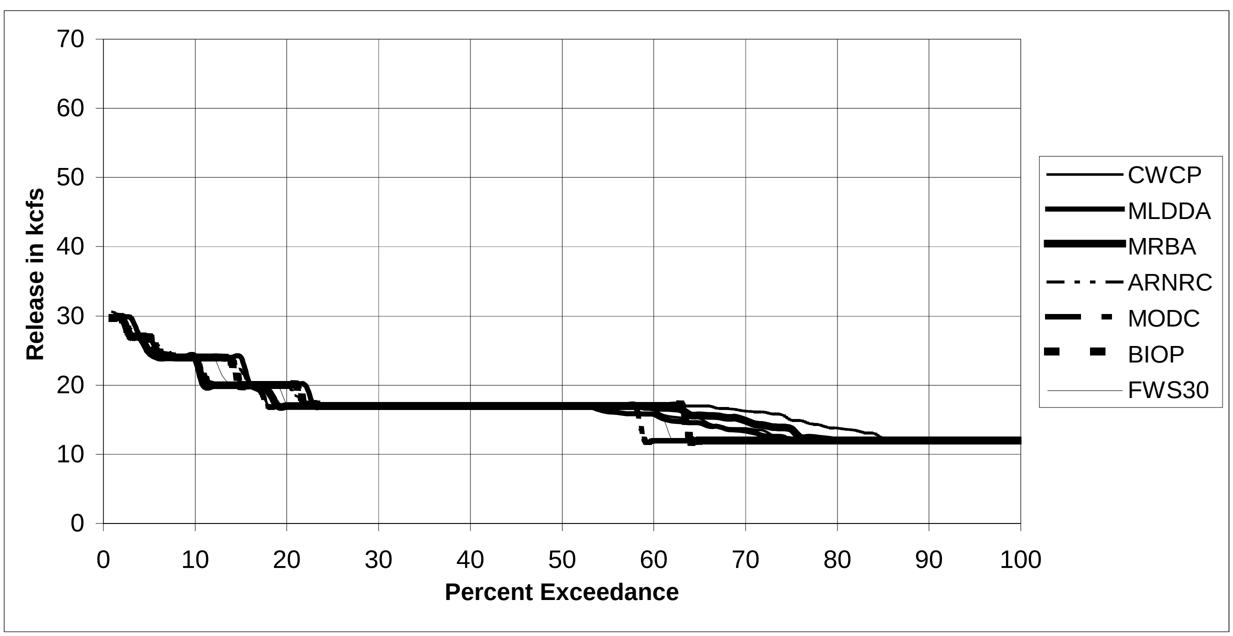

Figure 5.2-11. Gavins Point Dam release duration, February.

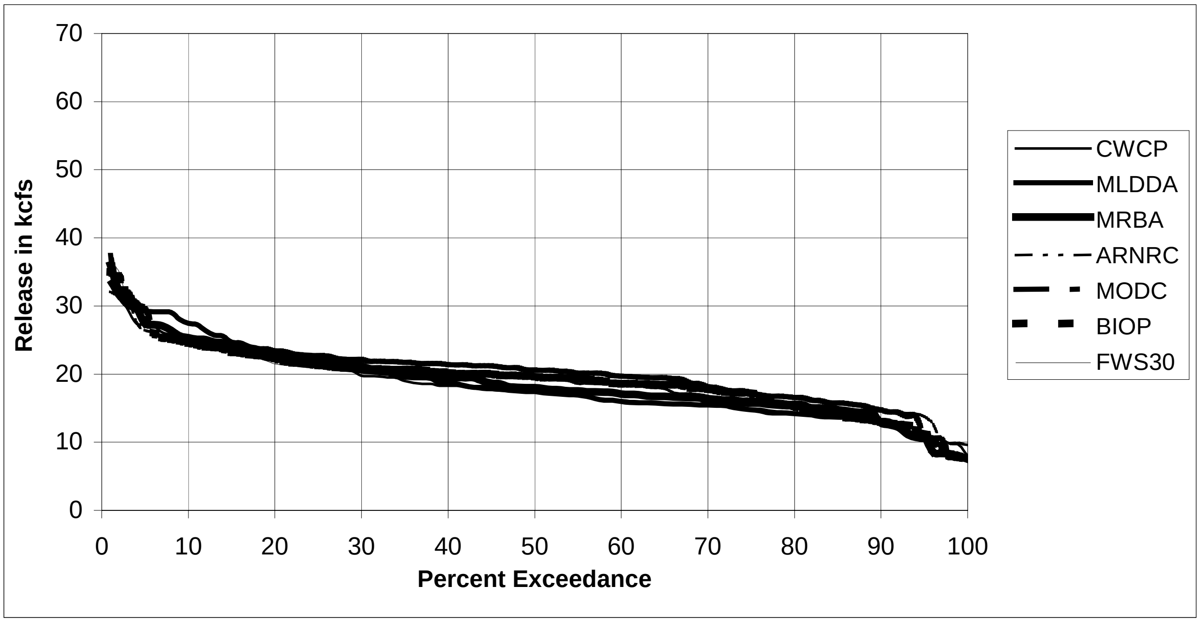

Figure 5.2-12. Gavins Point Dam release duration, March.

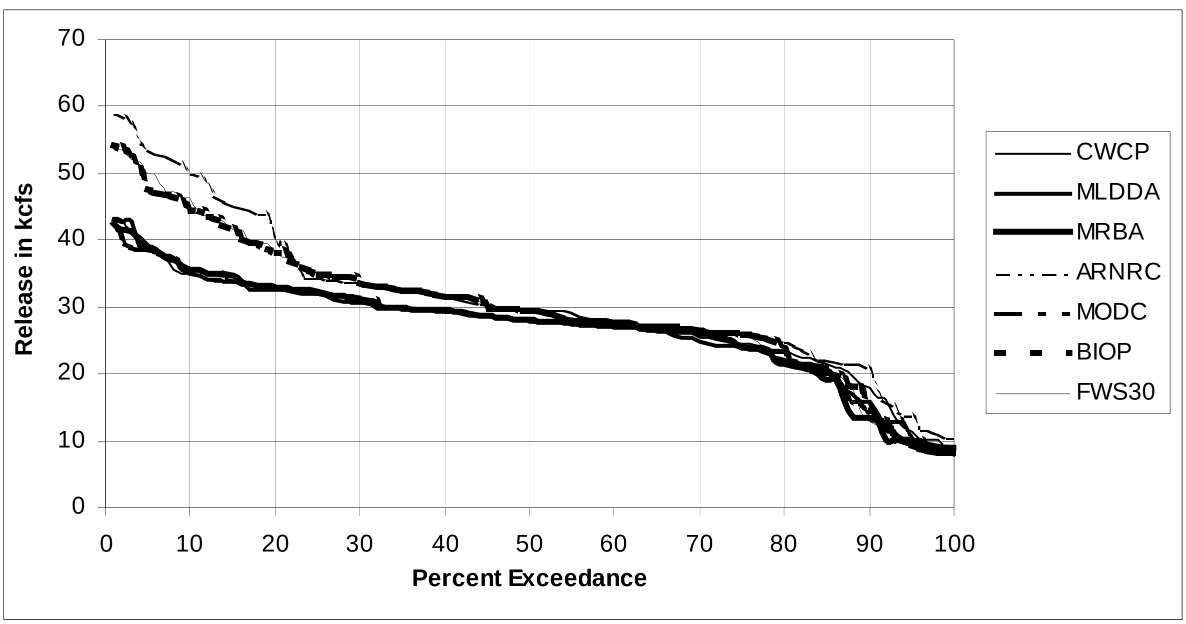

Figure 5.2-13. Gavins Point Dam release duration, April.

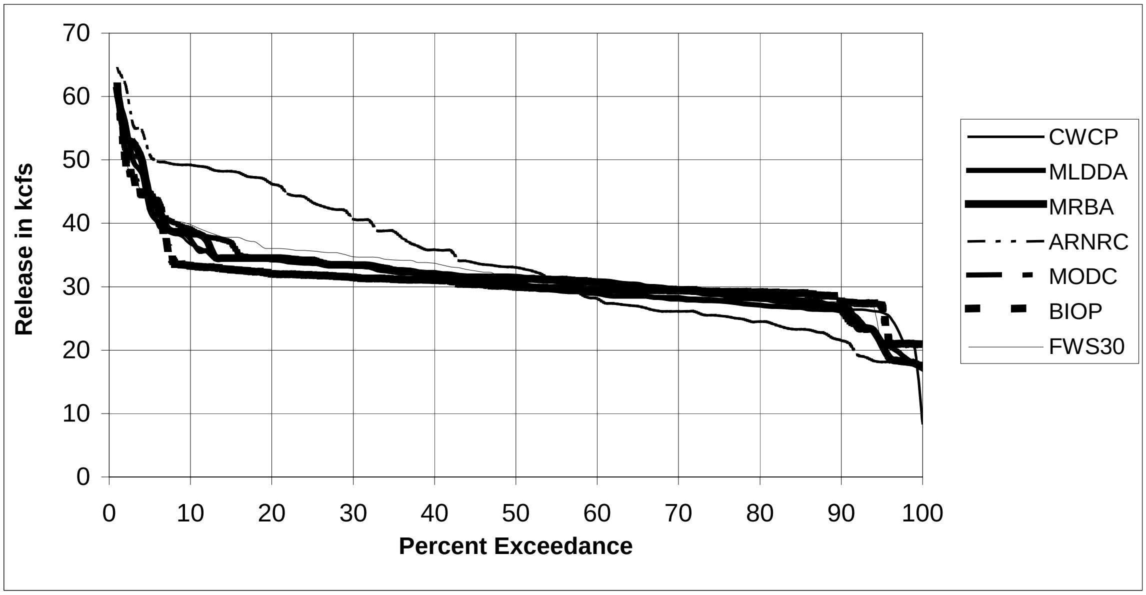

Figure 5.2-14. Gavins Point Dam release duration, May.

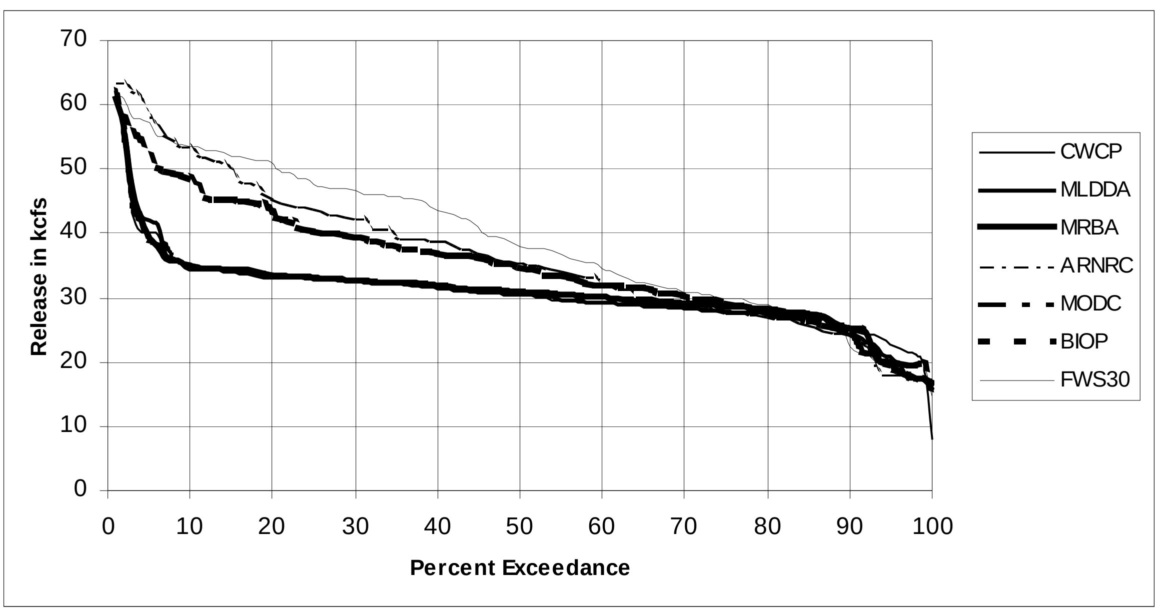

Figure 5.2-15. Gavins Point Dam release duration, June.

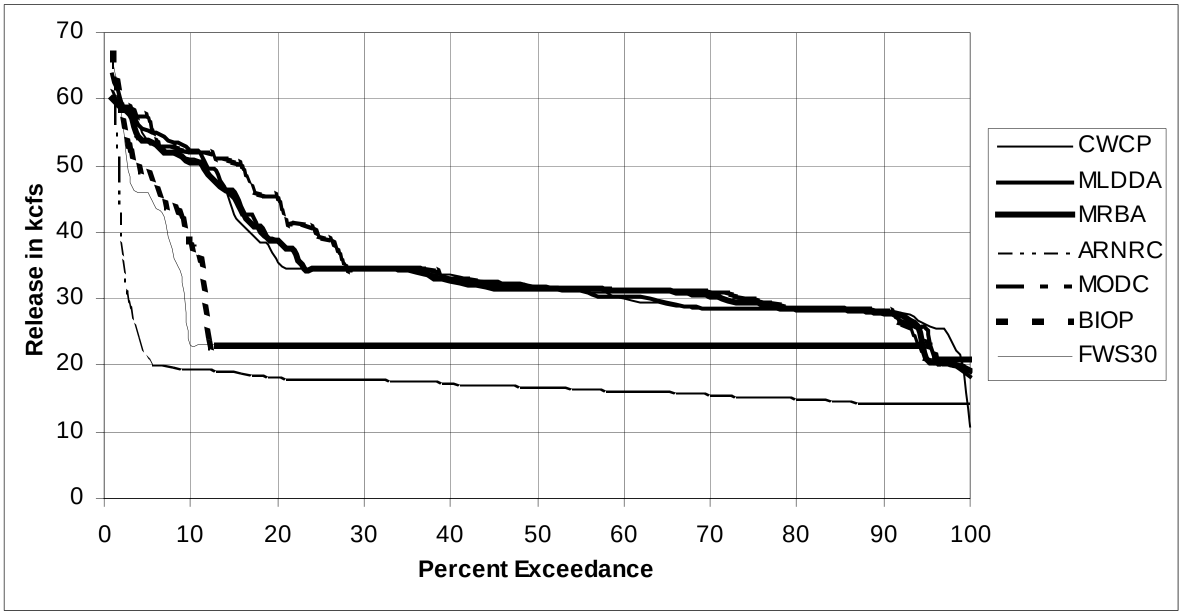

Figure 5.2-16. Gavins Point Dam release duration, July.

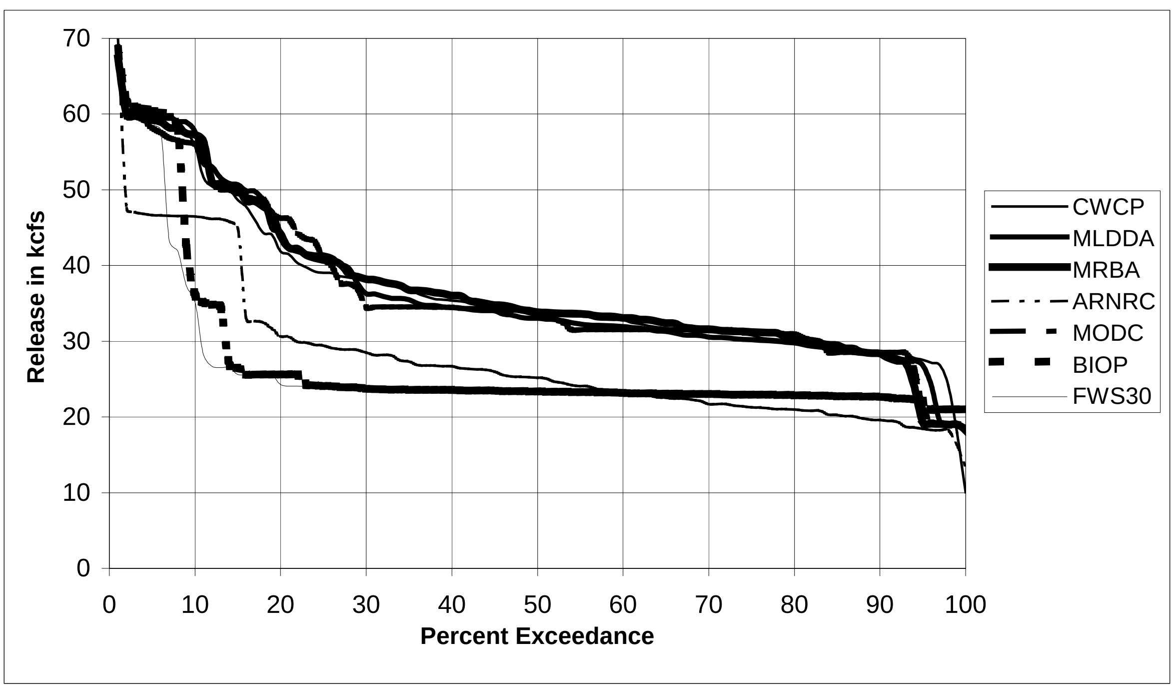

Figure 5.2-17. Gavins Point Dam release duration, August.

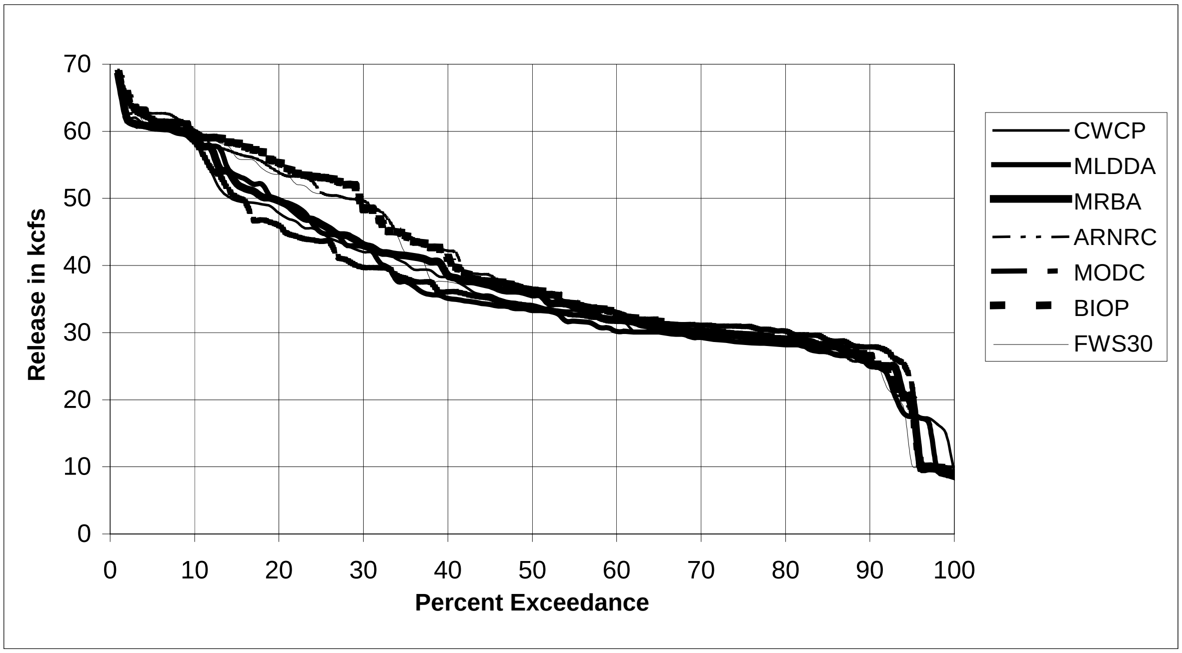

Figure 5.2-18. Gavins Point Dam release duration, September.

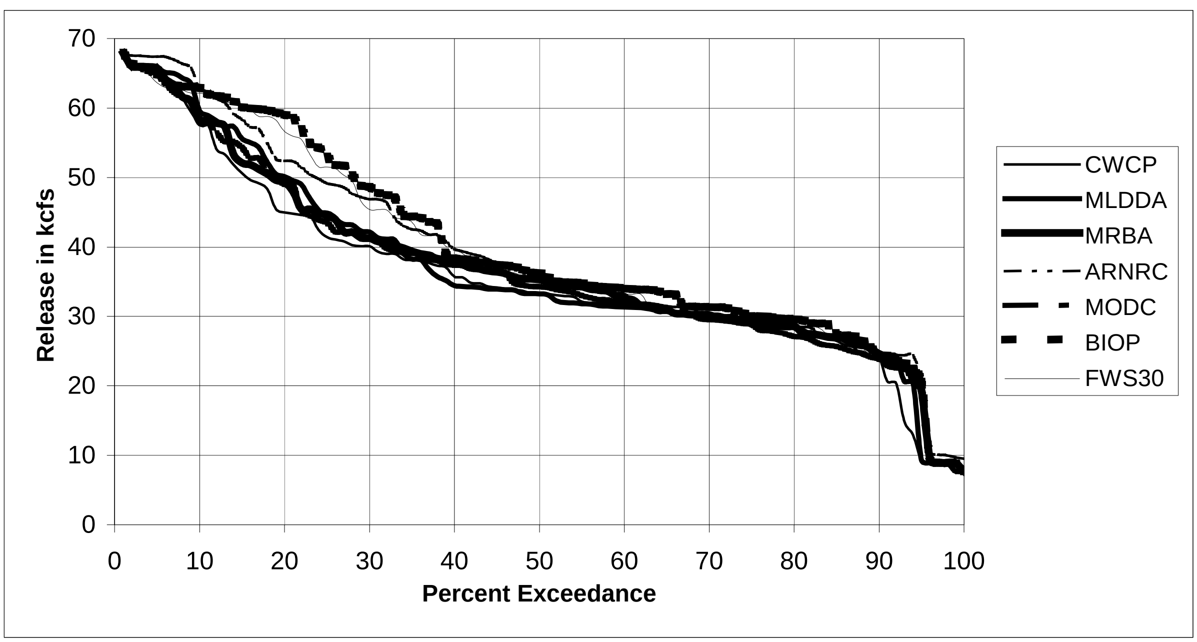

Figure 5.2-19. Gavins Point Dam release duration, October.

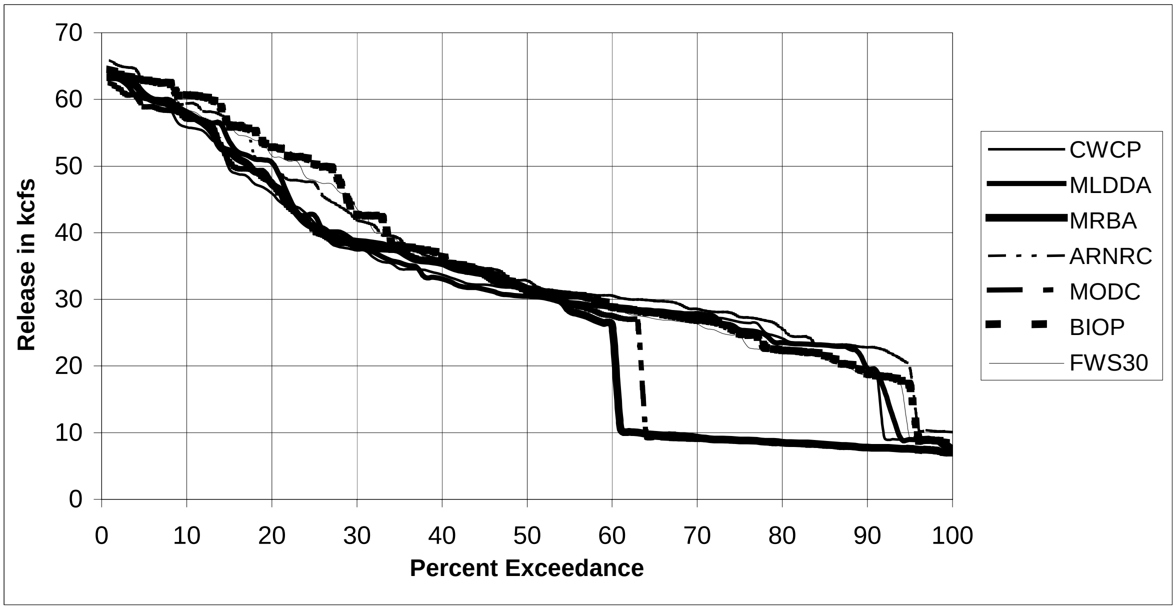

Figure 5.2-20. Gavins Point Dam release duration, November.

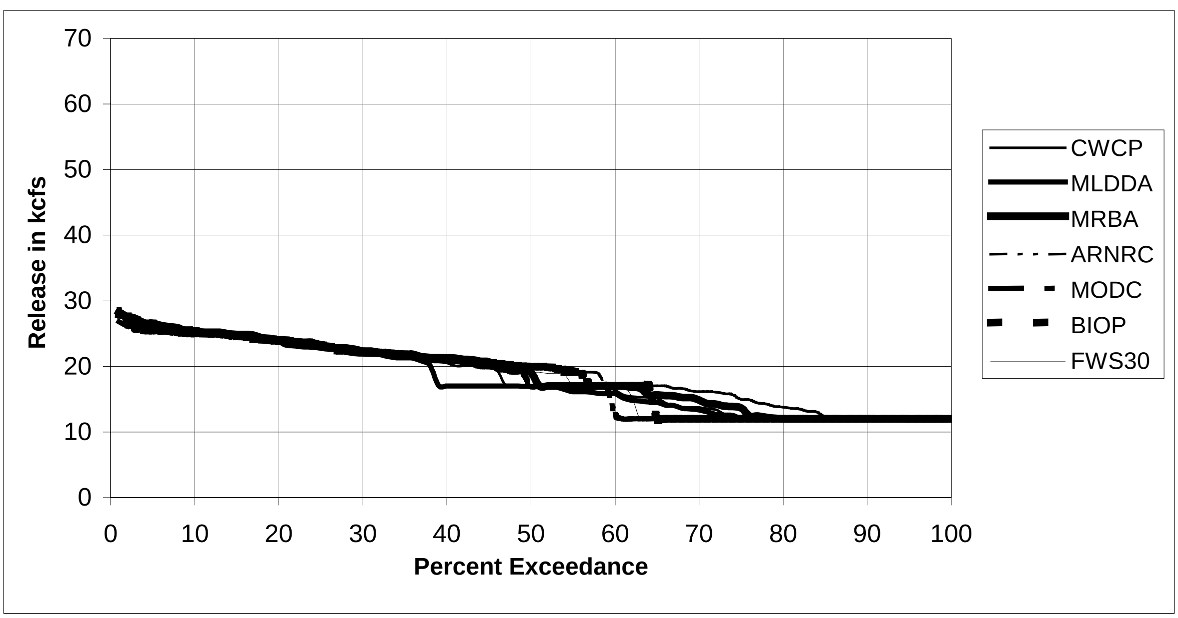

Figure 5.2-21. Gavins Point Dam release duration, December.

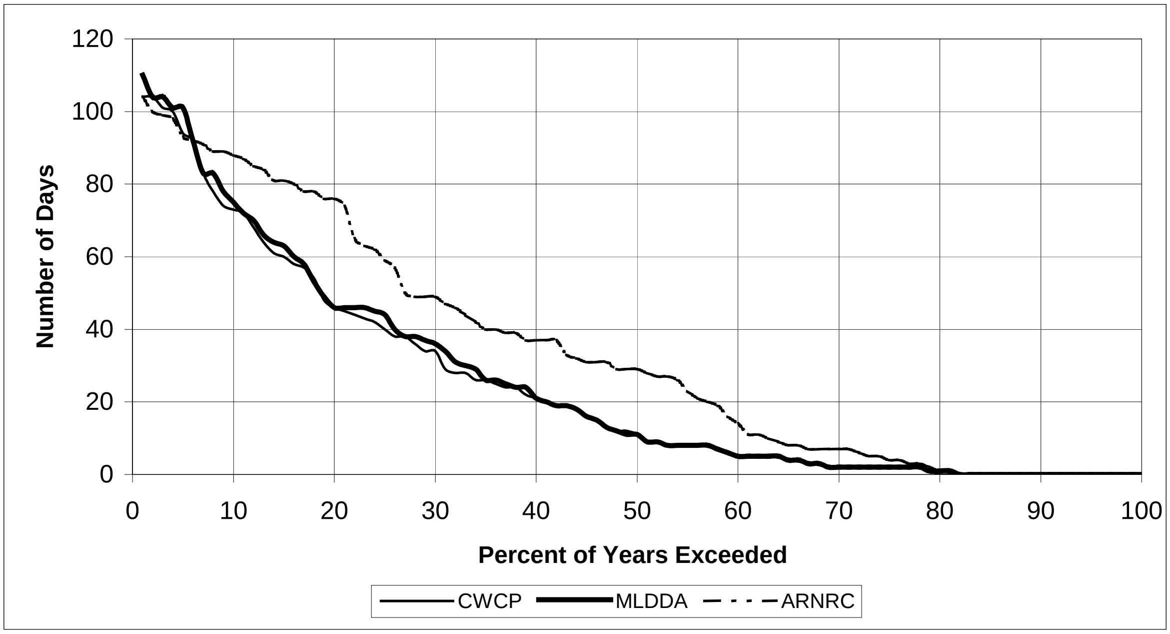

Figure 5.2-22. Missouri River at Nebraska City: Number of days flows exceed 55 kcfs, April through July for CWCP, MLDDA, and ARNRC alternatives.

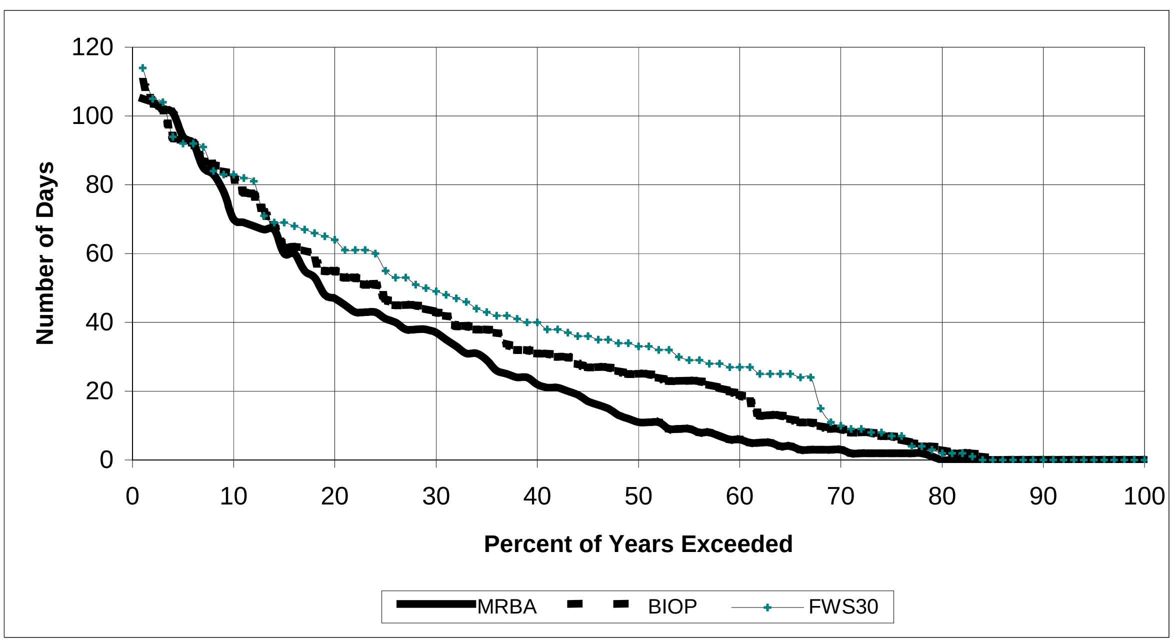

Figure 5.2-23. Missouri River at Nebraska City: Number of days flows exceed 55 kcfs, April through July for MRBA, BIOP, and FWS30 alternatives.

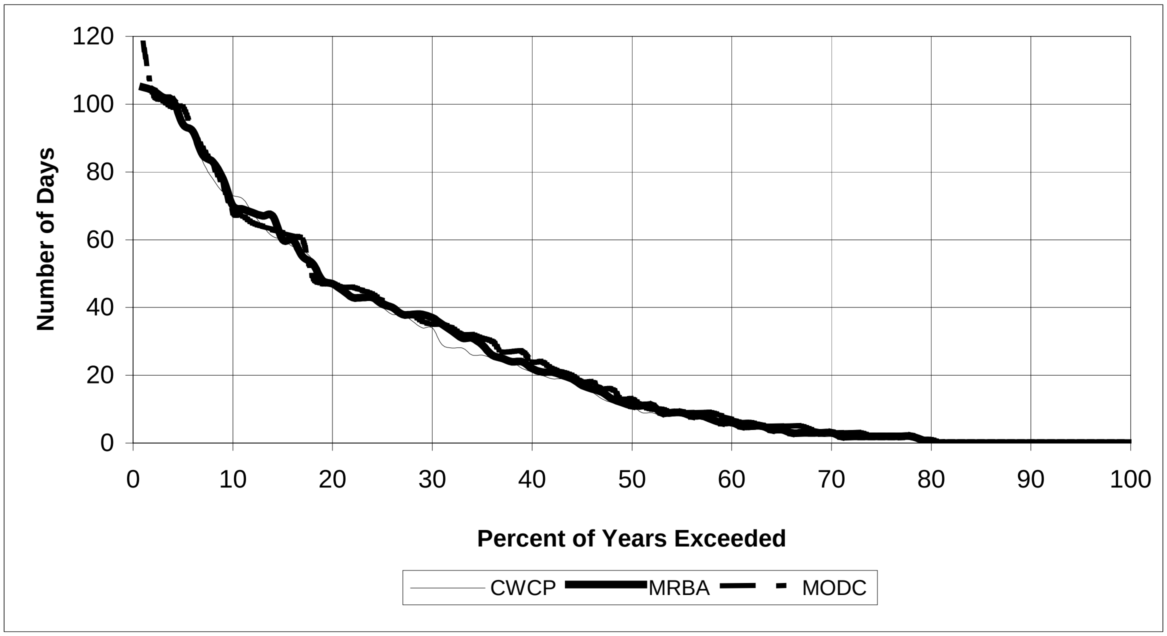

Figure 5.2-24. Missouri River at Nebraska City: Number of days flows exceed 55 kcfs, April through July for CWCP, MRBA, and MODC alternatives.

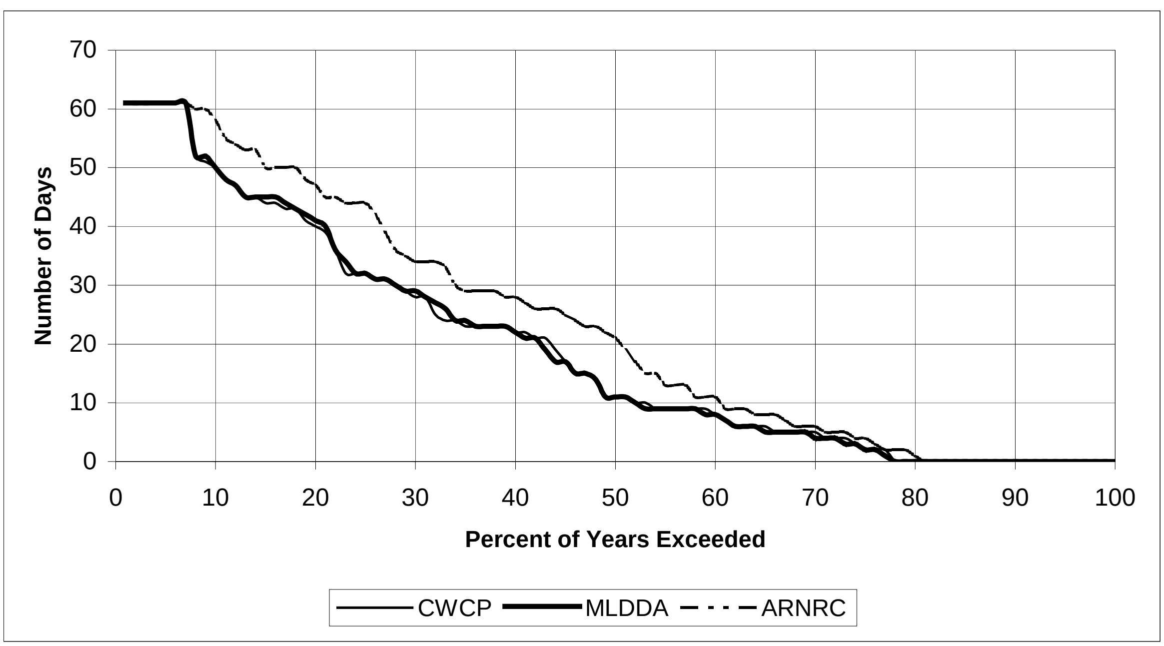

Figure 5.2-25. Missouri River at Boonville: Number of days flows exceed 90 kcfs, May through June for CWCP, MLDDA, and ARNRC alternatives.

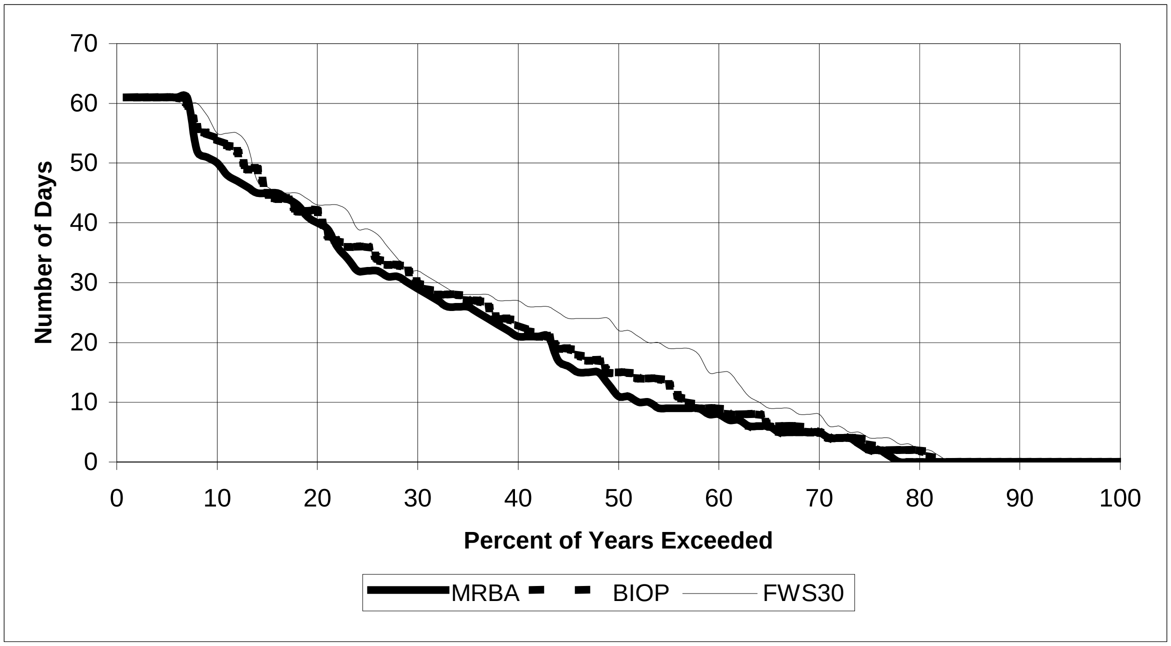

Figure 5.2-26. Missouri River at Boonville: Number of days flows exceed 90 kcfs, May through June for MRBA, BIOP, and FWS30 alternatives.

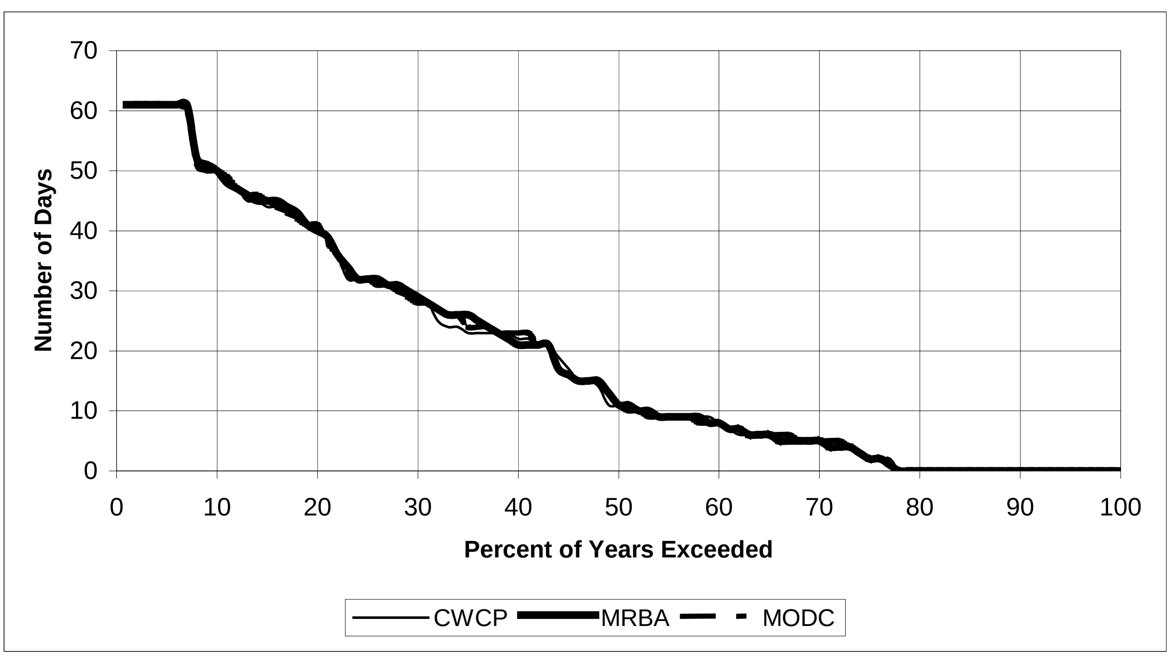

Figure 5.2-27. Missouri River at Boonville: Number of days flows exceed 90 kcfs, May through June for CWCP, MRBA, and MODC alternatives.

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5.3 SEDIMENTATION, EROSION, AND ICE PROCESSES

The amount of water in storage in the Mainstem Reservoir System lakes affects sedimentation (deposition) patterns and shoreline erosion within and upstream from the individual lakes. Differences in releases from the lakes affect the downstream riverbed and bankline erosion and ice processes. This section discusses in qualitative terms the relative effects of the alternatives on these processes. For additional technical analysis, please consult two technical reports on this subject: Aggradation, Degradation, and Water Quality Conditions (Corps, 1994f) and Cumulative Erosion Impacts Analysis (Corps, 1998h).

5.3.1 Sedimentation and Erosion

Mainstem Reservoir System operations have the potential to have a noticeable impact on sedimentation and erosion processes in extreme, short-lived situations. For example, the extreme high releases from Garrison Dam and subsequent flows past Bismarck in the late summer of 1997 resulted in considerable erosion in the Bismarck reach of the river. If erosion increases in one location, deposition must increase in another reach, in this case, the headwaters of Lake Oahe. Many, especially those affected by the erosion of reaches, would consider these impacts extensive. Storage losses due to sedimentation will continue at historic rates irrespective of how the Mainstem Reservoir System is operated. Although releases caused erosion, the more dominant factor affecting erosion was the extremely high water volumes (twice normal levels) flowing into the Mainstem Reservoir System in 1997.

In 1995, the Corps initiated an analysis to quantify the potential effects of flows on erosion as part of the Study. This analysis examined the data that the Corps has acquired over the last 4 to 5 decades on erosion in four reaches. These reaches are located between Fort Peck Lake and Lake Sakakawea, between Lake Sakakawea and Lake Oahe, between Lake Francis Case and Lewis and Clark Lake, and downstream from Lewis and Clark Lake. Although not addressed specifically in the analysis, the Fort Peck Reservation and the Yankton Reservation are directly related to these reaches. The conclusions of this analysis are summarized in Table 5.3-1. Sedimentation and erosion impacts for all of the alternatives are not addressed specific to individual Reservations, but rather to the reaches as a whole. The most relative conclusions of the erosion analysis are those comparing the CWCP with the past preferred alternative of the 1994 DEIS. Basically, the analysis found no relationship among the annual hydrograph and channel features affected by sediment erosion and deposition. Based on this statement, there appears to be little merit in further discussing the effects of the alternatives on the sediment erosion and deposition processes.

5.3.2 Ice Processes

Ice formation and movements are problems to contend with during the three winter months. All of the alternatives have the same minimum flow criteria downstream from Gavins Point Dam (12 kcfs average in winter months). Minimum flows are, therefore, not expected to be a problem among the alternatives. Higher flows tend to create more problems with ice, especially when the flows are transitioning from a lower flow to a higher flow.

Transitioning is a problem in two situations. The first is when ice initially forms but does not completely cross the channel. The movement of pieces of ice in the channel can be impeded, which allows the ice to collect and form an ice bridge across the channel that may restrict flows. Flooding can also be a problem if an ice bridge is too restrictive and does not break up. The second transitioning problem occurs once the ice has completely covered the channel. In such cases, the ice-covered channel may have a limited capacity that prevents an increase of flows. Differences among the plans that affect these two transitioning situations are not anticipated.

Table 5.3-1. Erosion study conclusions on erosion and deposition of channel features, additional stabilization, and operational changes.

Feature	Downstream of Fort Peck Lake	Downstream of Lake Sakakawea	Downstream of Lake Francis Case	Downstream of Lewis & Clark Lake
Bank Erosion	Rate of bank erosion in all of the reaches is declining with time. Trends are indicating that not all the banks are stable. Eroded material is entrained into the alluvial processes to build sandbars and channel border fills, but eroded material no longer builds high bank land.			
Bed Erosion	Approaching equilibrium	Approaching equilibrium	Still in adjustment phase	Factors from both ends of reach keep this reach most active.
Turbidity	Not analyzed	No correlation with flow	Not analyzed	No correlation with flow
Island Size	Not related to flow	Indirectly related	Directly related	Directly related
Sand Bar Size	Not related to flow	Indirectly related	Directly related	Directly related
Chutes/Border Fills	Discussion of these features was limited to changes with time and other channel feature changes and not related to flow.			
Downstream Lake Storage Losses	10 percent from the banks	6 percent from the banks 7 percent from the bed	20 percent from the banks	No downstream lake
Comparison of CWCP Versus the Past Preferred Alternative of the DEIS	The average channel velocities of the two plans are essentially identical; therefore, no significant difference in bank and channel bed erosion is expected even though annual variations in the hydrographs are significant. Annual sediment yields will be about the same. There should be no impact on the turbidity in the water. There should be no significant impact on islands, sandbars, and chutes.			

5.4 WATER QUALITY

5.4.1 Water Quality in the Lakes of the Mainstem Reservoir System

Water quality impacts to the Mainstem Reservoir System lakes were analyzed for the alternatives submitted for consideration by the Corps. The water quality impacts associated with the CWCP are described in Section 3.5. Table 5.4-1 qualitatively summarizes the effects on lake water quality of the submitted alternatives compared to the effects of the CWCP. No numeric impact values are given for the alternatives. Instead, a general indication is given of no change, a positive change, or a negative change to the mainstem lake water quality relative to the CWCP. The table provides a detailed description of the potential water quality impacts, the qualitative impacts of the alternatives relative to the CWCP, the rationale for the conclusion regarding the potential effects, and non-operational impact reduction activities. Overall, there is little difference between the potential impacts on water quality in the mainstem lakes of the CWCP and the submitted alternatives. Improved water quality conditions might be realized primarily from drought conservation measures that retain more water in the mainstem lakes during droughts than the CWCP.

The CWCP and the MLDDA alternative both include a balanced intrasystem regulation and do not include an additional spring and summer release, but the MLDDA alternative decreases the base of flood control storage by 2 MAF. A reduction in the system's base of flood control storage generally has little effect on water quality for the mainstem lakes. There is little difference in drought conservation between the CWCP and the MLDDA alternative.

Unlike the CWCP, the ARNRC alternative has increased drought conservation, an unbalanced intrasystem regulation, and a split navigation season (releases from Gavins Point Dam are not adequate to support navigation from mid-June through August). In comparison to the CWCP discharge flows, the ARNRC alternative contains a spring release increase of 15 kcfs and a lower summer release of 18 kcfs at Gavins Point Dam. The combination of an additional spring and a lower summer release from Gavins Point Dam mimics the natural flow of the Lower River and retains more water in the lakes through the mid-summer and fall period. The drought conservation measures have the most significant effect on lake water quality. These measures result in improved water quality by increasing the volume of water in the mainstem lakes, thus increasing the dilution of pollutants and reducing rapid fluctuation in lake levels during extended droughts.

The MRBA alternative maintains a flat release from Gavins Point Dam during the summer; however, intrasystem regulation is unbalanced and conservation of water in the upper three lakes during droughts is increased. The latter change, increased conservation during droughts, results in an overall improvement in water quality in the mainstem lakes by increasing lake-surface elevation and volume during droughts compared to the CWCP. The MRBA alternative reduces the drastic fluctuations in lake levels, thereby improving coldwater fish habitat in some of the drought years. It also provides greater protection against developing eutrophic conditions by having more water in storage to dilute nutrient loading from tributaries. The MRBA and ARNRC alternatives have similar levels of water conservation in the lakes during droughts; the major differences between the two alternatives are the higher spring releases and lower summer releases from Gavins Point Dam and the higher spring releases from Fort Peck Dam in many years that are in the ARNRC alternative.

Compared to the CWCP, the MODC alternative improves lake water quality, primarily during droughts. The MODC has the same conservation measures and spring and summer flows as the MRBA alternative but includes a longer, 34.5-kcfs release until mid-September in response to delaying the evacuation of excess water in the flood control zones. It also includes a spring rise out of Fort Peck Lake.

The lower summer releases from Gavins Point Dam that are part of the BIOP and FWS30 alternatives improve water quality in the mainstem lakes. Both the BIOP and FWS30 alternatives have the same drought conservation measures as the MRBA and MODC alternatives; however, they also have a spring rise release from Gavins Point Dam. The lower summer flows slightly reduce the drawdowns of the lakes because the flows are slightly lower during the summer in drought years. Increased water conservation and reduced lake drawdown in the summers during droughts will improve water quality conditions by reducing eutrophic conditions and increasing coldwater fish habitat.

5.4.2 Water Quality in the River Reaches of the Missouri River

This section compares the impacts of the submitted alternatives on water quality in the Upper and Lower River reaches with the impacts of the CWCP. Water quality impacts on river reaches associated with the CWCP are discussed in Section 3.5. Table 5.4-2 qualitatively summarizes the effects on water quality in the river reaches of the submitted alternatives compared to the CWCP. No numeric impact values are given for the alternatives. Rather, a general indication is given of no change, a positive change, or a negative change to the water quality in the river reaches relative to the CWCP. The table provides a detailed description of the potential water quality impacts to the Missouri River reaches, the qualitative impacts of the alternatives relative to the CWCP, the rationale for the conclusion regarding the potential effects, and non-operational impact reduction activities. The negative impacts are primarily related to alternatives that have lower summer releases at Gavins Point Dam than the CWCP.

The CWCP and the MLDDA alternative both include a balanced intrasystem regulation and do not include an additional spring and summer release, but the MLDDA alternative decreases the base of flood control storage by 2 MAF. There is little difference in water conservation between the CWCP and the MLDDA alternative. A reduction in the system's base of flood control storage generally has little effect on the water quality of the Missouri River reaches.

The ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season, unlike the CWCP. Compared to the releases under the CWCP, the ARNRC alternative includes a spring release increase of 15 kcfs in many years and a lower summer release of 18 kcfs at Gavins Point Dam. The combination of an additional spring and a lower summer release from Gavins Point Dam that mimics the natural flow of the Lower River can affect water quality conditions. Improved water quality conditions will result in the Upper River, where the Fort Peck Dam spillway will be used to reduce coldwater thermal discharge impacts downstream; however, some contend that the spillway discharges could adversely affect downstream water quality by increasing streambank erosion and sediment loading in the river. At this time, the Corps believes additional erosion on an annual basis will be limited to the bankline directly across the river from the spillway. Other negative changes to water quality in the Upper River involve the use of the spillway, which may increase total dissolved gas concentrations above the National standard of no more than 110 percent of saturation. The negative changes to water quality in the Lower River result from the ARNRC alternative's reduced summer releases out of Gavins Point Dam, which provide less dilution of pollutants (including thermal waste discharges) entering the river from point and nonpoint sources.

The MRBA alternative maintains a flat release from Gavins Point Dam during the summer; however, intrasystem regulation is unbalanced and drought conservation in the upper three lakes is increased above the CWCP level. This alternative results in no water quality changes to the Upper and Lower River relative to the CWCP.

Compared to the CWCP, the MODC alternative has both positive and negative effects on water quality. Improved water quality conditions will result in the reach downstream from Fort Peck Dam. The Fort Peck Dam spillway will be used in many springs to reduce the thermal impacts of coldwater releases downstream. During these spring rises, the spillway discharges may adversely affect downstream water quality by temporarily increasing streambank erosion and sediment loading in the river. The spillway discharges also have the potential to increase total dissolved gas concentrations above the National standard. The MODC alternative has the same spring- and summertime flows as the CWCP, but has a longer,

Table 5.4-1. Water quality effects of submitted alternatives on the Missouri River mainstem lakes[1/]. Page 1 of 3

			Effects of Alternatives Compared to the CWCP							
Potential Impact	**Description**	**Lake**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**	**Rationale for Effect**	**Impact Reduction**
Arsenic concentrations may increase in water column, exceeding Tribal and State water quality standard for domestic drinking water and aquatic life.	Arsenic from the Missouri River basin (natural background and nonpoint sources) becomes adsorbed onto solids entering and being deposited in the lakes. The wave action erodes and agitates the lake sediments during low lake levels, potentially causing elevated dissolved arsenic concentrations in the water column. Elevated arsenic concentrations during low lake elevations and drought conditions may affect domestic water use (requiring additional treatment prior to domestic use) and cause chronic effects to aquatic life in lakes.	FPL, SAK, OAHE	NC	NC	NC	NC	NC	NC	Adverse effects are greatest during droughts when lakes are drawn down and bottom sediments are exposed to erosive effects of waves on the lakes. The alternatives generally have lower or higher lake levels than the CWCP during droughts and, no matter what the alternative is, the lake levels will expose sediments containing adsorbed arsenic.	Sediments with arsenic are already deposited in the lakes from background, point, and nonpoint sources. Accumulation of additional arsenic in the top layers of deposited sediments can be reduced if the arsenic can be stopped at the source. Domestic water systems should test for arsenic, metals, and other pollutants to ensure water supplies are protective of human health.
There may be an increase in exposure of fish to sediment containing mercury, pesticides, and other toxic pollutants that will accumulate in fish tissue.	Advisories have been issued for fish caught in the mainstem lakes in the States of Montana, North Dakota, South Dakota, and Nebraska. Montana suggests limiting the consumption of walleye, northern pike, lake trout, and Chinook salmon due to elevated levels of mercury. In North Dakota, all species and size of fish tested were found to contain mercury. Elevated levels of PCBs and dieldrin in channel catfish taken from the river were found in Nebraska.	All	NC	NC	NC	NC	NC	NC	The alternatives presented will not affect the loading and ultimate fate of metals, pesticides, and other toxic pollutants. Increased methylation of mercury in the lake sediments is not expected to change under these alternatives compared to the CWCP.	The EPA should work with Tribes, States, and other entities to establish an integrated monitoring program to assess increased bioaccumulation of toxic pollutants in lakes. As part of the Missouri River adaptive management process, bioaccumulation of metals and pesticides should be addressed based upon reliable water quality and fish monitoring data. Action needs to be taken in the watershed to reduce point and nonpoint sources of pollutants that bioaccumulate in fish tissue.

Table 5.4-1. Water quality effects of submitted alternatives on the Missouri River mainstem lakes[1/]. Page 2 of 3

Potential Impact	Description	Lake	Effects of Alternatives Compared to the CWCP: MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30	Rationale for Effect	Impact Reduction
Severe fluctuations in lake elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe may affect the size and quality of coldwater fish habitat.	Reduction in coldwater habitat in lower levels of lakes occurs in Fort Peck Lake, Lake Oahe, and Lake Sakakawea. The low lake volume in combination with warmwater temperatures can decrease the dissolved oxygen concentrations below State water quality standards. The hypolimnion during summer stratification conditions can offer limited habitat area for coldwater fish species that require dissolved oxygen greater than 5 mg/L and a water temperature of less than 10°C.	FPL, SAK, OAHE	NC	+	+	+	+	+	The alternative with NC means that no change relative to the CWCP is expected since the summer flows are the same and there is no water conservation. The ARNRC, MRBA, BIOP, FWS30, and MODC alternatives all have more drought water conservation than the CWCP. These alternatives get a + because the increase in conservation will cause less severe fluctuations in lake levels during drought conditions. The ARNRC, BIOP, and FWS30 alternatives have summer releases from Gavins Point Dam that limit drawdown of lakes in summer relative to the CWCP.	States should make a lake management decision about maintaining a coldwater fishery in lakes during droughts. Drought conditions, by decreasing suitable coldwater habitat, affects coldwater species. States need to consider management options such as re-stocking after droughts or introducing more temperature-tolerant species.
Low lake levels contribute to the development of eutrophic conditions (nutrient enrichment) in the lakes.	Nutrient concentrations in lakes may increase due to reduced lake volumes during extended droughts that provide less dilution to nutrient loads under normal conditions. Nutrient and metal releases from anoxic conditions may occur. The decomposition of organic matter may decrease available dissolved oxygen concentrations in the hypolimnetic region of the lake. Blue green algae blooms can also cause aesthetic and water quality problems.	FPL, SAK, OAHE	NC	+	+	+	+	+	The alternative with NC means that no change relative to the CWCP is expected since the summer flows are the same and there is no change in water conservation. The ARNRC, BIOP and FW30 alternatives all have lower summer flows and more water conservation than the CWCP. These alternatives plus MODC have greater drought conservation measures than the CWCP. These alternatives get a + because of the increase in conservation and lower summer releases that will result in more water volume to dilute nutrient loading during drought in summer months, when eutrophic responses are most noticeable. The MODC has the same flow and conservation conditions as the CWCP and therefore no change is expected.	Reduce nutrient loading from point and nonpoint sources within the watersheds. Under the Missouri River adaptive management strategy, the Corps, Tribes, and States should review potential water quality concerns, referencing water quality monitoring data specific to eutrophic conditions.

Table 5.4-1. Water quality effects of submitted alternatives on the Missouri River mainstem lakes[1/]. Page 3 of 3

			Effects of Alternatives Compared to the CWCP							
Potential Impact	**Description**	**Lake**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**	**Rationale for Effect**	**Impact Reduction**
Missouri River flows will transport and deposit large amounts of sediment, causing more problems in achieving narrative sediment standards.	Narrative water quality standards for sediment (siltation) are being exceeded in four lakes (Sharpe, Oahe, Francis Case, and Lewis and Clark Lakes). Siltation and sediment accumulation are the primary reasons for lake impairment and habitat changes.	SRP, LFC, LC, OAHE	NC	NC	NC	NC	NC	NC	Sediment erosion, transport, and deposition are a normal process when operating dam systems. The dam system developed on the Missouri River has resulted in less total suspended solid loading throughout the river system. The total amount of sediment loading will not be affected by the alternatives' flow regimes in the river during the spring and summer. High sediment loading into lakes comes from tributaries within the watershed with highly erodible soils. Tributaries with high sediment loading into the mainstem lakes include the Bad River (Lake Sharpe), the White River (Lake Francis Case), the Niobrara River (Lewis and Clark Lake), and Cheyenne River Arm (Lake Oahe).	Control sediment loading through source control in the watersheds. Implement nonpoint and stormwater control practices such as the Section 319 Project on the Bad River. Erosion control studies that involve both structural controls and best management practices are needed to reduce high sediment loading.

1/ legend for abbreviations used in table:
(+) means positive change or improvement to environment
NC means no change
(-) means negative impact to environment
All – All lakes in Mainstem Reservoir System
FPL – Fort Peck Lake
SAK – Lake Sakakawea
OAHE – Lake Oahe
SRP – Lake Sharpe
LFC – Lake Francis Case
LC – Lewis and Clark Lake

34.5-kcfs release to mid-September. The MODC alternative also has the same water conservation conditions and unbalancing of the storage among the upper three lakes as the MRBA alternative, which results in no water quality changes in the river reaches.

The lower summer flows associated with the BIOP and FWS30 alternatives may have a negative effect on water quality in the Missouri River reaches. Both the BIOP and FWS30 alternatives include the low summer releases from Gavins Point Dam, ranging from 21 to 25 kcfs, thereby creating lower flow conditions downstream of Gavins Point Dam (and also Fort Randall Dam) than the CWCP. Most of the negative impacts in the Lower River result from reduced summer flow that provides less dilution of pollutants entering the river. Under extended drought conditions, these alternatives have more years during which navigation would not be served than the CWCP (5 years versus 1 year), which is also the case for the MRBA and MODC alternatives. The summer flow would drop to 18 kcfs in these years. Flows could be as low as 9 kcfs in the non-summer months in many of the drought years; however, these low flows would also occur under the CWCP. In those years during which the summer release from Gavins Point Dam would be 18 kcfs, even less dilution of pollutants would occur. Low-flow conditions during droughts may negatively affect aquatic life and recreational uses due to a loss of pollutant dilution. All of the low-flow conditions may negatively affect powerplant thermal discharge permits and thermal conditions within the river. Under the BIOP and FWS30 alternatives, improved water quality conditions will result in the Upper River, where the Fort Peck Dam spillway will be used to reduce the thermal impacts of coldwater releases downstream relative to the CWCP. The spillway discharges may negatively affect downstream water quality by increasing streambank erosion and sediment loading in the river during the spring rise from Fort Peck Dam.

5.4.3 Water Quality for Tribal Reservations

There are numerous uses for the Missouri River designated by the Tribes, EPA, and the States. These designated uses include coldwater and warmwater aquatic life, domestic drinking water, recreation, agriculture, and industrial uses. Tribes have water rights to the Missouri River and are actively involved with managing their water resources.

Overall, there is no change in water quality associated with the MLDDA alternative compared to the CWCP in water segments associated with Tribal Reservations. Both alternatives have a balanced intrasystem regulation and do not have an additional spring and summer release, but the MLDDA alternative decreases the base of flood control storage by 2 MAF. A reduction in the system's base of flood control storage generally has little effect on water quality for Tribes located near the mainstem lakes. There is little difference in water conservation between the CWCP and the MLDDA alternatives.

The MRBA has flow characteristics similar to those of the CWCP but it has an unbalanced intrasystem regulation and greater drought conservation measures. The ARNRC, BIOP, and FWS30 alternatives have increased drought conservation, an unbalanced intrasystem regulation, and a split navigation season, unlike the CWCP. The combination of an additional spring and a lower summer release from Gavins Point Dam that mimics the natural flow of the Lower River retains more water in the lakes during the mid-summer through fall period. The drought conservation measures are most beneficial for Reservations that are adjacent to the lakes in the upper portion of the basin. These alternatives result in improved water quality conditions for the Tribes by increasing the volume of water in the mainstem lakes, thus increasing the dilution of pollutants and reducing the fluctuation of the lake levels during drought conditions.

The submitted alternatives have different impacts to individual Reservations, depending on the location of the Reservation in the Missouri River basin. The Missouri River reach downstream from Fort Peck Dam that is adjacent to Fort Peck Reservation has the following designated uses: domestic drinking water, recreation, agriculture, and industry. There are several water quality problems or concerns for the Missouri River reach serving Fort Peck Reservation, which include coldwater releases and erosion of sediment into the river. No change in water quality is anticipated under the MLDDA and MRBA alternatives because they have Fort Peck releases similar to the CWCP. The other four submitted alternatives have a spring rise out of Fort Peck Dam, with a portion of the release coming over the spillway. The coldwater problem is expected to improve with the warmer spillway release in the spring. Increased erosion is expected

Table 5.4-2. Effects of submitted alternatives on the river reaches of the Missouri River[1/]. Page 1 of 4

Potential Impact	Description	River Reach	Effects of Alternatives Compared to the CWCP						Rationale for Effect	Impact Reduction
			MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30		
Water discharged from dams causes channel alterations via bank and channel cuts that affect aquatic life habitat.	Dam discharges are considered to be aggressive since they are not in equilibrium with the receiving water sediment conditions, causing sediment erosion downstream. Erosion of river banks and channels near the dam discharge location can also be influenced by discharge velocity, channel morphology, and soil erosion potential. Erosion scours the river bed, which affects benthic aquatic life and lowers the elevation of the riverbed. The lowering of the riverbed elevation in turn lowers the local groundwater table, which affects vegetation and side channels.	Downstream of Fort Peck Dam	NC	-	NC	-	-	-	Four of the alternatives have a negative (-) impact relative to the CWCP. They have a spring water release from Fort Peck Dam. The spillway on the Fort Peck Dam will be used to draw warm water from the lake. The spillway will discharge water into the downstream reach at a high velocity, causing streambank erosion on the opposite side of the discharge. Increased bank erosion and sediment loading may occur.	Pilot testing will be performed by the Corps to assess potential erosion problems from using the spillway for thermal mixing downstream. Portions of the streambank areas being eroded by the high-velocity spillway discharges may be stabilized using best management practices for erosion control.
Coldwater releases at Fort Peck, Garrison, and Oahe Dams may affect downstream habitat by not meeting thermal water quality standards.	Discharge water from dams comes from releases of cold hypolimnetic water. Coldwater releases into designated warmwater habitats can affect aquatic life downstream until temperature equilibrium conditions are achieved. Montana is the only State on the Missouri River to list thermal modifications as a problem (Fort Peck only).	Downstream of Fort Peck Dam	NC	+	NC	+	+	+	Under the alternatives with a +, Fort Peck spillway will be used to discharge warmer water from the lake. Mixing with water released from the powerhouse will increase water temperatures downstream.	Construction of a selective withdrawal structure through which releases could be taken from optimum lake depths would improve thermal problems downstream. The TMDL study being performed by the State of Montana, EPA, and Fort Peck Tribe will review and assess alternatives to achieve water quality standards below Fort Peck Dam.
	North and South Dakota have not recognized that coldwater releases from Garrison and Oahe Dams contribute to water quality problems.	Downstream of Garrison and Oahe Dams	NC	NC	NC	NC	NC	NC	Garrison and Oahe Dam releases are not significantly affected by the alternatives.	N/A

Table 5.4-2. Effects of submitted alternatives on the river reaches of the Missouri River[1/].

Potential Impact	Description	River Reach	Effects of Alternatives Compared to the CWCP						Rationale for Effect	Impact Reduction
			MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30		
Flow regime changes from Gavins Point Dam will affect downstream NPDES permits for thermal discharges.	Lower flow conditions, especially during summer split and drought conditions, may affect critical low-flow assumptions (7Q10) in permits. Change in flow regimes may cause temperature violations by industries using water for once-through cooling water. Reduced flows in the Missouri River could cause some river segments to not meet thermal water quality standards.	Downstream of Gavins Point Dam to the Mississippi River	NC	-	NC	NC	-	-	Relative to the CWCP, alternatives MLDDA, MRBA, and MODC have no change. The downstream discharges of these alternatives from Gavins Point Dam are similar to the CWCP. Alternatives ARNRC, BIOP, and FWS30 have lower summer flows, with the lowest discharge at Gavins Point Dam at 21 kcfs. The alternatives that have summer flows lower than 25 kcfs at Gavins Point Dam may cause thermal problems downstream.	States will enforce NPDES permit conditions for thermal discharges. Renewed NPDES permits may need to be changed due to the change in flow regimes from Gavins Point Dam. Powerplants may need to consider using cooling ponds or towers to reduce thermal discharges into the river. Powerplants may have to reduce power generation capabilities when discharges at Gavins Point Dam are less than 25 kcfs. EPA is studying thermal discharges and verifying mixing zone calculation assumptions on the Missouri River.
Flow regime changes from Gavins Point Dam will affect downstream NPDES permits for industrial and Publicly Owned Treatment Works (POTW) dischargers.	Lower flow conditions during summer split and drought conditions may affect low-flow assumptions in permits. Flows used to determine chronic effluent discharge limits (7Q10) and acute discharge limits (1Q10) may change. With less dilution available, water quality-based NPDES permit limits may have to be reduced.	Downstream of Gavins Point Dam to the Mississippi River	NC	NC	NC	NC	NC	NC	NC means that there will be no change relative to the CWCP. Studies have indicated that above 9 kcfs, adequate flows exist for NPDES 7Q10 flows. Historically, releases from Gavins Point Dam occurred during the drought years. No water quality problems associated with NPDES permits or water quality impacts from these releases were reported to the Corps.	N/A

Table 5.4-2. Effects of submitted alternatives on the river reaches of the Missouri River[1/]. Page 3 of 4

Potential Impact	Description	River Reach	Effects of Alternatives Compared to the CWCP						Rationale for Effect	Impact Reduction
			MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30		
Changing flow regimes will affect waters designated as outstanding water resources (Tier III Anti-degradation)	Low-flow conditions may affect Missouri River's designation as "outstanding waters" in Nebraska and Iowa due to sediment erosion, deposition, and elevated pollutant concentrations. According to the Clean Water Act, the water quality of outstanding waters must be maintained and protected. No water quality degradation can occur.	Iowa-Missouri state line to Big Sioux confluence and Nebraska from Nebraska-South Dakota state line to Niobrara River and from Niobrara River to Big Sioux River	NC	NC	NC	NC	NC	NC	The alternatives have a spring flow range of 34.5 to 50 kcfs and a summer low-flow range of 21 to 34.5 kcfs. These flows are well within the range of flows that have occurred under the CWCP. No water quality degradation has occurred in these outstanding water resources under the CWCP. No change in the condition of outstanding water resources is expected.	No water quality impacts expected. The Missouri River adaptive management process should be used to ensure that designated high quality water resources will not be negatively affected.
Low-flow conditions may cause portions of the river unsuitable for domestic drinking water uses.	Low-flow conditions in the Missouri River may provide less dilution of tributary loading of pollutants. Higher concentrations of pollutants may be realized in isolated stream reaches, exceeding domestic drinking water standards.	Below Gavins Point Dam	NC	NC	NC	NC	NC	NC	Low-flow studies performed by the Corps conclude that the critical flow from Gavins Point Dam that will affect drinking water quality is 9 kcfs. Alternative flows are well above this critical flow value. No change in water quality is expected.	No water quality concerns expected. The Missouri River adaptive management process should be used to assess the river water quality and operational changes necessary to ensure that impairment to drinking water resources will not occur in the Missouri River.
Low-flow conditions may cause portions of the river exceed water quality standards for recreation and aquatic life uses.	During low-flow conditions, less dilution may be available to reduce pollutant concentrations in the Missouri River. Pollutant loading may be from tributaries, overland runoff, stormwater drainage from urban areas, combined sewer overflows, and wastewater bypassing. Water quality standards criteria for aquatic life (chronic) and recreation may be exceeded, especially near tributaries and urban areas. Metal, nutrient, pathogen, and basic water quality criteria may be exceeded periodically.	Downstream of Gavins Point Dam to the Mississippi River	NC	-	NC	NC	-	-	Alternatives with a - have low summer flows below 25 kcfs. There is a lack of available information to determine the critical summer flow at Gavins Point Dam that could cause aquatic life criteria to be exceeded below flows of 25 kcfs. It seems possible that Lower River flows in combination with lower tributary flows could create conditions that cause aquatic life criteria to be temporarily exceeded. During drought conditions, there is the possibility that some water quality criteria with low values may be exceeded in the Missouri River. Chronic water quality standards may be exceeded in localized river segments. During the last drought, no water quality problems were reported to the Corps.	The Missouri River adaptive management process should review monitoring data collected on the Missouri River to determine if water quality problems occur during low summer flow and drought conditions. Water quality studies to address this critical flow issue should be designed and executed by the Tribes, States, EPA, and the Corps. Modeling studies can be performed to estimate critical flow to maintain water quality standards. Modeling studies need to be verified by water quality monitoring and analysis.

Table 5.4-2. Effects of submitted alternatives on the river reaches of the Missouri River[1/]. Page 4 of 4

Potential Impact	Description	River Reach	Effects of Alternatives Compared to the CWCP						Rationale for Effect	Impact Reduction
			MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**		
Pollutant loading from the Missouri River basin into the Mississippi River contributes to the Gulf of Mexico's poor water quality conditions.	Nonpoint sources such as nutrients, pesticides, metals, and sediment from the Missouri River basin are discharged into the Missouri River. The combination of the nutrient and organic chemical loading from both the Mississippi River and Missouri River basins causes poor water quality conditions in the Gulf of Mexico (low dissolved oxygen, eutrophic conditions).	Confluence with the Mississippi River to the Gulf of Mexico	NC	NC	NC	NC	NC	NC	The alternatives will have no effect on the hypoxic conditions in the Gulf of Mexico. Essentially, the same amount of water and mass loading of chemical constituents will be released at Gavins Point Dam on an annual basis relative to the CWCP.	Nonpoint source pollution needs to be controlled at the source within watersheds. Best management practices need to be implemented to control pollutant runoff into surface waters.
Releases from dams may exceed the National standard of 110% saturation for total dissolved gases.	Waters being discharged from dams can become aerated to the extent that supersaturation of gases, especially nitrogen, can occur. States have not listed total dissolved gases as a cause of water quality impairment.	Tailwaters of dams located on the Missouri River mainstem.	NC	-	NC	-	-	-	It is possible that aeration will occur during spring rise discharges over spillways, which can lead to high total dissolved gases. The CWCP has fewer historic operational spillway discharges. Alternatives ARNRC, BIOP and FWS30 have spillway discharges that will occur more frequently at Fort Peck Dam and Gavins Point Dam. MODC has Fort Peck Dam discharges only. High concentrations of dissolved gases are harmful to fish; therefore, a negative (-) impact is shown. The alternatives showing an NC mean no spillway discharges that differ from the CWCP.	As part of the Missouri River Adaptive Management process, the Corps should monitor dissolved gas concentrations during spillway discharge conditions. No water quality problems have been observed by the Corps from spillway discharges at Gavins Point Dam.

1/ legend for abbreviations used in this table:
NC means no change relative to the CWCP
(+) means a positive change or improved impact to environment
(-) means negative impact to environment
N/A – Not applicable

across the river from the spillway because these releases are directed at the opposite bank. Local residents are concerned about increased erosion in the spring, but Corps studies indicate that long-term erosion beginning a few miles downstream from the spillway (where the spillway releases have fully merged with the powerhouse releases) should be similar for alternatives with or without the spring rise.

Water quality concerns for Fort Berthold Reservation is dependent on the conditions of Lake Sakakawea. Lake Sakakawea water quality concerns include metals, nutrient loading, loss of coldwater habitat, and accumulation of metals and other toxic elements in fish tissue. The MRBA, MODC, ARNRC, BIOP, and FWS30 are the best alternatives for increased lake elevations during drought conditions. Limiting the decline of the lake level under these alternatives through increased conservation during droughts will maintain greater amounts of coldwater habitat for species that rely on this habitat and provide greater volumes of water in the lakes to dilute nutrient loads and reduce eutrophication. The MLDDA alternative does not decrease the lake level fluctuations, and it provides no improvement in coldwater fish habitat, nutrient loading, or eutrophication relative to the CWCP. None of the alternatives limit the suspension of metals in the water column and the accumulation of metals and other toxic elements in fish tissue in Lake Sakakawea.

Standing Rock and Cheyenne River Reservations are located on Lake Oahe. This lake has the same water quality issues as Lake Sakakawea. As stated above, the only alternatives that will improve any of the water quality conditions are those with increased water conservation during droughts: the ARNRC, MRBA, MODC, BIOP, and FWS30 alternatives. The severity of eutrophication and coldwater habitat issues will be reduced during droughts under these alternatives relative to the CWCP.

Lower Brule and Crow Creek Reservations are located on Lake Sharpe. Water quality concerns are bioaccumulation of metals and other toxic elements in fish tissue and accumulated sediment. For this Missouri River reach, there is no difference among the alternatives and the CWCP in terms of addressing these two water quality issues.

Yankton Reservation has two water quality concerns: bioaccumulation of metals and other toxics in fish tissue and accumulated sediment. This Reservation is located primarily along Lake Francis Case. Little difference relative to the CWCP is expected to occur among the alternatives in terms of lake levels. Tributaries carrying pollutant loads from highly erodible watersheds heavily influence the water quality of Lake Francis Case. For the part of the Reservation downstream from Fort Randall Dam, there are water quality issues related to the designation of this reach as an outstanding water resource by the State of Nebraska. The lower summer flows of the ARNRC, BIOP, and FWS30 alternatives may have an impact on this designation.

Ponca Tribal Lands and Santee Reservation are located adjacent to the headwaters of Lewis and Clark Lake. Water quality concerns include bioaccumulation of metals and other toxics in fish tissue and accumulated sediment. The alternatives will have no effect on the sediment loading and siltation within the lake relative to the CWCP because the sediment loading and siltation are influenced by tributary inputs. No difference in lake levels are expected among the alternatives relative to those under the CWCP; therefore, no differences in the two water quality issues are expected.

There are several Reservations located on the Missouri River downstream from Sioux City: Winnebago, Omaha, Iowa, and Sac and Fox Reservations. These Reservations are located below the Gavins Point Dam and in the Lower River portion of the basin, which has been influenced by river channelization. The water quality issues in this river reach include nutrient loading, NPDES permit limits, thermal discharges, designation of the reach adjacent to Omaha and Winnebago Reservations by the State of Iowa as an outstanding water resource, drinking water degradation, water quality standards for recreation and aquatic life, and habitat modification. The alternatives with lower summer flows—the ARNRC, BIOP, and FWS30 alternatives—may adversely affect several of these issues. The issues that may be adversely affected include the NPDES permit limits, thermal discharges, and the outstanding water resource designation.

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5.5 WETLAND AND RIPARIAN HABITAT

This section focuses on the differences in the impacts of the CWCP and the submitted alternatives on wetland and riparian habitat along the Mainstem Reservoir System and 10 Tribal Reservations. Analysis of the changes in wetland and riparian habitats is based on the inventory of habitat at 42 representative sites along the Mainstem Reservoir System and the Lower River. Vegetation changes at these sites respond to water surface elevations adjacent to and in the 42 sites. Because the total acreage is constant and is composed of wetland vegetation types, riparian vegetation types, and water, an increase in wetland vegetation generally results in a decrease in riparian vegetation. A complete inventory of wetland and riparian habitat found along the Missouri River is contained in Environmental Studies-Wetland and Riparian Habitat (Corps, 1994o; Corps, 1994p).

5.5.1 Wetland Habitat

Table 5.5-1 presents the total and reach breakdown of the average annual wetland habitat for the seven alternatives during the full period of analysis from 1898 to 1997 of the 42 sites analyzed. The total data are also presented in graphic form in Figure 5.5-1. The CWCP provides 156,100 acres of habitat on an average annual basis. This total acreage at the sites analyzed is distributed among the lake deltas (22.5 percent), Upper River sites (28.3 percent), and Lower River sites (49.2 percent).

Figure 5.5-1 graphically shows that the CWCP and most of the other alternatives are closely grouped together between 154,800 and 156,900 acres, a difference of only 2,100 acres. The ARNRC alternative stands out at 160,400 acres. This alternative has 3,500 acres more than the top end of the range for the other alternatives.

The CWCP and MLDDA alternatives are similar in that they both have a balanced intrasystem regulation and do not have an additional spring and summer release. The major difference between the two alternatives is that the MLDDA alternative reduces the system's base flood control storage from 57.1 to 55.1 MAF. The 2-MAF decrease in the base of flood control results in a variation of the average values of total wetland vegetation acres within the Mainstem Reservoir System of less than 1.0 percent. There is a slight increase in the lake deltas and Upper River (100 and 200 acres, respectively) and a slight decrease in wetland habitat the Lower River (200 acres).

Unlike the CWCP, the ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season. From Gavins Point Dam, there is a spring release increase of 15 kcfs and a lower summer release of 18 kcfs after the spring release. The total wetland acreage for the ARNRC alternative is the highest of the seven alternatives in this chapter, a 2.8-percent increase over that of the CWCP. Under the ARNRC alternative, wetland vegetation acreage decreases between 6.3 percent in the lake deltas and increases by 6.8 percent in the Upper River. Wetland acreage values in the Lower River also increase (by 4.6 percent) compared to the CWCP.

Table 5.5-1. Average annual wetland habitat (thousands of acres)[1/].

	1898 to 1997			
Alternative	**Total**	**Lake Deltas**	**Upper River**	**Lower River**
CWCP	**156.1**	35.1	44.2	76.8
MLDDA	**156.1**	35.2	44.4	76.6
ARNRC	**160.4**	32.9	47.2	80.3
MRBA	**154.8**	32.1	45.6	77.1
MODC	**156.9**	32.4	46.7	77.8
BIOP	**155.3**	31.1	45.5	78.6
FWS30	**156.9**	32.0	45.0	79.9

1/ Based on 42 representative sites.

The MLDDA, MRBA, and MODC alternatives maintain a flat release from Gavins Point Dam during the summer; however, under the MRBA and MODC alternatives, intrasystem regulation among the upper three lakes is unbalanced and conservation in the upper three lakes is increased. These scenarios result in different impacts on the wetland sites, with the total value going down for the MRBA alternative and up for the MODC alternative. Under the MRBA alternative, the wetland habitat in the lake deltas is reduced (8.5 percent less than the value for the CWCP) and the wetland values in the Upper and Lower Rivers are slightly higher (3.2 and 0.4 percent, respectively). Under the MODC alternative, the lake deltas acreage is reduced less (7.7 percent less than the value for the CWCP) and the Upper and Lower Rivers acreage is increased more (5.7 and 1.3 percent, respectively).

The BIOP and FWS30 alternatives have unbalanced intrasystem regulation and variable spring/summer release criteria, when compared to the CWCP. These alternatives would increase the spring rise by 17.5 and 30 kcfs, respectively and decrease summer flows to a minimum of 21 kcfs. Overall, these two alternatives provide either more or less wetland habitat at the analyzed sites than the CWCP. The BIOP alternative decreases total habitat by 0.5 percent while the FWS30 alternative increases total habitat by the same percentage. The greatest amount of wetland habitat increase (ranging from 1.8 to 4.0 percent) occurs in the Upper River and Lower River, while a considerable decrease (11.4 percent for the BIOP alternative and 8.8 percent for the FWS30 alternative) occurs in the lake deltas.

The annual values of total wetland vegetation acres for the seven alternatives are shown on Figures 5.5-2 through 5.5-4 for the 42 representative sites. Generally, the three alternatives with spring rises (ARNRC, BIOP, and FWS30) have lower values in many years in the early years in the analysis. This was a very wet period in general, and the spring rises may be a factor in reduced total habitat in wet periods.

Conversely, the spring rise alternatives provide the most habitat in many of the years starting in about 1950. This may indicate that the spring rises are beneficial for wetland habitat in dry to normal runoff periods, which was the case in much of the 1950 to 1997 period.

Wetland Habitat for 10 Tribal Reservations

Table 5.5-2 presents the alternatives' average annual wetland habitat under the submitted alternatives for 10 Tribal Reservations during the full period of analysis from 1898 to 1997. The Reservations analyzed are those within the lake deltas (Standing Rock, Cheyenne River, and Santee Reservations and Ponca Tribal Lands), the Upper River (Fort Peck and Yankton Reservations), and the Lower River (Winnebago, Omaha, Iowa, and Sac and Fox Reservations).

As shown in Table 5.5-2, total wetland habitat associated with the analyzed sites and adjacent to these Reservations equals 27,910 acres for the CWCP. Three of the submitted alternatives increase this wetland habitat: MLDDA by 4.8 percent, ARNRC by 1.1 percent, and MRBA by 0.7 percent. The other three alternatives decrease total wetland habitat associated with the Reservations: MODC by 1.2 percent, BIOP by 6.0 percent, and FWS30 by 3.3 percent. These net changes from the CWCP result from a combination of positive and negative changes for individual Reservations.

Fort Peck Reservation has 4,750 acres of average annual wetland habitat under the CWCP. The only submitted alternatives that increase wetland habitat over the CWCP are the MRBA alternative (6.3 percent) and the ARNRC alternative (0.6 percent). The remaining four alternatives decrease wetland habitat within this Reservation. The MODC and MLDDA alternatives decrease wetland habitat by 0.2 and 6.1 percent, respectively. The FWS30 alternative reduces habitat by 11.6 percent, while the BIOP alternative has the greatest percentage decrease of wetland habitat within Fort Peck Reservation (13.7 percent).

Under the CWCP, Standing Rock Reservation has 1,430 acres of average annual wetland habitat. Two of the submitted alternatives increase habitat over the CWCP, the MLDDA alternative by 79.7 percent and the ARNRC alternative by 21.0 percent. Under the MRBA alternative, wetland decreases in this Reservation equal 7.0 percent, the lowest reduction in habitat of the remaining three and MODC alternative reduce greater amounts of habitat (22.4 and 35.0 percent, respectively). The greatest reduction in wetland habitat within Standing Rock Reservation occurs under the BIOP alternative (45.0 percent).

Table 5.5-2. Average annual wetland habitat (thousands of acres) for 10 Tribal Reservations[1/].

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	4.75	4.46	4.78	5.05	4.74	4.10	4.20
Standing Rock	1.43	2.57	1.73	1.33	0.93	0.78	1.11
Cheyenne River	0.74	1.05	0.72	0.55	0.67	0.53	0.55
Yankton	4.14	4.25	4.29	4.20	4.11	4.34	4.39
Ponca Tribal Lands and Santee	8.62	8.81	8.13	8.54	8.52	8.13	8.00
Winnebago and Omaha	4.31	4.22	4.04	4.45	4.54	4.28	4.45
Iowa and Sac and Fox	3.92	3.89	4.53	3.98	4.07	4.07	4.28
Total	**27.91**	**29.25**	**28.22**	**28.10**	**27.58**	**26.23**	**26.98**

1/ Based on appropriate representative sites.

Cheyenne River Reservation has 740 acres of wetland habitat under the CWCP. The MLDDA alternative is the only submitted alternative that increases wetland habitat (41.9 percent). Habitat is reduced under the remaining five submitted alternatives. The ARNRC and MODC alternatives result in the least amount of habitat decrease, 2.7 and 9.5 percent, respectively. Both the MRBA and FWS30 alternatives decrease wetland habitat by 25.7 percent. The BIOP alternative results in the greatest percentage decrease of wetland habitat at the Cheyenne River Reservation (28.4 percent).

Yankton Reservation has 4,140 acres of wetland habitat under the CWCP. All the submitted alternatives except one, the MODC alternative, increase the amount of wetland habitat within this Reservation. The FWS30 alternative provides the greatest percentage increase (6.0 percent), while the MRBA alternative provides the smallest percentage increase (1.4 percent). The MLDDA alternative provides a 2.7 percent increase in habitat. The BIOP and ARNRC alternatives increase wetland habitat amounts by 4.8 and 3.6 percent, respectively. The MODC alternative decreases wetland habitat in Yankton Reservation by 0.7 percent.

Under the CWCP, Ponca Tribal Lands and Santee Reservation have the greatest amount of wetland habitat of any of the Reservations, 8,620 acres. Of the submitted alternatives, the MLDDA alternative is the only one that increases wetland habitat (2.2 percent). All other submitted alternatives reduce habitat. The MRBA alternative reduces the least amount of wetland habitat (0.9 percent), while the FWS30 alternative reduces the most wetland habitat (7.2 percent). Compared to the CWCP, the MODC alternative reduces wetland habitat by 1.2 percent, and both the ARNRC and BIOP alternatives reduce wetland habitat by 5.7 percent.

The CWCP provides 4,310 acres of wetland habitat within the Winnebago Reservation and Omaha Reservation. The MODC alternative provides an additional 5.3 percent of wetland habitat over the CWCP, while the MRBA and FWS30 alternatives both increase habitat by 3.2 percent. The BIOP, MLDDA, and ARNRC alternatives decrease wetland habitat, by 0.7, 2.1, and 6.3 percent, respectively.

Iowa Reservation and Sac and Fox Reservation have 3,920 acres of wetland habitat under the CWCP. Five of the submitted alternatives provide an increase in habitat within this Reservation. The submitted alternatives that provide the greatest percentage increase in wetland habitat over the CWCP are the ARNRC alternative (15.6 percent) and the FWS30 alternative (9.2 percent). Both the MODC and BIOP alternatives increase wetlands by 3.8 percent. The MRBA alternative provides the least percentage increase in wetland compared to the CWCP (1.5 percent). One submitted alternative, the MLDDA alternative, decreases habitat within Iowa Reservation and Sac and Fox Reservation (0.8 percent).

5.5.2 Riparian Habitat

As discussed earlier, riparian habitat values should vary inversely with the values presented for the wetland habitat. The methodology for the analysis of changes in riparian and wetland habitat is based on field surveys of existing wetland sites. All of the sites had vegetation types that could be classified as either wetland or riparian, and the methodology identified changes in the vegetation types with changes in water levels in the wetland sites. As water levels declined, wetland vegetation types were likely replaced with riparian vegetation types, and vice versa. The methodology did not identify expansion or contraction of the size of each site except for the conversion of vegetation to open water at extremely high water levels. This also leads to the general conclusion that if there is an increase in wetland habitat, there will be a corresponding decrease in riparian habitat.

Table 5.5-3 presents the total and reach breakdown of the average annual riparian habitat of the 42 representative sites for the submitted alternatives during the full period from 1898 to 1997. The total data are also presented in graphic form in Figure 5.5-5. The CWCP provides 108,100 acres of riparian habitat on an annual basis. This total acreage at the sites analyzed is distributed among the lake deltas (11.1 percent), Upper River sites (38.8 percent), and Lower River sites (50.1 percent)

Figure 5.5-5 graphically shows that three of the alternatives are grouped together between 108,100 and 109,800 acres, a difference of 1,700 acres, and the other four are grouped between 102,000 and 105,000 acres, a difference of 3,000 acres. The MLDDA alternative increases total riparian habitat for the representative sites by 1,700 acres (1.6 percent more than the CWCP) whereas the ARNRC and FWS30 alternatives reduce the habitat by the greatest amount, 6,100 acres (5.6 percent less than the CWCP).

The alternative with the greatest increase in total average annual riparian habitat for the representative sites over the CWCP is the MLDDA alternative. Under this alternative, total riparian acreage increases as the system storage (flood control) is reduced from 57.1 MAF to 55.1 MAF. This decrease in the base of flood control would result in varied average values of total riparian vegetation acres within the reservoir system. The greatest increase in riparian habitat over the CWCP occurs in the lake deltas (8.3 percent), and there would be a slight increase along the Upper River (2.1 percent). The MLDDA Alternative results in a 0.2 percent decrease in riparian habitat along the Lower River.

The ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season, which generally reduces the amount of riparian habitat. The greatest reduction in riparian habitat acreage under the ARNRC alternative occurs in the lake deltas, where there is 12.5 percent less habitat than under the CWCP. There is also a slight decrease in riparian habitat in the Upper and Lower River sites (3.8 and 5.2 percent, respectively).

Although the MRBA and MODC alternatives both maintain a flat release from Gavins Point Dam during the summer, have an unbalanced intrasystem regulation, and increase conservation in the upper three lakes, they result in different impacts on riparian habitat, with the total value for the representative sites going up slightly for the MRBA alternative and down for the MODC alternative. Under the MRBA alternative, the acres of riparian habitat in the Upper River are increased (1.4 percent more than the CWCP) and the acres of riparian habitat are slightly decreased in the lake deltas and Lower River (1.7 and 0.5 percent less, respectively). Under the MODC alternative, riparian acreage is reduced in all three reaches. The greatest amount of reduction occurs in the Upper River (4.2 percent less habitat than the value for the CWCP), and the least amount occurs in the Lower River (1.3 percent less).

The BIOP and FWS30 alternatives also have most of the components of the MRBA and MODC alternatives; however, there is variation in the additional spring/summer release criteria compared to the CWCP. These two alternatives provide less riparian habitat within each of the three sets of reaches. The BIOP alternative reduces riparian habitat by 4.1 percent while the FWS30 alternative reduces riparian habitat by 5.6 percent. The greatest reduction in riparian habitat occurs in the lake deltas under the BIOP alternative (9.2 percent less riparian habitat than the CWCP) and in the Lower River

Table 5.5-3. Average annual riparian habitat (thousands of acres)[1/].

	1898 to 1997			
Alternative	**Total**	**Lake Deltas**	**Upper River**	**Lower River**
CWCP	**108.1**	12.0	41.9	54.1
MLDDA	**109.8**	13.0	42.8	54.0
ARNRC	**102.0**	10.5	40.3	51.3
MRBA	**108.2**	11.8	42.5	53.8
MODC	**105.0**	11.6	40.1	53.4
BIOP	**103.7**	10.9	39.9	52.9
FWS30	**102.0**	11.6	40.0	50.4

1/ Based on 42 representative sites.

under the FWS30 alternative (6.8 percent less). The reduction in the amount of riparian habitat in the Upper River under the BIOP and FWS30 alternatives would be similar, with a 4.8 and 4.5 percent reduction in habitat, respectively.

The annual values of riparian vegetation acres for the representative sites for the seven submitted alternatives are shown on Figures 5.5-6 through 5.5-8. Generally, the submitted alternatives show an increase in riparian habitat beginning in 1922, reaching their highest values in the 3-year period between 1940 and 1943, which occurs at the end of the 1930 to 1941 drought. Between 1940 and 1943, all of the submitted alternatives show a maximum increase in annual values for riparian habitat. The alternatives with higher annual values during this period are the MLDDA and FWS30 alternatives. From 1943 to 1997, riparian habitat generally decreases but is more abundant than in the years prior to 1940. The alternative that shows the greatest variability from the CWCP is the ARNRC alternative, under which total annual values for the representative sites are generally mixed in the years prior to 1940 and lower after 1943. There is little variation between the CWCP and the MRBA alternative.

Riparian Habitat For 10 Tribal Reservations

Table 5.5-4 presents the total average annual riparian habitat for the sites analyzed adjacent to the Reservations under the submitted alternatives for 10 Tribal Reservations during the full period, 1898 to 1997. The Reservations analyzed are those within the lake deltas (the Standing Rock, Cheyenne River, and Santee Reservations and Ponca Tribal Lands), the Upper River (the Fort Peck and Yankton Reservations), and the Lower River (the Winnebago, Omaha, Iowa, and Sac and Fox Reservations).

Total riparian habitat associated with these Reservations under the CWCP is 20,120 acres. Only one alternative, MLDDA, increases total riparian habitat over the CWCP (+1.4 percent more habitat). The remaining five alternatives all reduce habitat: ARNRC by 6.3 percent, MRBA by 0.5 percent, MODC by 0.9 percent, BIOP by 4.1 percent, and FWS30 by 5.5 percent.

Compared to the other Reservations evaluated, the CWCP provides the greatest amount of riparian habitat within Fort Peck Reservation, 5,550 acres. The MLDDA alternative is the only submitted alternative that does not change the amount of riparian habitat within this Reservation. All five of the remaining submitted alternatives decrease riparian habitat by the same amount, 0.2 percent.

The CWCP provides 1,730 acres of riparian habitat within Standing Rock Reservation. The MLDDA, MRBA, FWS30, and MODC alternatives increase riparian habitat by 3.5, 2.9, 1.2, and 0.6 percent, respectively. Two of the submitted alternatives, the ARNRC and BIOP alternatives, reduce riparian habitat within Standing Rock Reservation. The BIOP alternative has the second largest habitat reduction (21.4 percent decrease), and the ARNRC alternative has the greatest reduction in habitat (37.6 percent decrease).

Within Cheyenne River Reservation, the CWCP provides only 180 acres of riparian habitat. The MRBA alternative does not result in a change in habitat over the CWCP. The only submitted alternative that provides an increase in habitat over the CWCP is the MLDDA alternative (an additional 400 acres, or 122.2 percent increase). The remaining four submitted alternatives all result in a decrease in riparian habitat within the

Table 5.5-4. Average annual riparian habitat (thousands of acres) for 10 Tribal Reservations[1/].

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	5.55	5.55	5.54	5.54	5.54	5.54	5.54
Standing Rock	1.73	1.79	1.08	1.78	1.74	1.36	1.75
Cheyenne River	0.18	0.40	0.11	0.18	0.16	0.11	0.13
Yankton	2.18	2.23	2.17	2.13	2.19	2.10	2.01
Ponca and Santee	0.66	0.66	0.71	0.63	0.64	0.69	0.70
Winnebago and Omaha	4.85	4.78	4.58	4.81	4.75	4.64	4.25
Iowa and Sac and Fox	4.97	4.99	4.67	4.94	4.91	4.86	4.63
Total	**20.12**	**20.40**	**18.86**	**20.01**	**19.93**	**19.30**	**19.01**

1/ Based on appropriate representative sites

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Cheyenne River Reservation. Compared to the CWCP, the FWS30 alternative results in a 27.8 percent decrease in alternative results in the smallest percentage decrease (0.5 percent), and the FWS30 alternative results in the largest percentage decrease (7.8 percent). The MRBA and BIOP alternatives decrease riparian habitat within Yankton Reservation by 2.3 and 3.7 percent, respectively.

Under the CWCP, there are 660 acres of riparian habitat within Ponca Tribal Lands and Santee Reservation. Of the submitted alternatives, the MLDDA alternative is the only one that does not result in a change in riparian habitat. Three submitted alternatives provide an increase in habitat, the ARNRC alternative (7.6 percent), the FWS30 alternative (6.1 percent), and the BIOP alternative (4.5 percent). The remaining two submitted alternatives, the MODC and MRBA alternatives, decrease riparian habitat by 3.0 and 4.5 percent, respectively.

The CWCP provides 4,850 acres of riparian habitat within Winnebago Reservation and Omaha Reservation. All of the other submitted alternatives analyzed decrease riparian habitat compared to the CWCP. The MRBA alternative results in the smallest percentage decrease (0.8 percent), and the FWS30 alternative results in the largest percentage decrease (12.4 percent). The MLDDA, MODC, BIOP, and ARNRC alternatives decrease riparian habitat by 1.4, 2.1, 4.3, and 5.6 percent, respectively.

The CWCP provides 4,970 acres of riparian habitat within Iowa Reservation and the Sac and Fox Reservation. One alternative, the MLDDA alternative, increases this habitat over the CWCP by 0.4 percent. All of the other submitted alternatives decrease riparian habitat compared to the CWCP. The FWS30 alternative results in the greatest decrease (6.8 percent), and the MRBA alternative results in the least percentage decrease (0.6 percent). The MODC, BIOP, and ARNRC alternatives decrease riparian habitat by 1.2, 2.2, and 6.0 percent, respectively.

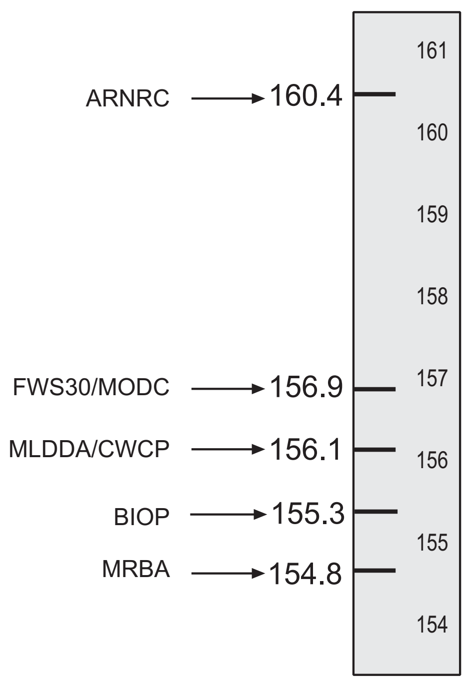

Figure 5.5-1. Average annual wetland habitat for submitted alternatives (thousands of acres).

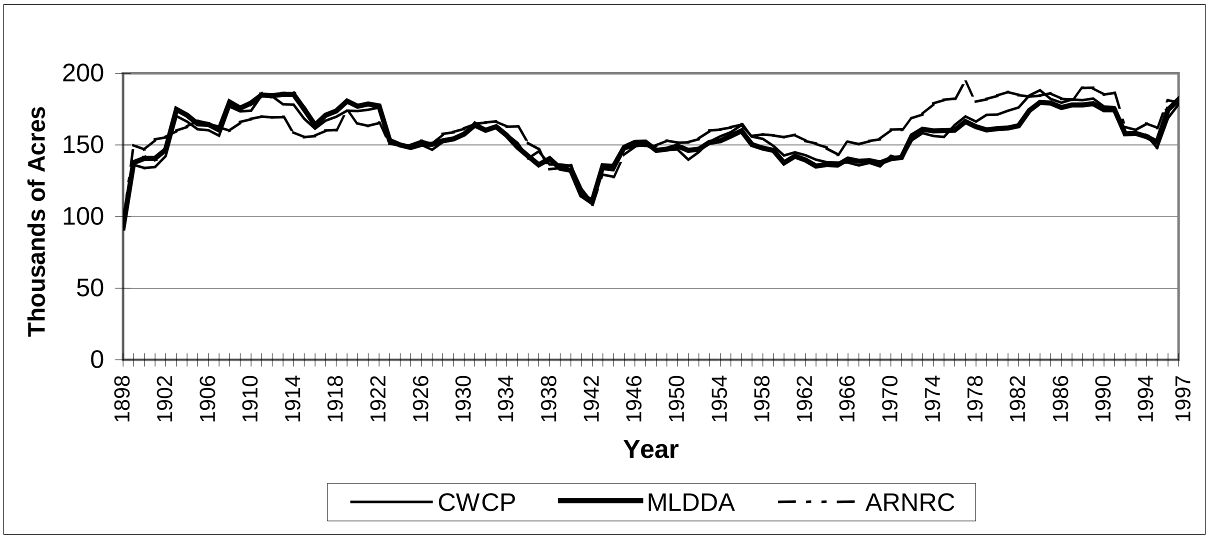

Figure 5.5-2. Annual wetland vegetation acres for alternatives CWCP, MLDDA, and ARNRC.

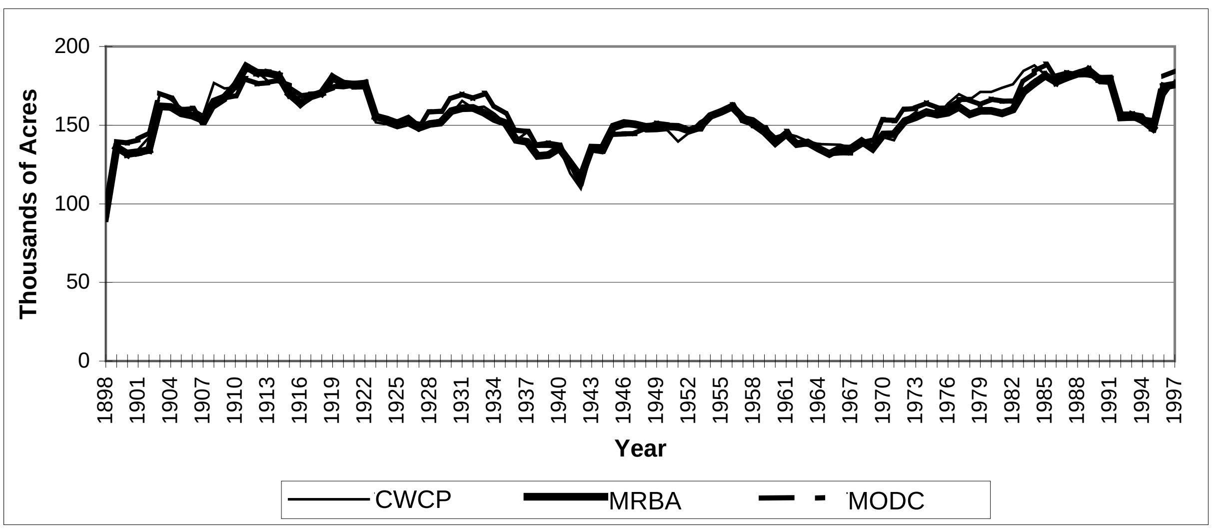

Figure 5.5-3. Annual wetland vegetation acres for alternatives CWCP, MRBA, and MODC.

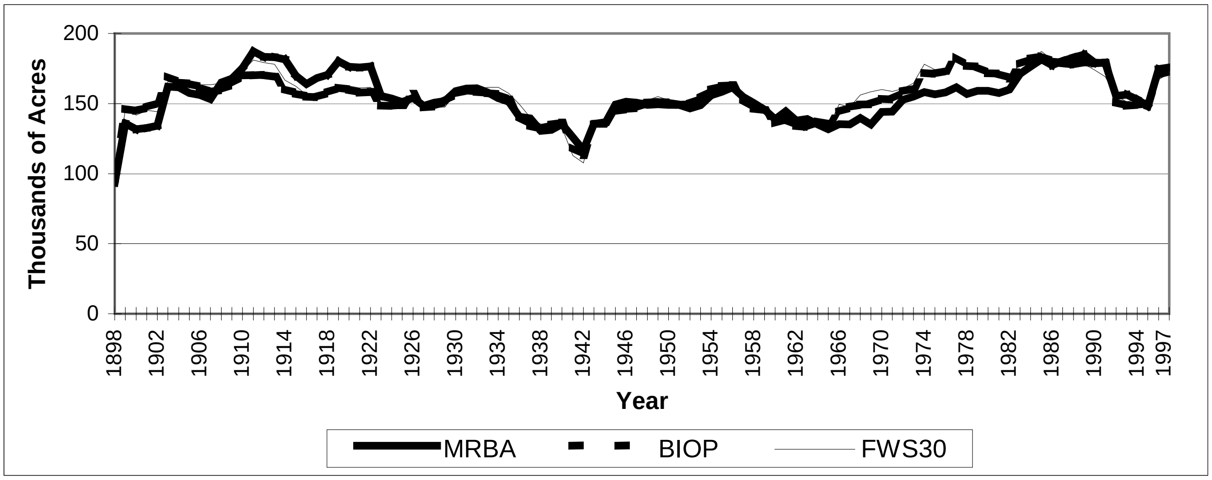

Figure 5.5-4. Annual wetland vegetation acres for alternatives MRBA, BIOP, and FWS30.

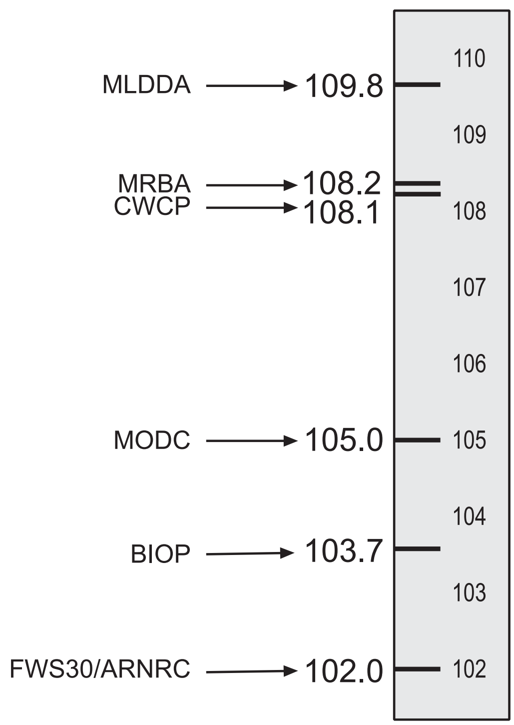

Figure 5.5-5. Average annual riparian habitat for submitted alternatives (thousands of acres).

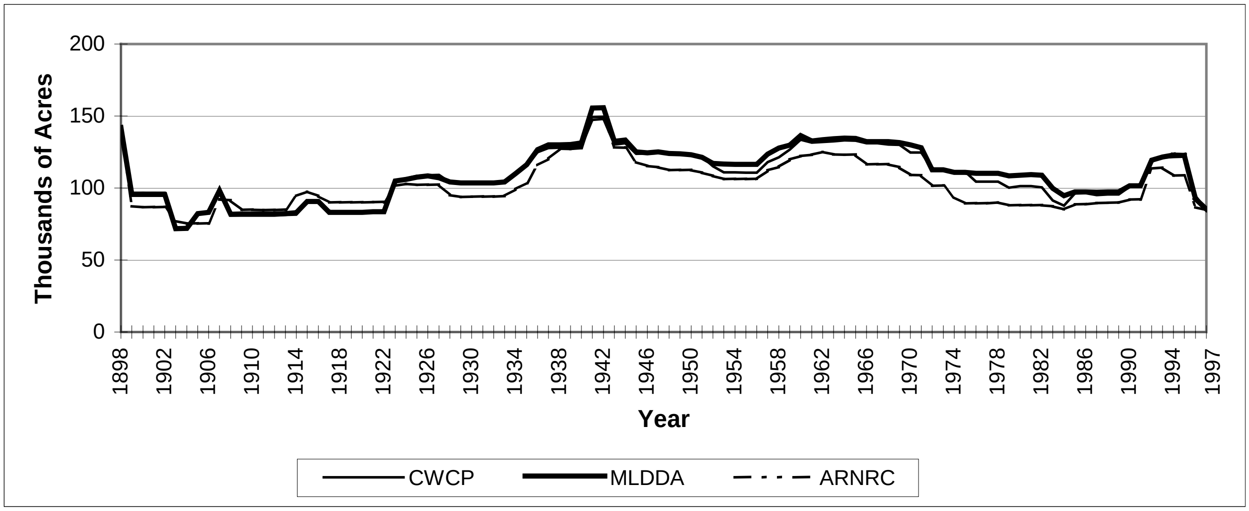

Figure 5.5-6. Annual riparian vegetation acres for alternatives CWCP, MLDDA, and ARNRC.

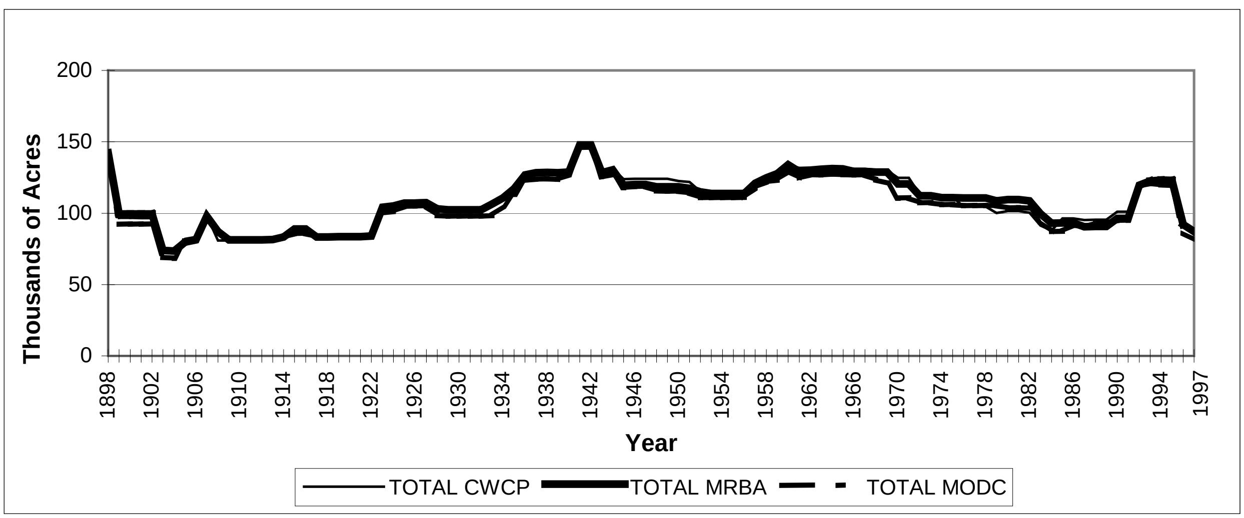

Figure 5.5-7. Annual riparian vegetation acres for alternatives CWCP, MRBA, and MODC.

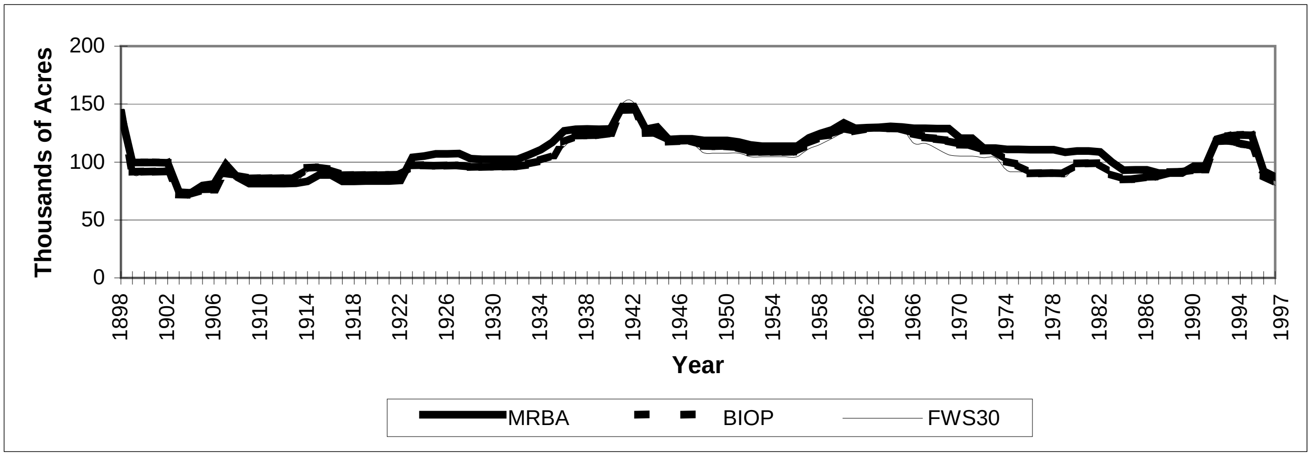

Figure 5.5-8. Annual riparian vegetation acres for alternatives MRBA, BIOP, and FWS30.

5.6 WILDLIFE RESOURCES

Diverse species of wildlife depend on the Missouri River floodplain habitats. The endangered interior least tern and threatened piping plover nest on exposed sandbars and are consequently directly affected by river flows. Periodic high flows are required to remove encroaching vegetation. However, during and following the nesting season, stable or declining flows are needed to avoid nest flooding and stranding immature birds on the lower parts of sandbars and islands. These birds also nest on bare sand exposed when the lakes drop during droughts; however, this analysis does not include that habitat.

Effects on other wildlife species were not individually modeled. However, changes in the wetland and riparian habitat values provide some insight into the effects of a change from the CWCP to one of the other alternatives. The tern and plover model simulates the vegetation encroachment and removal process as river flows and associated stages rise and fall in four river reaches. These reaches are downstream from Fort Peck, Garrison, Fort Randall, and Gavins Point Dams. The baseline habitat acreage was that acreage existing in the early 1990s in these four reaches. Unfortunately, the model does not simulate the geomorphic process of island and sandbar building that takes place at very high flows with a relatively long duration, such as occurred in 1997. Not enough is currently known about this geomorphic process to incorporate it into the model at this time. Habitat acreages presented are, therefore, representative values useful for comparing alternatives and do not represent absolute acreages provided by the alternatives. A more comprehensive discussion of least tern and piping plover populations and habitat along the Missouri River is contained in Environmental Studies—Least Tern and Piping Plover (Corps, 1994q) and in the Supplemental Biological Assessment included as Appendix D to the FEIS. Uncertainties associated with the tern and plover model are discussed in Section 6.5.6.

An analysis of the number of acres of relatively clear island and sandbar habitat was conducted for each alternative as part of the modeling effort to determine potential impacts to the terns and plovers. Based on this analysis, the average annual available habitat for terns and plovers for all submitted alternatives is presented in Table 5.6-1 and shown in Figure 5.6-1. The table also provides data on the individual reaches for the full period of analysis. Two factors need to be considered as the data are reviewed. First, the reach downstream from Garrison Dam has almost half of the total habitat, even though there are four reaches with the habitat. Second, the reach downstream from Gavins Point Dam has provided the greatest number of fledged birds in recent years, even though it has approximately 60 percent less habitat than the reach downstream from Garrison Dam.

The CWCP provides 220.5 acres of tern and plover habitat on an average annual basis. This total acreage along the four downstream reaches analyzed is distributed among the Fort Peck reach (22.8 percent), Garrison reach (44.4 percent), Fort Randall reach (14.8 percent), and Gavins Point reach (18.0 percent).

Figure 5.6-1 graphically shows that three of the alternatives are grouped between 300.1 acres and

Table 5.6-1. Average annual tern and plover habitat downstream of mainstem dams (acres).

Alternative	1898 to 1997				
	Total	**Fort Peck**	**Garrison**	**Fort Randall**	**Gavins Point**
CWCP	**220.5**	50.3	97.9	32.7	39.5
MLDDA	**231.7**	56.3	90.0	38.2	47.3
ARNRC	**302.2**	22.3	136.4	74.3	69.3
MRBA	**300.6**	69.6	147.8	38.8	44.4
MODC	**300.1**	47.6	177.9	33.8	40.8
BIOP	**382.8**	27.5	212.4	65.0	77.9
FWS30	**374.3**	23.3	210.1	68.9	72.0

302.2 acres, a difference of only 2.1 acres. Two of the other alternatives are grouped, ranging between 374.3 and 382.8 acres (a difference of 8.5 acres), while the remaining two alternatives are between 220.5 and 231.7 acres (an 11.2-acre difference). The CWCP provides the lowest total amount of average annual tern and plover habitat of the submitted alternatives. Generally, the total average annual number of acres of tern and plover habitat increases as the existing balanced system of intrasystem regulation is modified. Adding the increase in spring releases and the decrease in summer releases from Gavins Point Dam provides additional habitat. One of the alternatives with this change, the BIOP alternative, provides the greatest total increase (162.3 acres, or 73.6 percent) in the amount of relatively clear island and sandbar habitat compared to the CWCP. This is primarily due to the increased amount of tern and plover habitat downstream of Garrison, Fort Randall, and Gavins Point Dams. An additional alternative is included in Figure 5.6-1. This alternative, called the run-of-river alternative (ROR alternative) in the figure, simulates what would happen should flows enter and move through the system uncontrolled. Compared to the CWCP and the remaining alternatives in Figure 5.6-1, the ROR alternative creates the greatest amount of total clear island and sandbar habitat downstream of the four dams at 584.7 acres. This is a dramatic increase over the amount of habitat available under the submitted alternatives. It represents an increase of 265 percent over the amount of habitat under the CWCP and a 153 percent increase over the amount of habitat under the BIOP alternative.

The CWCP and the MLDDA alternative both have a balanced intrasystem regulation and do not have an additional spring and summer release, but the MLDDA alternative decreases the base of flood control storage by 2 MAF. A reduction in the system's base of flood control storage generally increases the amount of tern and plover habitat in three of the downstream reaches: Fort Peck (11.9 percent), Fort Randall (16.8 percent), and Gavins Point (20.2 percent). It reduces this habitat by 8.1 percent downstream of Garrison Dam.

The ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season that mimics the natural flow of the Missouri River. It is apparent that the combination of an additional spring and a lower summer release from Gavins Point Dam that mimics the natural flow of the Lower River creates an increase in habitat downstream of all dams except Fort Peck, where there is a 55.7 percent decrease in habitat. Under the ARNRC alternative, the greatest increase in habitat occurs downstream of Fort Randall Dam, where 127.2 percent more tern and plover habitat is created over that of the CWCP.

The MRBA alternative maintains a flat release from Gavins Point Dam during the summer; however, intrasystem regulation is unbalanced and drought conservation in the upper three lakes is increased. These changes result in an overall increase in tern and plover habitat in all four downstream locations compared to the CWCP. Under the MRBA alternative, the greatest increase in habitat occurs downstream of Garrison Dam, where an additional 49.9 acres (or 50.9 percent) of clear island and sandbar habitat is created. Downstream of Fort Peck and Fort Randall Dams, there is a 38.3 and 18.6 percent increase in habitat, respectively. The reach below Gavins Pont Dam, an area that has fledged the greatest numbers of birds in recent years, would yield an additional 4.9 acres (12.4 percent) of relatively clear island and sand bar habitat for terns and plovers. This alternative and the ARNRC alternative have similar levels of conservation of water in the lakes during droughts, and the major differences between the two alternatives is the higher spring releases and lower summer releases from Gavins Point Dam and the higher spring releases from Fort Peck Dam. With these two changes, the increase in habitat for the ARNRC alternative is only 1.6 acres, an increase of 0.5 percent over the total amount of habitat provided by the MRBA alternative. There is a difference, however, in the distribution of this habitat, as noted above.

When compared to the CWCP, the MODC alternative results in greater tern and plover habitat in three of the four downstream locations; however, there is a 5.4 percent reduction in habitat downstream of Fort Peck Dam. This reduction is likely due to the increased releases in July at Fort Peck Dam that occur under the simulation of this alternative. This changed flow pattern likely results from the extra water that is held in the lakes in many years because of the delayed evacuation in the late August and early September timeframe of many years. The greatest increase in habitat occurs downstream of Garrison Dam where the MODC alternative would create an additional 80.0 acres (81.7 percent) of relatively clear island and sandbar habitat. Compared to the CWCP, the MODC alternative creates an additional 3.4 percent of habitat downstream of Fort Randall Dam and 3.3 percent more habitat downstream of Gavins Point Dam.

An additional spring release, as with the BIOP and FWS30 alternatives, generally increases the amount of tern and plover habitat in all downstream reaches except downstream from Fort Peck Dam. Here, the BIOP alternative would decrease tern and plover habitat by 54.7 percent and the FWS30 alternative would decrease habitat by 53.6 percent. This reduction is likely due to the forced spring rise from Fort Peck Dam that is incorporated as a component in these alternatives. The greatest increase in tern and plover habitat occurs downstream of Garrison Dam, where there is a 116.9 percent increase in habitat under the BIOP alternative and a 114.6 percent increase under the FWS30 alternative. Downstream of Fort Randall Dam, the FWS30 alternative would create the greatest amount of habitat (110.7 percent more than the CWCP) of the submitted alternatives, and the BIOP alternative would create the most habitat downstream of Gavins Point Dam (97.2 percent more than the CWCP).

The annual values of total tern and plover habitat for the submitted alternatives are shown on Figures 5.6-2 thorough 5.6-3. Tern and plover habitat is highly variable during the entire period of analysis, and it is not possible to identify a specific pattern for any of the alternatives. The years with the greatest increase in habitat are 1936, 1975, and 1984 with the MLDDA alternative, 1984 with the BIOP alternative, and 1920 for the FWS30 alternative. The CWCP, MRBA, and MODC alternatives all reach habitat acreages between 1,400 and 1,700 acres during the mid to late 1980s. After this period, tern and plover habitat declines significantly to less than 400 acres with all alternatives.

5.6.1 Tern and Plover Habitat for Four Tribal Reservations

Table 5.6-2 presents the average annual tern and plover habitat under the submitted alternatives for four Tribal Reservations along two river reaches included in the analysis during the full period, 1898 to 1997. The Reservations analyzed are Fort Peck Reservation, located downstream of Fort Peck Dam, and Yankton Reservation, Ponca Tribal Lands, and Santee Reservation, all located downstream of Fort Randall Dam. The latter two Reservations are located adjacent to Lewis and Clark Lake; however, they are included as benefiting from increased habitat in the nearby upstream river reach.

Total tern and plover habitat associated with these Reservations is 83.05 acres under the CWCP. Five of the six other alternatives increase total tern and plover habitat over the CWCP: MLDDA by 13.8 percent, ARNRC by 16.2 percent, MRBA by 30.5 percent, BIOP by 11.4 percent, and FWS30 by 11.0 percent. The remaining alternative, MODC, reduces habitat by 2.0 percent.

The CWCP provides 50.4 acres of tern and plover habitat within the Fort Peck Reservation. Of the six submitted alternatives, the only habitat increases within this Reservation occur under the MRBA alternative (38.2 percent) and MLDDA alternative (11.9 percent). The MODC alternative reduces tern and plover habitat by 5.4 percent. The BIOP, FWS30, and ARNRC alternatives all result in larger decreases in tern and plover habitat within this Reservation, 45.4, 53.8, and 55.8 percent, respectively.

The Yankton Reservation, Ponca Tribal Lands, and Santee Reservation yield 32.7 acres of tern and plover habitat under the CWCP. All the other alternatives increase tern and plover habitat compared to the CWCP. The largest percentage increase over the CWCP occurs under the ARNRC, FWS30, and BIOP alternatives, with which tern and plover habitat increase by 127.1, 110.7, and 98.7 percent, respectively. Lesser increases, 18.7, 16.7, and 3.3 percent, occur under the MRBA, MLDDA, and MODC alternatives, respectively.

Table 5.6-2. Average annual tern and plover habitat (acres) for four Tribal Reservations.

Reservation	1898 to 1997						
	CWCP	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	50.4	56.3	22.3	69.6	47.6	27.5	23.3
Yankton, Ponca Tribal Lands, and Santee	32.7	38.2	74.3	38.8	33.8	65.0	68.9
Total	**83.1**	**94.5**	**96.5**	**108.4**	**81.4**	**92.5**	**92.2**

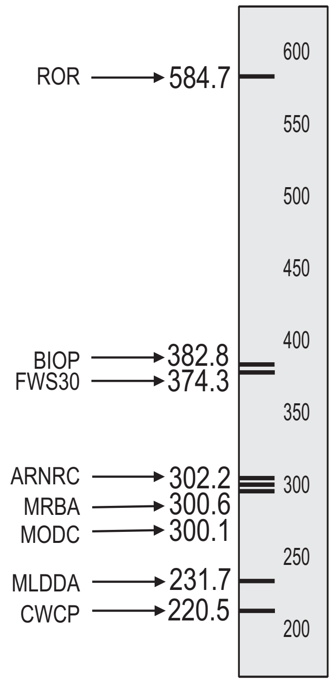

Figure 5.6-1. Average annual tern and plover habitat for submitted alternatives (acres).

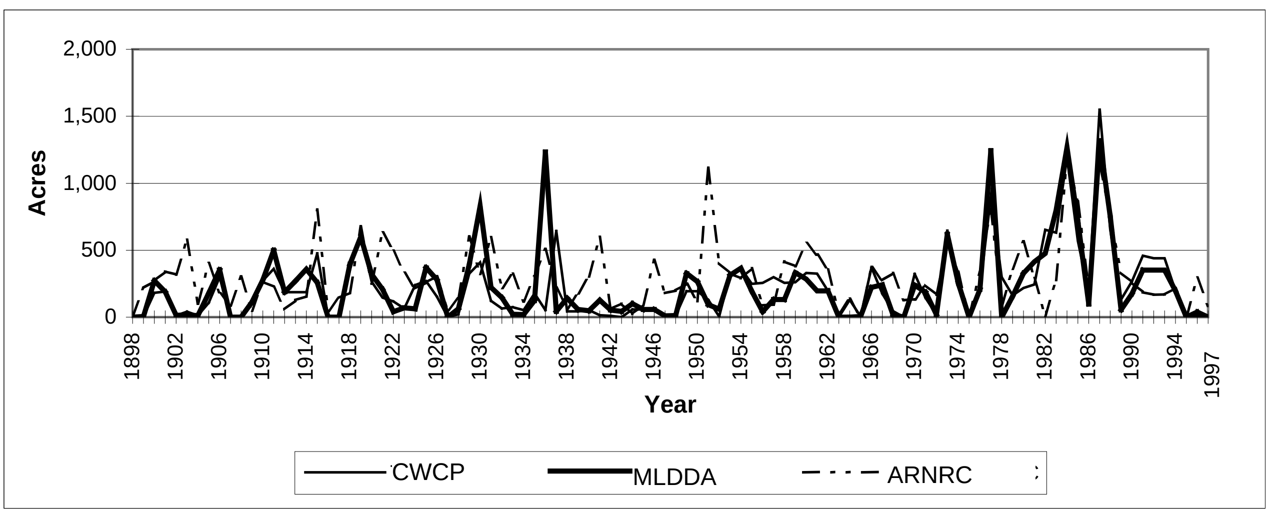

Figure 5.6-2. Annual tern and plover habitat for alternatives CWCP, MLDDA, and ARNRC.

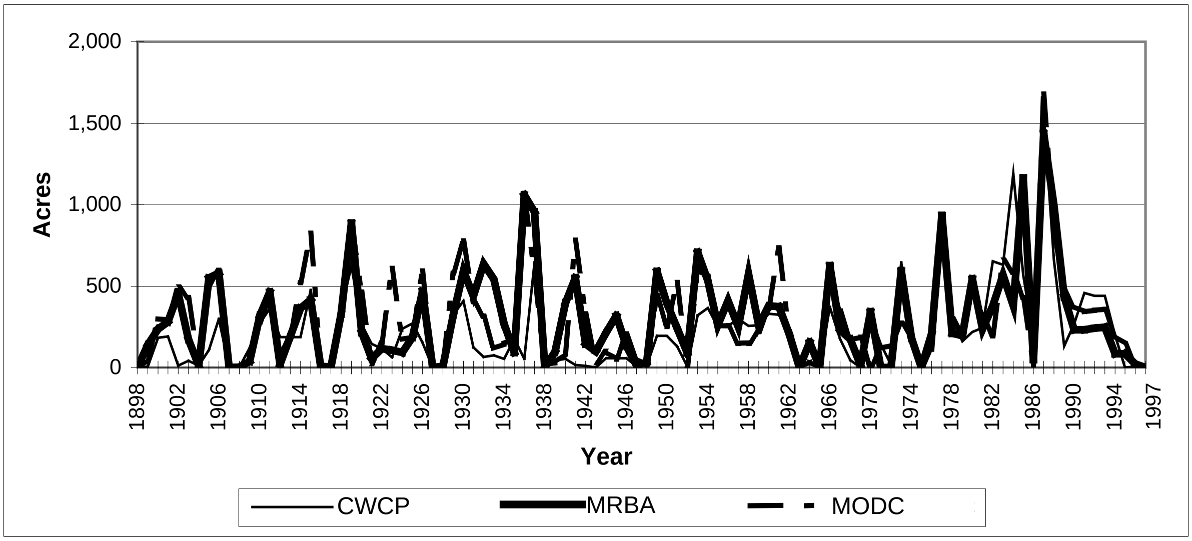

Figure 5.6-3. Annual and plover habitat for alternatives CWCP, MRBA, and MODC.

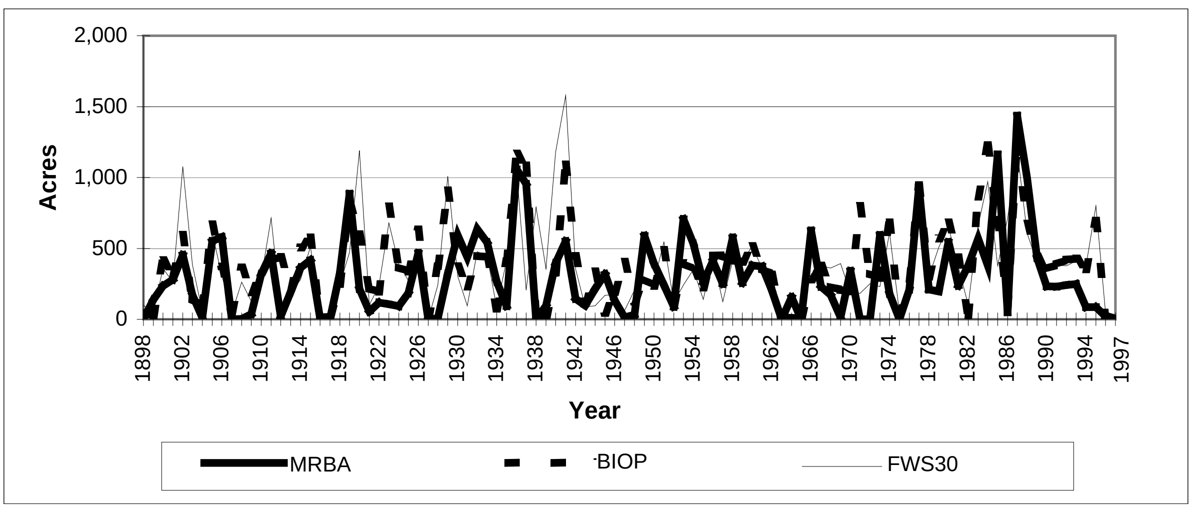

Figure 5.6-4. Annual tern and plover habitat for alternatives MRBA, BIOP, and FWS30.

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5.7 FISH RESOURCES

The analysis of the effects of the alternatives on fish resources was accomplished using the results of eight models. These models predicted young fish production in the lakes, coldwater fish habitat in the lakes, coldwater fish habitat in river reaches, warmwater fish habitat in river reaches, physical habitat for native river fish in river reaches, connectivity of the river to low-lying lands along much of the Lower River, spring spawning cue along the Lower River, and shallow water habitat along the Lower River. Several technical reports document the development of these models for assessing reservoir and riverine fishes, the model assumptions, and the data produced by the model runs (Corps, 1994j; Corps, 1994k; Corps, 1994l; Corps, 1994m; Corps, 1994n). In addition, supplemental information was recently published on riverine fishes (Corps, 1998f; Corps, 1998g). Information on the basic modeling techniques for each of the models are described in the corresponding discussions of the effects defined by model results in this section of Chapter 5.

5.7.1 Young Fish Production in Mainstem Lakes

The young-of-year fish production index uses annual hydrologic data to model fish productivity. It was developed through a process of correlating annual catch data for various species to hydrologic variables, such as lake levels, inflows, and amount of shore area. For further detail, see Volume 7A: Environmental Studies, from the 1994 Missouri River Master Water Control Manual Review and Update Study. The values presented in the following discussion are useful as an indicator of the relative effects of the different alternatives. For example, if an alternative results in a young-of-year index value that is 2 percent higher than that of the CWCP, this indicates the potential for a slight increase in annual fish production under that alternative. Table 5.7-1 and Figures 5.7-1 through 5.7-4 present the data from the young fish production model, commonly referred to as the "young-of-year model."

Figure 5.7-1 graphically shows that four of the alternatives are closely grouped together between 2.00 and 2.04 units, a difference of 4 hundredths. The remaining alternatives are more closely related and are grouped between 2.10 and 2.12 units, a difference of only 2 hundredths.

The average annual total relative index value for the CWCP is 2.00, the lowest of the alternatives. Both the CWCP and MLDDA alternatives have a balanced intrasystem regulation; however, the MLDDA decreases the system's base of flood control storage by 2 MAF. This decrease in the base of flood control storage is slightly more beneficial to total young fish production in the mainstem lakes compared to the CWCP, with an average annual value increase of only 1 hundredth. The ARNRC and MRBA alternatives equally benefit the average annual values compared to the CWCP (value increase of 4 hundredths), even though they both have an unbalanced intrasystem regulation and greater conservation but different criteria for additional spring/summer releases. Delaying flood storage evacuation to the Lower River until mid-September combined with increased conservation of water in the lakes during droughts, as with the MODC alternative, results in the greatest benefit in total young fish production. This alternative also has a spring rise from Fort Peck Dam on the average of about every 3 years, water conditions allowing. The total average annual value of the MODC alternative is 12 hundredths, or 6.0 percent, greater than the CWCP.

Table 5.7-1. Average annual young fish production in the mainstem lakes (relative index), 1898 to 1997.

Alternative	Total	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Lake Sharpe	Lake Francis Case	Lewis & Clark Lake
CWCP	**2.00**	0.55	0.46	0.40	0.23	0.20	0.16
MLDDA	**2.01**	0.53	0.48	0.42	0.23	0.19	0.16
ARNRC	**2.04**	0.51	0.49	0.39	0.17	0.27	0.20
MRBA	**2.04**	0.58	0.45	0.41	0.22	0.20	0.18
MODC	**2.12**	0.55	0.49	0.43	0.22	0.21	0.21
BIOP	**2.10**	0.52	0.51	0.40	0.21	0.26	0.20
FWS30	**2.11**	0.52	0.51	0.41	0.21	0.26	0.20

The BIOP and FWS30 alternatives have a spring rise and decreasing summer flows out of Gavins Point Dam with the same level of conservation in droughts as the MRBA and MODC alternatives, which is also more beneficial for total young fish production than the CWCP. These two alternatives also have a spring rise out of Fort Peck Dam. Average annual values with these alternatives increase 10 and 11 hundredths, respectively.

The major difference between the CWCP and the MLDDA alternative is that the MLDDA alternative reduces the system's base of flood control storage from 57.1 to 55.1 MAF. Compared to the other alternatives, the increase in total average annual young fish production value is the lowest under the MLDDA alternative, a 1 hundredth, or 0.5 percent, increase over that of the CWCP. A 2-MAF decrease in the base of flood control storage decreases young fish production values in Fort Peck Lake by 3.6 percent and in Lake Francis Case by 5.0 percent. It increases the values in Lake Sakakawea by 4.3 percent and Lake Oahe by 5.0 percent. There is no change in young fish production values from the CWCP in Lake Sharpe or Lewis and Clark Lake. Compared to the other alternatives, the MLDDA alternative is the only one that actually reduces young fish production values in Lake Francis Case and maintains the CWCP value in Lewis and Clark Lake. Aside from the MODC alternative, the MLDDA alternative provides the second largest increase (5.0 percent) in young fish production value in Lake Oahe.

The ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season, unlike the CWCP. From Gavins Point Dam, there is a spring release increase of 15 kcfs and a lower summer release of 18 kcfs after the spring release. Compared to the other alternatives, the increase in total average annual young fish production value is among the lowest under the ARNRC alternative, a 4 hundredths or 2.0 percent increase over that of the CWCP. Two factors generally account for improved fish production values at Fort Peck Lake: an unbalanced intrasystem regulation and an increase in conservation in the upper three lakes. Two other factors generally account for reduced young fish production values at Fort Peck Lake: a spring rise from the lake and from a spring rise from Gavins Point Dam, both occurring with ARNRC alternative. Consequently, the ARNRC alternative decreases young fish production values within this lake the most (4 hundredths or 7.3 percent compared to the CWCP values) when compared to the other alternatives. In addition, the ARNRC alternative shows the greatest decrease in values in both Lake Oahe (2.5 percent) and Lake Sharpe (26.1 percent). Lake Sakakawea, Lake Francis Case, and Lewis and Clark Lake all experience an increase in young fish production values under the ARNRC alternative (6.5, 35.0, and 25.0 percent, respectively).

Although the ARNRC alternative has an unbalanced intrasystem regulation and an increase in conservation similar to the MRBA alternative, a major difference between these two alternatives is in the MRBA alternative's maintenance of a year-round steady flow, as with the CWCP. Spring rises are not included in the MRBA alternative. The steady flow combined with an unbalanced intrasystem regulation benefits young fish production in Fort Peck Lake and, when compared to the other alternatives, the MRBA alternative is the only one that provides a benefit or increase in young fish production value within this lake. The MRBA alternative also increases young fish production values in Lake Oahe by 1 hundredth, or 2.5 percent, and in Lewis and Clark Lake by 2 hundredths, or 12.5 percent; however, it decreases this value in Lake Sakakawea by 2.2 percent and Lake Sharpe by 4.3 percent. Compared to the other alternatives, the MRBA alternative is the only one that reduces young fish production values in Lake Sakakawea. There is no change in value from the CWCP in Lake Francis Case under this alternative.

The MRBA and MODC alternatives both maintain a year-round steady flow, have an unbalanced intrasystem regulation, and increase conservation in the upper three lakes; however, the MODC alternative has an extended flat release from Gavins Point Dam and a spring rise out of Fort Peck Dam. Compared to the other alternatives, the increase in total average annual young fish production value is among the highest under the MODC alternative, a 12 hundredths or 6.0 percent increase over that of the CWCP. A variation in the flat release from Gavins Point Dam results in different changes in young fish production values in all of the lakes except Lake Sharpe, where the value would be reduced by 1 hundredth, or 4.3 percent, which is the same as with the MRBA alternative. In Fort Peck Lake, the MODC alternative has the same benefit to young fish production as the CWCP. Compared to the other alternatives, it is the only one that provides this benefit to this lake. Maintaining lower flows for a longer period in the summer on the Lower River is most beneficial to young fish production in the remaining lakes. Values are increased over the CWCP in Lake Sakakawea (6.5 percent), Lake Oahe (7.5 percent), Lake Francis Case (5.0 percent), and Lewis and Clark Lake (31.3 percent). Compared to the other alternatives, the MODC alternative provides the greatest value increase over the CWCP in both Lake Oahe and Lewis and Clark Lake and the smallest value increase in Lake Francis Case.

The BIOP and FWS30 alternatives also have most of the components of the MRBA and MODC alternatives; however, there is variation in the additional spring/summer release criteria compared to the CWCP. Compared to the other alternatives, the increase in total average annual young fish production value is among the highest under the BIOP and FWS30 alternatives, a 5.0 and 5.5 percent increase over that of the CWCP, respectively. These two alternatives reduce young fish production values in Fort Peck Lake by 3 hundredths, or 5.5 percent, and in Lake Sharpe by 2 hundredths, or 8.7 percent. The greatest increase in young fish production values over the CWCP in Lake Sakakawea occurs under both the BIOP and FWS30 alternatives, with which there is a 10.9 percent increase in value. The BIOP alternative maintains the same level of young fish production in Lake Oahe as the CWCP, while the FWS30 alternative increases this value by 1 hundredth. In Lake Francis Case and Lewis and Clark Lake, young fish production values are increased under these alternatives by 30.0 and 25.0 percent, respectively. These results are similar to those of the ARNRC alternative.

The annual values for young fish production in the mainstem lakes for the submitted alternatives are shown on Figures 5.7-2 through 5.7-4. Generally, the submitted alternatives all show similar results during the full period of analysis as relative index values vary between 1 and almost 4 units. The years that show the greatest decrease in young fish production values are 1930, 1934, 1960, the late 1980s, and the early 1990s. These years are all during one of the three major drought periods. In very general terms, a close relationship exists between the annual average release from Gavins Point Dam and the annual fish production values. The greatest index value (between 3.50 and 4.00 units) occurs in 1986.

5.7.2 Coldwater Fish Habitat in Mainstem Lakes

The minimum coldwater fish habitat volume available from July through October in the upper three Mainstem Reservoir System lakes was estimated for each year of the 100-year simulation period. Modeling of the changes in this habitat was based on extensive water quality modeling of differing conditions in terms of lake levels, inflows to and outflows from the lakes, and ambient air conditions (warm year, cold year, etc.).

Regressions of the results of the water quality model runs were conducted to get equations to use for the Master Manual environmental impact model. Data files on the average ambient conditions for each year had to be included in the impact model, and data on inflows, outflows, and lake levels from the Daily Routing Model for each alternative simulation are used to compute changes in the volume of coldwater habitat in the lakes modeled. Table 5.7-2 and Figure 5.7-5 present the average annual values for the 100-year period of analysis for the upper three lakes. Even though Lake Francis Case was modeled, data for this lake are not included because the average annual values are essentially zero.

The CWCP provides 9.88 MAF of coldwater fish habitat on an annual basis. This total volume at the sites analyzed is distributed among Fort Peck Lake (36.3 percent), Lake Sakakawea (28.3 percent), and

Table 5.7-2. Average annual coldwater fish habitat in the mainstem lakes (MAF).

	1898 to 1997			
Alternative	**Total**	**Fort Peck Lake**	**Lake Sakakawea**	**Lake Oahe**
CWCP	**9.88**	3.59	2.81	3.47
MLDDA	**9.62**	3.51	2.75	3.36
ARNRC	**10.76**	3.66	3.15	3.95
MRBA	**10.17**	3.76	2.75	3.66
MODC	**10.42**	3.78	2.97	3.67
BIOP	**10.55**	3.75	2.90	3.90
FWS30	**10.57**	3.77	2.93	3.87

Lake Oahe (35.4 percent). As shown in Figure 5.7-5, the CWCP and MLDDA alternatives are closely grouped together between 9.62 and 9.88 MAF, a difference of 0.26 MAF. The remaining alternatives range between 10.17 and 10.76 MAF, a difference of 0.59 MAF.

The 2-MAF decrease in the base of flood control storage under the MLDDA alternative results in a decrease in total coldwater fish habitat for all three of the upper lakes, and it provides the least amount of total habitat of all the alternatives (3.0 percent less habitat than the CWCP). The MLDDA alternative decreases coldwater fish habitat by 2.2 and 2.1 percent in Fort Peck Lake and Lake Sakakawea, respectively, and by 3.2 percent in Lake Oahe. The alternative with the greatest increase in total average annual coldwater fish habitat is the ARNRC alternative. Under this alternative, total habitat increases as the existing balanced system of intrasystem regulation is modified, drought conservation levels are increased, and additional spring/summer releases mimic the natural flow of the river. This alternative has the highest level of drought conservation, which is the primary factor for the increased values over those of the CWCP.

Compared to the CWCP, the ARNRC alternative provides a 9.0 percent increase in total coldwater fish habitat. It increases coldwater fish habitat by 1.9 percent in Fort Peck Lake and by 12.1 and 13.8 percent in Lake Sakakawea and Lake Oahe, respectively. These changes are likely due to the increased amount of water stored in the upper three lakes during the droughts, which results from the increased drought conservation measures of this alternative. This alternative also permits no flood storage evacuation in most of the years, which allows the lakes to stay higher through the summer period and maintain coldwater fish habitat values at a higher level.

The CWCP and MRBA alternatives maintain a year-round steady flow; however, the MRBA alternative has an unbalanced intrasystem regulation and increased conservation in the upper three lakes. As a result, the MRBA alternative yields a 4.7 and 5.5 percent increase in coldwater fish habitat in Fort Peck Lake and Lake Oahe, respectively, and a 2.1 percent decrease in habitat in Lake Sakakawea.

The MODC alternative also includes conservation measures similar to the MRBA alternative; however, it delays the start of system flood storage evacuation from late August to mid-September in many years. This change results in slightly more coldwater habitat in the lakes than the MRBA alternative. It results in a 5.3 percent increase in coldwater fish habitat in Fort Peck Lake and a 5.7 and 5.8 percent increase in habitat in Lake Oahe and Lake Sakakawea, respectively.

The BIOP and FWS30 alternatives both increase the amount of total coldwater fish habitat in all three lakes; however, the greatest amount of habitat increase occurs in Lake Oahe, where there is an 12.4 percent increase under the BIOP alternative and an 11.5 percent increase under the FWS30 alternative. These alternatives have the same conservation measures as the MRBA and MODC alternatives; however, the combination of the spring rise and summer low flow in the BIOP and FWS30 alternatives results in less outflow from the lakes by the time the low flow ends. This means that the lakes are slightly higher in the latter part of the summer and early fall, which results in more coldwater habitat for fish.

The annual values of total reservoir coldwater fish habitat for the submitted alternatives are shown in Figures 5.7-6 through 5.7-8. The 1930 to 1941 drought period yields the least amount of total coldwater fish habitat for all the submitted alternatives. The alternative that has the most habitat during this period is the ARNRC alternative because it has the greatest drought conservation measures of the submitted alternatives. During the other two major droughts, there is another reduction in habitat; however, these droughts were less severe in terms of amount of lake drawdown and duration than the earlier drought period. Other than during these three periods, annual coldwater fish habitat is fairly stable during the 100-year period of analysis.

5.7.3 Coldwater Fish Habitat in River Reaches

The number of miles of coldwater fish habitat downstream from Fort Peck and Garrison Dams was computed for the months of April through September. Two factors were used to determine the amount of habitat for coldwater fish species: the amount of water released from the upstream dam and the water temperature. Generally, higher lake levels and higher releases result in more miles of coldwater habitat below the dams. Differences in the amount of this habitat for the submitted alternatives are discussed in this section. Annual values were computed and then averaged to compute a single value for each of the two reaches. Table 5.7-3 and Figure 5.7-9 present the combined, or total, value for the two reaches. Table 5.7-3 also presents the value for each reach over the 100-year period of analysis.

The CWCP provides 183.6 miles of coldwater fish habitat in the two coldwater river reaches of the Mainstem Reservoir System on an annual basis. This total volume at the sites analyzed is distributed among the river reaches below Fort Peck Dam (76.4 percent) and Garrison Dam (23.6 percent).

Figure 5.7-9 shows that four of the submitted alternatives are closely grouped together between 182.4 and 187.9 miles, a difference of 5.5 miles. The remaining three alternatives range between 195.8 and 198.1 miles, a difference of only 2.3 miles. These latter three alternatives all have spring rises out of Gavins Point Dam, followed by lower summer releases.

Compared to the CWCP, the 2-MAF decrease in the base of flood control storage under the MLDDA alternative creates a small amount of additional coldwater fish habitat (0.7 percent increase) below the Fort Peck Dam and reduces this habitat by 5.1 percent below Garrison Dam. The MLDDA alternative has the lowest total average annual value of coldwater fish habitat for the 100-year period of analysis when the values for the two reaches are combined.

Of the submitted alternatives, the ARNRC alternative has the highest total value for coldwater fish habitat in the two combined reaches. Modifying dam operations for high water levels in the spring and low levels in the summer provides a 9.5 and 3.0 increase in the amount of coldwater fish habitat below the Fort Peck and Garrison Dams, respectively. Increased drought conservation under this alternative also means that the releases during the droughts may be colder and may help increase the number of miles of coldwater fish habitat on an average annual basis.

Compared to the CWCP, it is apparent that the MRBA's unbalanced intrasystem regulation and increased conservation in the upper three lakes creates an increase in coldwater fish habitat below both Fort Peck and Garrison Dams. Under this alternative, the greatest percentage increase (2.5 percent) over the CWCP occurs below Garrison Dam while slightly higher habitat values (1.5 percent) occur below Fort Peck Dam. The MODC alternative results are opposite of the MRBA alternative since slightly higher habitat values (1.6 percent) occur below Garrison Dam and a greater amount of habitat (2.6 percent more than the CWCP) occurs below Fort Peck Dam.

Table 5.7-3. Average annual coldwater fish habitat in the river reaches (miles).

	1898 to 1997		
Alternative	**Total**	**Fort Peck**	**Garrison**
CWCP	**183.6**	140.2	43.4
MLDDA	**182.4**	141.2	41.2
ARNRC	**198.1**	153.5	44.7
MRBA	**186.8**	142.3	44.5
MODC	**187.9**	143.8	44.1
BIOP	**197.2**	153.6	43.6
FWS30	**195.8**	152.6	43.2

As modeled, both the BIOP and FWS30 alternatives increase spring releases from Fort Peck Dam and subsequently create more coldwater fish habitat below this dam than the CWCP. The BIOP alternative creates 9.5 percent more habitat, while the FWS30 alternative creates 8.8 percent more habitat than the CWCP. The impact model does not recognize that on average every third year much of the spring rise will be obtained from the surface of the lake and run down the spillway. Consequently, the actual miles of coldwater habitat should diminish for these alternatives as well as the ARNRC and MODC alternatives. The precise number of miles of coldwater fish habitat converted to warmwater fish habitat during the Fort Peck flow modification will depend on the actual climatological and hydrologic conditions, the lake water temperature, and the division of flow between the powerhouse and the spillway. The Fort Peck flow modification will not impact the coldwater trout fishery immediately below the dam because the spillway and powerhouse releases meet 6 miles below the dam.

Figures 5.7-10 through 5.7-12 graphically depict the annual values for total coldwater river fish habitat for the submitted alternatives. Generally, all of the alternatives maintain an average 200 miles of habitat during the full period of analysis. Habitat is reduced to between 100 and 150 miles during the 1930 to 1941 drought and continues into the early 1940s; however, the ARNRC, BIOP, and FWS30 alternatives maintain higher habitat values during this period than the remaining alternatives. These three alternatives also maintain higher habitat levels during the other two major droughts, with little drop in value compared to the other four alternatives.

5.7.4 Warmwater Fish Habitat in River Reaches

The number of miles of warmwater river fish habitat downstream from Fort Peck, Garrison, and Fort Randall Dams in each month from April through August was estimated using another fish habitat model. In general, the amount of warmwater habitat is expected to be lower for an alternative that has higher amounts of water in storage over the period of analysis and has higher releases. This is the opposite of the effects described for coldwater fish habitat. As noted in the previous section, the impacts of the warmwater release during the Fort Peck flow modification is not modeled. The following compares the effects on warmwater fish habitat of the submitted alternatives. Table 5.7-4 and Figure 5.7-13 present the average annual warmwater river fish habitat for the 100-year period of analysis. The total value shown on the table is the sum of all three reaches, with the reach downstream from Fort Peck Dam providing more than 60 percent of the habitat.

The CWCP provides 52.9 miles of warmwater fish habitat in the river reaches of the Mainstem Reservoir System on an annual basis. This total volume at the sites analyzed is distributed among the river reaches below Fort Peck Dam (62.0 percent), Garrison Dam (11.5 percent), and Fort Randall Dam (26.3 percent).

Figure 5.7-13 shows that three of the submitted alternatives are closely grouped together between 44.2 and 45.6 miles, a difference of only 1.4 miles. The remaining four alternatives range between 48.1 and 52.9 miles, a difference of 4.8 miles.

A balanced intrasystem regulation and 2-MAF reduction in the base of flood control storage, as with the MLDDA alternative, and an unbalanced intrasystem regulation and spring rise followed by a

Table 5.7-4. Average annual warmwater fish habitat in the river reaches (miles).

	1898 to 1997			
Alternative	**Total**	**Fort Peck**	**Garrison**	**Fort Randall**
CWCP	**52.9**	32.8	6.1	13.9
MLDDA	**51.4**	32.5	5.6	13.3
ARNRC	**44.2**	26.7	5.7	11.8
MRBA	**48.1**	29.4	6.0	12.7
MODC	**50.2**	30.1	7.0	13.1
BIOP	**44.9**	27.3	6.6	10.9
FWS30	**45.6**	28.4	6.5	10.7

lower summer flow that mimics the natural flow, as with the ARNRC alternative, generally decreases the amount of warmwater fish habitat downstream of the three dams. The alternative with the greatest amount of total average annual warmwater fish habitat, aside from the CWCP, is the MLDDA alternative; however, it provides 2.8 percent less habitat than the CWCP. The MLDDA alternative reduces warmwater fish habitat by as much as 8.2 percent below Garrison Dam. Reduction in habitat also occurs below Fort Peck Dam (0.9 percent) and Forst Randall Dam (4.3 percent). The ARNRC alternative provides the least amount of total habitat of all the alternatives. Compared to the CWCP, the ARNRC alternative causes an 18.6 percent reduction in habitat below Fort Peck Dam and a 15.1 percent reduction in habitat below Fort Randall Dam.

The unbalanced intrasystem regulation and increased conservation in the upper three lakes under the MRBA alternative results in an overall decrease in fish habitat in the reaches below Fort Peck, Garrison, and Fort Randall Dams. Compared to the CWCP, the MRBA alternative shows the greatest percent decreases in habitat downstream of Fort Peck and Fort Randall Dams, where there is a 10.4 and 8.6 percent reduction in habitat, respectively. The warmwater fish habitat downstream of Garrison Dam is reduced by 1.6 percent.

Compared to the CWCP, the MDOC alternative provides mixed results for the three downstream locations. Warmwater fish habitat is reduced in the river reaches downstream of Fort Peck and Fort Randall Dams (8.2 and 5.8 percent less habitat, respectively), and it is increased downstream of Garrison Dam (14.8 percent).

The BIOP and FWS30 alternatives would increase the spring rise and decrease summer flows. Compared to the CWCP, an additional spring/ summer release decreases the amount of warmwater fish habitat in the river reaches below Fort Peck and Fort Randall Dams and increases this habitat in the river reach below Garrison Dam. The greatest percentage reduction (23.0 percent) in warmwater habitat occurs under the FWS30 alternative downstream of Fort Randall Dam. Compared to the CWCP, the BIOP and FWS30 alternatives create 8.2 and 6.5 percent more warmwater fish habitat, respectively, downstream of Garrison Dam.

As shown on Figures 5.7-14 through 5.7-16, there is an overall increase in warmwater fish habitat during the 1930 to 1941 drought. Of the fish models analyzed thus far, the warmwater fish habitat model is the only one that has shown an overall benefit in habitat during this period. The CWCP and MLDDA alternative show the greatest benefit during this 13-year drought. The ARNRC, MRBA, and MODC alternatives show the least amount of benefit.

5.7.5 Physical Habitat for Native River Fish

Native river fish habitat values were computed for the river reaches downstream from four of the dams and for five subreaches on the Lower River downstream from Sioux City. An index value (correlation coefficient) was computed for each month based on how closely the velocity and/or depth distributions for a given river reach match the "natural" flow conditions based on pre-Mainstem Reservoir System channel conditions. In April, May, and June, the habitat value is dependent on the potential for overbank flooding for each reach. The index can range between 0 and 1.0 with a value of 1.0 assigned to a perfect match. The values for each of the 12 months are summed to compute an annual index value for each reach and can be as high as 12.0. A total annual value is computed by combining the values from the nine reaches. Average annual values are the means for the individual and total reaches. This section discusses the physical habitat index values for native river fish that were computed for the submitted alternatives. The total and individual reach average annual values are presented in Table 5.7-5, and the total value only is presented in Figure 5.7-17.

As shown in Figure 5.7-17, all of the alternatives are closely grouped together between 81.5 and 83.2 units, a difference of 1.7 units. The total relative index value for the CWCP is the lowest of the submitted alternatives. The run of river (ROR) alternative represents unregulated releases from the dams and has a total average annual index value of 90.49. Compared to the CWCP, the ROR alternative provides 11.1 percent higher value for total physical habitat for native fish.

The balanced intrasystem regulation and 2-MAF reduction in the base of flood control storage under the MLDDA alternative slightly increase physical habitat values below Fort Peck, Garrison, and Fort Randall Dams and within the Nebraska City and St. Joseph reaches.

Table 5.7-5. Average annual physical habitat for native river fish in nine river reaches (relative index).

	1898 to 1997									
Alternative	**Total**	**Fort Peck**	**Garrison**	**Fort Randall**	**Gavins Point**	**Sioux City**	**Nebraska City**	**St. Joseph**	**Kansas City**	**Boonville**
CWCP	**81.46**	9.03	7.86	8.56	9.30	10.22	7.98	7.93	10.03	10.55
MLDDA	**81.53**	9.06	7.91	8.57	9.30	10.18	8.00	7.94	10.03	10.54
ARNRC	**83.17**	9.49	8.03	8.44	9.20	10.27	8.46	8.30	10.28	10.70
MRBA	**81.67**	9.09	7.95	8.50	9.24	10.23	8.06	8.00	10.04	10.55
MODC	**81.76**	9.14	7.85	8.55	9.28	10.23	8.11	8.01	10.04	10.56
BIOP	**81.95**	9.18	7.82	8.45	9.35	10.08	8.19	8.16	10.10	10.63
FWS30	**82.48**	9.20	7.81	8.46	9.36	10.18	8.31	8.27	10.20	10.69

With the ARNRC alternative, several factors affect the total average annual values for physical habitat for native river fish, including an unbalanced intrasystem regulation, greater conservation in the upper three reservoirs, and changes in the spring and summer releases that mimic the Missouri River's natural flow. These factors result in the greater index values for total average annual physical habitat compared to the other alternatives (2.1 percent more than the CWCP). The ARNRC alternative provides higher values than the CWCP in the river reaches below Fort Peck and Garrison Dams and the five subreaches on the Lower River downstream from Sioux City.

The MRBA alternative shows a 0.3 percent higher index value than the CWCP. Slight increases in habitat values occur below the Fort Peck and Garrison Dams and in the four of the five subreaches of the Lower River downstream from Sioux City. The Boonville subreach habitat value is the same as the value for the CWCP. Results are similar for the MODC alternative except at Boonville, where this alternative would provide a 0.1 percent increase in habitat value over the CWCP, and below Garrison Dam, where it would provide a slightly lower value.

Increasing drought conservation and the spring rise and decreasing summer flows, as with the BIOP and FWS30 alternatives, are also more beneficial for total physical habitat for native river fish than the CWCP. Index values are higher than the CWCP downstream of Fort Peck and Gavins Point Dams and lower below Garrison and Fort Randall Dams. Four of the five subreaches in the Lower River downstream from Sioux City would have higher values under the BIOP and FWS30 alternatives, whereas the Sioux City subreach would have lower index values.

The annual values of total river fish physical habitat for the submitted alternatives are shown on Figures 5.7-18 through 5.7-20. In general, the relative index values remain between 80.0 and 85.0 units during the full period of analysis. During the early 1920s and mid-1950s, the relative index values increase for all alternatives to about 87.0 units, whereas values decrease to about 77.0 units during 1913 and 1979.

5.7.6 Missouri River Connectivity to Low-Lying Lands During the Spring Rise

As stated in the November 2000 USFWS BiOp, "Floodplain connectivity refers to the seasonal flooding of areas adjacent to the river. The spring flood pulse often provides connectivity between the floodplain to the river. For native river fish like the pallid sturgeon, this floodplain connectivity, especially during May/June, provided spawning areas for forage species, increased phytoplankton production, and redistributed carbon to the river" (USFWS, 2000). This carbon, in the form of detritus scoured off of the floodplain, settled out in the shallow water areas along the river where the microscopic biota grew. As the pallid sturgeon hatched, the larval fish would float downstream during the first few days of life. After 5 to 8 days, which coincides with the absorption of the yolk sac, the larval sturgeon would settle out into suitable habitat downstream from the spawning site and begin foraging (Kynard et al., 1998).

The physical habitat model discussed in the previous subsections on fish impacts acknowledges this important component for the growth of the young-of-year pallid sturgeon. The model requires over-bank flooding to get high index values in April, May, and June. This is the period when organic matter needs to be flushed into the river to provide biota in shallow water areas with a food source so that the larval pallid sturgeon have adequate food after spawning. Examination of the physical habitat output files for these 3 months shows very low index values, which means that river flows were generally lower than necessary for overbank flooding. To better understand how much floodplain connectivity may be occurring along the Lower River from Sioux City to the mouth, the Corps undertook an analysis. As a first step in the analysis, the Corps estimated the acreage and elevation of the low-lying lands (areas adjacent to oxbow lakes and chutes) that could be inundated by high river flows. The elevations were then converted to river stages for the output nodes of the DRM hydrologic model to determine when the spring rises were inundating these areas. The months of May and June, the period when the spring rise was modeled in most of the DRM simulation runs, were checked to see how many acres were flooded for a varying number of days for the alternatives being analyzed. All six of the alternatives submitted for consideration were analyzed with this model of connectivity.

The graphical results of the analyses of connectivity are duration plots of acres inundated versus percent of the time. Duration plots were developed for inundation for at least 2 days up to over 10 days. As the number of days is increased, the amount of acres inundated diminished, and the curves slid to the lower left on the plots. The duration plot of the 2-day analysis is shown as Figure 5.7-21. This figure shows that the various alternatives provide similar duration plots of connectivity, with the number of acres of connectivity for 2 days sometime during May or June, increasing as the amount of spring rise increases (e.g., BIOP acres [17.5-kcfs rise] are less than FWS20 acres [30-kcfs rise]). This figure also includes the duration plot for the ROR alternative to provide a perspective for how often these low-lying lands would have been inundated for 2 days with no flow control. This flow scenario has considerably higher values across the entire range of the plot from near zero percent to near 100 percent.

Table 5.7-6 presents the total values for the 25th percentile (lower quartile) from Figure 5.7-21 with a breakdown among the reaches making up the total reach from Sioux City to the mouth of the Missouri River. The 25th percentile was selected for presentation in the EIS because the alternatives were designed to have spring rises about one-third of the time, and the 25th percentile falls within the range when spring rises may be affecting the amount of connectivity. The total values are also shown in Figure 5.7-22.

The CWCP provides a total of 3,282 acres of connectivity. The greatest share of this connectivity, 39.8 and 23.4 percent, respectively, is provided in the Hermann and upstream Boonville reaches. The remaining acres are fairly evenly divided among the five other reaches, with the Nebraska City reach having the lowest amount at only 4.1 percent.

Figure 5.7-22 shows the 25th percentile acres of connectivity for the submitted alternatives, the ROR scenario, and the CWCP. The CWCP and the MLDDA, MRBA, and MODC alternatives result in the lowest acres. They are clustered in a range of only 14 acres. The BIOP alternative has about 120 acres more than the lowest group. The ARNRC and FWS30 alternatives have about 140 acres more than the BIOP alternative. This grouping is essentially by amount of spring rise. What is not apparent from the description of the ARNRC alternative is that it moves considerably more water than the 15-kcfs spring rise it includes because very little extra water is released in most years above the summer low-flow flat release of

Table 5.7-6. Missouri River connectivity to low-lying lands for 2 days from mid-May to mid-June.

	(Acres for the 25th percentile)						
	CWCP	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Sioux City	249	251	358	257	251	310	359
Omaha	270	270	403	267	273	311	399
Nebraska City	136	136	137	137	137	137	137
St. Joseph	287	287	287	287	287	287	287
Kansas City	265	251	262	261	261	271	273
Boonville	768	768	768	768	768	768	768
Hermann	1,307	1,307	1,307	1,307	1,307	1,307	1,307
Total	**3,282**	**3,270**	**3,523**	**3,284**	**3,284**	**3,390**	**3,529**

18 kcfs. This requires that water be moved earlier in the year to ensure that the extra water in flood storage can be evacuated at a relatively safe rate in the fall months. This mode of operation makes this alternative perform like an alternative with a higher spring rise, such as the FWS30 alternative. Finally, the ROR scenario, which has no inflow control (uncontrolled releases from Gavins Point Dam), has the highest value at 646 acres higher than the CWCP and almost 400 acres more than the higher spring rise alternatives.

The MLDDA alternative provides an additional 2 MAF of flood control storage than the CWCP. In most years, this alternative has releases from Gavins Point Dam very similar to the CWCP; therefore, it has a connectivity value for the 25^{th} percentile that is only 0.4 percent less than that for the CWCP.

The ARNRC alternative has a 15-kcfs spring rise that appears to be even greater than specified, as discussed above. (Review of the data plots of Gavins Point Dam releases supports this conclusion.). The 25th percentile value for the ARNRC alternative is 7.3 percent higher than that of the CWCP. The greatest share of the increase occurs in the two reaches analyzed that are closest to Gavins Point Dam: Sioux City (43.8 percent increase for this reach) and Omaha (49.4 percent increase). All of the other reaches have either a change of less than 1 percent or a slight negative change.

The MRBA alternative has no spring rise and no summer low flow period. Without a forced spring rise in most years, it provides essentially the same connectivity as the CWCP. There is some variation in the reaches, but the changes are in the range of a 3.0 percent increase to a 1.5 percent decrease. The Kansas City reach is the one that most often decreases, which is the case for the MRBA alternative.

The MODC alternative is essentially the same on the Lower River as the MRBA alternative except that the flood storage evacuation is delayed until mid-September in many years. It has essentially the same value as the MRBA alternative (when rounded), which is a 0.1 percent increase over the CWCP. Changes in the individual reaches range from an increase of 1.1 percent to a decrease of 1.5 percent.

The BIOP alternative has a spring rise of 17.5 kcfs, which provides greater connectivity along the Lower River than the CWCP. It provides an increase of 3.3 percent. As with the ARNRC alternative, the greatest increases are in the Sioux City (24.5 percent) and the Omaha (15.0 percent) reaches. The changes in the other reaches range from 0 to 2.1 percent compared to the CWCP values.

A 30-kcfs spring rise is the primary component of the FWS30 alternative affecting its connectivity to the low-lying areas along the Lower River. Its 25^{th} percentile value is 7.5 percent higher than the CWCP. Again, the greatest changes occur in the two reaches closest to Gavins Point Dam: Sioux City (44.1 percent) and Omaha (47.7 percent). Two of the next three downstream reaches have changes of 0.7 percent (St. Joseph) and 2.8 percent (Kansas City).

The model was not set up to provide year-to-year values for acres of connectivity. If it had, the results would have shown considerable fluctuation throughout the 100-year period of analysis because the forced spring rises from Gavins Point Dam would have increased connectivity in the upstream reaches. The downstream reaches would have also shown considerable year-to-year variability as the flows on the lower reaches fluctuated with tributary inflows in the spring.

5.7.7 Shallow Water Habitat along the Lower River

In its November 2000 BiOp (USFWS, 2000), the USFWS states that shallow water habitat has value to all life stages of native big river fish and other river organisms. As stated in the introductory remarks of the connectivity analysis discussion, shallow water habitat is especially important during the first few months of the life of the larval pallid sturgeon, an endangered species. The Corps and USFWS agreed during the formal consultation for, and the review of, the November 2000 BiOp, that 20 to 30 acres of shallow water habitat per mile may provide the habitat necessary for initial recovery of the pallid sturgeon. This part of the fish section of the FEIS focuses on the amount of shallow water habitat occurring in the Lower River for the CWCP and the alternatives submitted for Corps consideration.

The analysis of existing habitat under the various alternatives was conducted using data obtained for the physical habitat model. As part of the development of that model, cross sections were taken at a representative subreach of seven reaches of the Lower River and hydraulically modeled. These data provided a basis for determining the amount of habitat fitting into a variety of depth and velocity classes for each of the seven reaches (habitat per mile times reach length). Shallow water habitat for the purpose of this analysis is habitat up to 5 feet deep with a velocity no greater than 2.5 feet per second. The amount of habitat in each depth and velocity class could be determined based on the amount of flow in each river reach. Using these relationships, the Corps developed a model that would provide duration plots of the acres of habitat per mile in each reach for any timeframe of interest.

Generally, the Corps looked at individual months; however, the lowest flows for two of the submitted alternatives occur from mid-July to mid-August. Data were computed for this period for the seven Lower River reaches. Figure 5.7-23 is one of the resulting plots for the submitted alternatives. Integration of the area under the duration curve leads to the average daily value per mile for shallow water habitat for each reach. Table 5.7-7 presents these data for all seven subreaches modeled for the CWCP and submitted alternatives.

Using these acres per mile, the total acreage available in each reach of the Lower River from Sioux City to the Osage River (River Mile 130) can be computed. The data for the five reaches are presented in Table 5.7-8 on a reach and total basis (data combined using data from two locations for the Sioux City to Omaha reach). Figure 5.7-24 shows the total acres for the five reaches from Sioux City to the Osage River for each of the submitted alternatives, the CWCP, and the ROR alternative (no control of system inflows by the Mainstem Reservoir System). Data are not presented for the reach downstream from Gavins Point Dam because there is already adequate habitat (63.8 acres per mile for the CWCP) in this reach.

The CWCP provides 3,717 acres of shallow water habitat for the five reaches. The greater share of this habitat is provided between the Grand and Osage Rivers in the central part of the State of Missouri: 2,193 acres, or 59.0 percent of the total. The Nebraska City to Kansas City reach provides 25.0 percent of the total, and the other three reaches provide only 16.0 percent of the total, with the Sioux City to Omaha reach providing about half of that.

Figure 5.7-24 shows that the total acreage varies among the CWCP, submitted alternatives, and the ROR scenario. These can be divided up into four groupings. The lowest grouping has four alternatives: the CWCP and the MODC, MRBA, and MLDDA alternatives. The values range from 3,712 to 3,776, a difference of 64 acres. The ROR scenario is in the second lowest group by itself at 4,061 acres, about 100 acres more than the middle value of the lowest group. Next come the two alternatives submitted by the USFWS for consideration. These two alternatives have values just above 4,900 acres, which is about 1,200 acres more than the lowest group. Finally, the ARNRC alternative has almost 5,600 acres, which is about 1,900 acres more than the lowest group.

Table 5.7-7. Expected daily shallow water habitat for representative subreaches for river fish (acre per mile).

Reach	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Gavins Point	63.8	63.5	71.7	63.1	62.1	72.0	72.4
Sioux City	2.2	2.4	8.0	2.3	2.3	5.8	5.9
Omaha	1.9	2.1	7.1	2.0	2.0	5.1	5.2
Nebraska City	4.5	4.6	6.9	4.6	4.6	6.0	6.0
St. Joseph	4.8	5.0	9.6	5.1	5.1	7.9	7.9
Kansas City	1.4	1.4	1.7	1.4	1.3	1.7	1.8
Boonville	18.3	18.3	18.9	18.2	18.0	18.7	18.8

Table 5.7-8. Expected daily shallow water habitat available during mid-July to mid-August (acres).

Reach	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30	ROR
Sioux City to Omaha	288	311	1,051	304	294	758	771	479
Omaha to Nebraska City	144	148	221	148	146	191	191	165
Nebraska City to Kansas City	929	966	1,852	971	970	1,513	1,526	1,187
Kansas City to Grand River	164	158	200	157	148	196	204	144
Grand River to Osage River	2,193	2,193	2,263	2,187	2,155	2,248	2,256	2,086
Total	**3,717**	**3,776**	**5,587**	**3,767**	**3,712**	**4,906**	**4,949**	**4,061**

The MLDDA alternative provides an additional 2 MAF of flood control storage as its primary difference from the CWCP; therefore, it generally has similar summer flows to that of the CWCP. As expected, it also has similar total shallow water habitat, at 3,776 acres as presented in Table 5.7-8. This total represents a 1.6 percent increase in shallow water habitat in the mid-July to mid-August timeframe. There is some variation among the reaches. The three reaches between Sioux City and Kansas City have increased habitat ranging from an increase of 2.8 percent in the middle of the three reaches to an increase of 7.8 percent in the Sioux City to Omaha reach. In contrast, the Kansas City to Grand River reach decreases by 3.7 percent.

An 18-kcfs release from Gavins Point Dam in the summer with greater limits on evacuation of water from flood storage in the summer result in the highest shallow water habitat values of the submitted alternatives. The 5,587 acres represents a 50.3 percent increase in habitat over the CWCP. A 265 percent increase in the Sioux City to Omaha reach is by far the greatest percentage increase. Three of the other reaches have increases ranging from 21.8 to 99.5 percent. The Grand River to Osage River reach increases by only 3.2 percent.

The MRBA alternative also has summer flows very similar to the CWCP; therefore, it has only a 1.3 percent increase in habitat compared to the CWCP. The increases range from 2.9 to 5.6 percent for the three upstream reaches. The two lower river reaches decrease by 0.3 and 4.3 percent.

The MODC alternative also has summer flows in the mid-July to mid-August timeframe similar to those of the CWCP; therefore, it has habitat values similar to the CWCP. Total habitat decreases by only 0.1 percent; however, the losses are downstream from Kansas City only, ranging from 1.7 percent to 10.2 percent. The gains in the three upstream reaches range from 1.7 to 4.4 percent increases.

The BIOP alternative has lower summer Gavins Point Dam releases than the CWCP. The 25/21 split season has a release of 21 kcfs during the mid-July to mid-August timeframe. This results in lower flows throughout the Lower River, which is reflected in the increased shallow water habitat of this alternative. It has 32.0 percent more habitat, which increases in all of the five reaches downstream from Sioux City. The increases range from a low of 2.5 percent for the most downstream reach to a high of 163 percent in the reach between Sioux City and Omaha.

The FWS30 alternative also has the 25/21-split summer release from Gavins Point Dam. An increase in habitat similar to the BIOP alternative occurs, as anticipated. The total increase is 33.1 percent with increases in all five reaches. Similar to the BIOP alternative, the increases range from 2.9 percent in the most downstream reach to a high of 168 percent in the Sioux City to Omaha reach.

Because the modeling process results in a duration plot, there are no annual data to plot. The summer low flow remains about the same throughout the period of analysis, which ran from 1898 to 1997. There are habitat decreases when evacuation of flood storage becomes necessary. Review of the duration plot, Figure 5.7-25, confirms that there must be periods of high flows because there are noticeably lower values at least 10 percent of the time.

An important point to note regarding the amount of habitat that exists per mile in the reaches from Sioux City to the Osage River is the following: with the exception of the Grand River to Osage River reach, habitat acreage is well below the minimum of 20 acres per mile that the Corps and USFWS agreed upon for the pallid sturgeon. Even though there are some significant increases in shallow water habitat (as discussed above and shown in Figures 5.7-23 and 5.7-25), the gains provided by release changes alone are not enough to provide the minimum 20 acres per mile. Because of this, the USFWS included in its November 2000 BiOp RPA the recommendation for the Corps to construct additional shallow water habitat.

5.7.8 Spawning Cue for the Lower River

The November 2000 USFWS BiOp RPA recommends a spring rise release from Gavins Point Dam to provide, among other biologically important functions, a spawning cue for native river fish, especially the endangered pallid sturgeon. The RPA specifies a modified annual release pattern that has a spring rise above the full navigation service releases of 15 to 20 kcfs. The peak period for this release is 2 weeks. The total duration for this release is 4 weeks, including the periods before and after the peaks, when the release is gradually increased and decreased. Discussions between USFWS and Corps staff determined that the spawning cue requirements of the pallid sturgeon are basically unknown at this time.

In an e-mail sent to the Corps on January 22, 2001, the USFWS requested the Corps to conduct some hydrologic analyses. This set of analyses included a spring rise analysis. The USFWS requested, "For gage sites downstream of Gavins Point, document spring rise spawning cues. Rises should be defined as increases of discharge of at least 20 percent above the mean discharge prevailing for the preceding 15 days, during the period May to July. The rise should take place over three days or less" (USFWS, 2000). The USFWS provided no information on what duration of rise to analyze. This lack of information supported the general understanding between the Corps and USFWS staff that the required spawning cue is basically unknown at this point in time. Corps staff understood that the aforementioned criteria were hypothetical, and they did not have supporting data, analysis, and documentation of associated spawning success. A discussion of the analysis conducted for evaluating a spawning cue follows.

A model was developed that would access the daily flow data for each Daily Routing Model (DRM) location from Gavins Point Dam to the mouth. A running average of the daily flows for the previous 15 days was conducted using the data starting on May 1 and ending on June 30 of each year. (The likelihood of spawning cues after June 30 is low, so it was not checked.) The flows for May 1, 2 and 3 were checked to determine if the flows over this 3-day period exceeded the prior 15-day average by at least 20 percent. If the flows on one of the days met the 20 percent increase, the model would continue to check the daily average flow until it dropped to less than 20 percent of the flows for the 15 days prior to May 1. The model would continue a day-by-day check of the prior 15 days, compute an average, and count the number of days the flows continued to be at least 20 percent above that prior 15-day average. This continued up to June 30.

In some years there were some shorter periods and some longer periods. The model recorded the longest period in terms of days. The longest period was recorded for each year, and when the 100 years of data were analyzed. The 100 annual values were sorted from highest to lowest with the highest value assigned a 1 (for equaled or exceeded 1 percent of the time) and the lowest value assigned a 100 (for equaled or exceeded 100 percent of the time). A plot of these data is called a duration plot, and Figure 5.7-26 is an example of such a plot for the Sioux City gage. This figure shows the duration plots for the CWCP at all of the gage locations in the DRM simulation output files for the Lower River from Sioux City downstream. A similar plot was completed for the six submitted alternatives.

Another set of curves was developed for the ROR scenario (no control of inflows to the mainstem of the Missouri River). Sets of curves can be compiled for each gage location using this first set of curves, as shown on Figure 5.7-27. This second set of curves, one for each gage location in the DRM, provides the spawning cues for a full range of days. For example, to determine how often a 20 percent increase in flow occurred for a total of 21 consecutive days, one would go to the point where the 21-day line crosses the duration curves. Next one would slide down and read off the percent of time from the bottom axis of the graph for each curve. In the case of the CWCP curve on the figure, this point is located at 7 percent of the time. Similarly, it is 28 percent of the time for the ARNRC alternative.

Because the USFWS did not specify a length for the spawning cue, one was selected for analysis based on the spring rise recommended in the November 2000 BiOp RPA. The total rise occurs over a 28-day period. If it takes 3 days to go up 20 percent, there will also be 3 days at the end of the spring rise where the releases will drop below the 20 percent value. This means that the spawning cue lasted 22 days (28 minus 6). Based on this basic consideration, a 3 week, or 21-day, length was evaluated for the spawning cue. Figure 5.7-28 shows a plot of the resulting data for all of the gage locations included in the DRM. The curves shown on this plot would shift upward for shorter lengths of spawning cues, and vice versa.

Figure 5.7-28 shows that the CWCP, the submitted alternatives, and the ROR scenario have spawning cues that occur for differing amounts of time. The values are presented in Table 5.7-9. For example, the Sioux City line on the plot shows that the percent of time increases for the CWCP in a downstream direction with a 21-day spawning cue occurring 7 percent of the time at Sioux City and a maximum of 38 percent of the time at Hermann. The values for Sioux City vary from alternative to alternative. For example, the ARNRC alternative with its 15-kcfs spring rise raises the value to 27 percent for Sioux City. The FWS30 alternative with its 30-kcfs spring rise has the highest values, ranging from 38 percent at St. Joseph to 48 percent at Gavins Point Dam.

Table 5.7-9. Percent of years with a 21-day spawning cue at Lower River gaging stations.

	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30	ROR
Gavins Point Dam	18	20	33	23	23	35	48	78
Sioux City	7	11	27	15	11	32	44	79
Omaha	7	9	30	16	12	32	46	79
Nebraska City	10	12	26	15	13	31	43	68
St. Joseph	17	19	24	19	21	26	38	63
Kansas City	33	31	42	35	33	39	44	62
Boonville	33	33	33	33	33	34	40	62
Hermann	38	38	37	39	38	38	42	54

Generally, for the reaches Kansas City upstream, the values are higher as the spring rise included in the alternative is higher. Downstream from Kansas City, however, the value for the percent of the time the spawning cue occurred remains relatively constant, with the values ranging from 37 to 42 percent of the time at Hermann, and 33 to 40 percent of the time at Boonville. A spring rise of 30 kcfs was required to make the percent change by more than 2 percent for the two lowest gage locations. The ROR scenario has more spawning cues because the uncontrolled flows were historically much higher than the modeled spring rises, with the percent values ranging from high on the reaches closest to Sioux City (78 or 79 percent) to the lowest value occurring at Hermann (54 percent).

5.7.9 Fish Resources for Tribal Reservations

Young-of-Year Lake Fish Production

Table 5.7-10 presents the relative index of average annual young fish production of the alternatives for seven Tribal Reservations along the mainstem lakes during the full period from 1898 to 1997. See Section 5.7.1 for a discussion of how the young fish index value was calculated.

The total index value for average annual young fish production associated with these Reservations is 1.65 for the CWCP. All of the submitted alternatives result in an increase in total young fish production values over the CWCP: the MLDDA alternative by 1.2 percent, the ARNRC alternative by 8.5 percent, the MRBA alternative by 0.4 percent, the MODC alternative by 7.3 percent, the BIOP alternative by 11.5 percent, and the FWS30 alternative by 12.1 percent.

Under the CWCP, the average annual index value for young fish production for the Fort Berthold Reservation (on Lake Sakakawea) is 0.46. Five of the submitted alternatives increase young fish production index values compared to the CWCP. The BIOP and FWS30 alternatives both provide the greatest percentage increase over the CWCP (10.9 percent). The ARNRC and MODC alternatives both result in a 6.5 percent increase in young fish production index values, while the MLDDA alternative provides a 4.3 percent increase. The MRBA alternative is the only submitted alternative that decreases the young fish production index value from the CWCP (2.2 percent).

The CWCP provides a young fish production index value of 0.40 within the Standing Rock Reservation and the Cheyenne River Reservation, both of which are located on Lake Oahe. The BIOP alternative does not result in an index value change over the CWCP. Under the ARNRC alternative, the index value within these Reservations decreases by 2.5 percent. The remaining four submitted alternatives all provide an index value increase. The MODC alternative provides the greatest percentage increase (7.5 percent), while the MRBA and FWS30 alternatives both result in the smallest percentage increase (2.5 percent). The MLDDA alternative yields a 5.0 percent increase in young fish production index value over the CWCP.

Within the Lower Brule Reservation and the Crow Creek Reservation, on the lower portion of Lake Oahe, the CWCP provides an index value of 0.43 for young fish production. The MODC alternative does not result in a change in young fish production index values over the CWCP. The BIOP and FWS30 alternatives both provide an index value increase of 9.3 percent. The ARNRC alternative also provides an index value increase over the CWCP, but it is only by 2.3 percent. The MLDDA and MRBA alternatives both result in a 2.3 percent decrease in index values.

Table 5.7-10. Average annual young fish production in the mainstem lakes for seven Reservations (relative index).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Berthold	0.46	0.48	0.49	0.45	0.49	0.51	0.51
Standing Rock and Cheyenne River	0.40	0.42	0.39	0.41	0.43	0.40	0.41
Lower Brule and Crow Creek	0.43	0.42	0.44	0.42	0.43	0.47	0.47
Yankton	0.20	0.19	0.27	0.20	0.21	0.26	0.26
Santee	0.16	0.16	0.20	0.18	0.21	0.20	0.20
Total	**1.65**	**1.67**	**1.79**	**1.66**	**1.77**	**1.84**	**1.85**

The CWCP yields a young fish production index value of 0.20 within Yankton Reservation, on Lake Francis Case. There is an index value increase under the ARNRC alternative (34.5 percent), the FWS30 alternative (29.9 percent), and the BIOP alternative (29.5 percent). The MODC alternative also provides an index value increase, but it is a much smaller value than the previously mentioned alternatives (5.4 percent). The MRBA and MLDDA alternatives both decrease the index value (1.3 and 5.2 percent, respectively).

Under the CWCP, the index value for young fish production for the Santee Reservation (on Lewis and Clark Lake) is 0.16. Compared to the CWCP, five of the submitted alternatives increase the young fish production index value for this Reservation. The MLDDA alternative does not result in a change in value from the CWCP. The MRBA alternative provides a 12.5 percent index value increase, while the ARNRC, BIOP, and FWS30 alternatives all provide a 25.0 percent increase. The MODC alternative results in the largest percentage index value increase over the CWCP (31.3 percent).

Coldwater Fish Habitat in Lakes

Table 5.7-11 presents the average annual volume of coldwater fish habitat (in MAF) for each alternative for three Tribal Reservations along the mainstem lakes during the full period from 1898 to 1997.

The total volume associated with the Fort Berthold, Standing Rock, and Cheyenne River Reservations is 6.28 MAF for the CWCP. Compared to the CWCP, only one of the submitted alternatives, the MLDDA alternative, decreases total coldwater fish habitat in the upper two mainstem lakes (decrease of 2.7 percent). The remaining five submitted alternatives all increase coldwater fish habitat: the ARNRC alternative by 13.1 percent, the BIOP and FWS30 alternatives by 8.3 percent, the MODC alternative by 5.7 percent, and the MRBA alternative by 2.1 percent.

The CWCP provides 2.81 MAF of coldwater fish habitat for the Fort Berthold Reservation, which is located on Lake Sakakawea. The ARNRC alternative provides the greatest increase (12.1 percent) in coldwater fish habitat over the CWCP within this Reservation. The MODC, FWS30, and BIOP alternatives increase habitat by 5.7, 4.3, and 3.2 percent, respectively. The MLDDA and MRBA alternatives both decrease coldwater fish habitat for the Fort Berthold Reservation by 2.1 percent.

For the Standing Rock Reservation and the Cheyenne River Reservation on Lake Oahe, the CWCP provides 3.47 MAF of coldwater fish habitat. One alternative, the MLDDA alternative, decreases coldwater fish habitat (3.2 percent), while the ARNRC, BIOP, and FWS30 alternatives all increase habitat by 13.8, 12.4, and 11.5 percent, respectively. The MRBA alternative also increases

Table 5.7-11. Average annual coldwater fish habitat for three Reservations along the mainstem lakes (MAF).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Berthold	2.81	2.75	3.15	2.75	2.97	2.90	2.93
Standing Rock and Cheyenne River	3.47	3.36	3.95	3.66	3.67	3.90	3.87
Total	**6.28**	**6.11**	**7.10**	**6.41**	**6.64**	**6.80**	**6.80**

coldwater fish habitat within the Standing Rock and Cheyenne River Reservations, but it is by a smaller amount (5.5 percent).

Coldwater Fish Habitat in the River

Table 5.7-12 presents the miles of average annual coldwater habitat of the alternatives for the Fort Peck Reservation during the full period from 1898 to 1997. The Fort Peck Reservation is located downstream of Fort Peck Dam.

The CWCP provides 140.2 miles of coldwater fish habitat for the Fort Peck Reservation. According to the model, the greatest increase in coldwater fish habitat for the Fort Peck Reservation is under the BIOP alternative. Under this alternative, the model shows a 9.5 percent increase over the habitat for the CWCP. The model also shows that the ARNRC and FWS30 alternatives increase habitat by 9.4 and 8.9 percent, respectively. Lesser increases occur under the MODC alternative (2.6 percent), the MRBA alternative (1.5 percent), and the MLDDA alternative (0.7 percent). The average annual values should actually be lower for the four alternatives that have a spring rise out of Fort Peck Dam (the ARNRC, MODC, BIOP, and FWS30 alternatives) because warmwater will be discharged from the spillway to benefit native river fish in this reach. Unfortunately, the coldwater model does not know that a portion of the flow will come from the spillway. The precise number of miles of coldwater fish habitat converted to warmwater fish habitat during the Fort Peck flow modification will depend on the actual climatological and hydrologic conditions, the lake water temperature, and the division of flow between the powerhouse and the spillway. The Fort Peck flow modification will not impact the coldwater trout fishery immediately below the dam because the spillway and powerhouse releases meet 6 miles below the dam.

Warmwater Fish Habitat in the River

Table 5.7-13 presents the miles of average annual warmwater habitat of the alternatives for Tribal Reservations along two river reaches during the full period from 1898 to 1997. The Reservations analyzed include the Fort Peck Reservation, located downstream of Fort Peck Dam, and the Yankton Reservation and Ponca Tribal Land, located downstream of Fort Randall Dam.

The CWCP provides an average 32.8 miles of warmwater fish habitat downstream from the Fort Peck Reservation. Compared to the CWCP, all of the submitted alternatives decrease warmwater fish habitat for this Reservation. The MLDDA and MODC alternatives reduce habitat by 0.9 and 8.3 percent, respectively. The MRBA alternative reduces habitat by 10.6 percent. The greatest decreases in warmwater fish habitat occur under the ARNRC alternative (18.6 percent), the BIOP alternative (16.8 percent), and the FWS30 alternative (13.4 percent). The same basic model generates both the warmwater habitat data and the coldwater habitat data. Data for the Fort Peck reach are not accurate because of the warmwater release over the Fort Peck Dam spillway in a portion of the period modeled. The number of warmwater habitat miles should be greater in some years for the four alternatives with the Fort Peck spring rise (the ARNRC, MODC, BIOP, and FWS30 alternatives). Overall, one could anticipate that the average annual number of miles would decline relative to

Table 5.7-12. Average annual coldwater fish habitat for the Fort Peck Reservation (miles).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	140.2	141.2	153.5	142.3	143.8	153.6	152.6

Table 5.7-13. Average annual warmwater fish habitat for Reservations for the river reaches downstream from Fort Peck and Fort Randall Dams (miles).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	32.8	32.5	26.7	29.4	30.1	27.3	28.4
Yankton and Ponca Tribal Lands	13.9	13.3	11.8	12.7	13.1	10.9	10.7
Total	**46.8**	**45.8**	**38.5**	**42.1**	**43.2**	**38.2**	**39.1**

the CWCP values, but not by as much as the table and narrative indicate.

Under the CWCP, the Yankton Reservation and Ponca Tribal Lands show 13.9 miles of warmwater fish habitat; however, all of the other submitted alternatives decrease warmwater fish habitat for the Yankton Reservation and Ponca Tribal Lands compared to the CWCP. The MLDDA, MODC, and MRBA alternatives reduce habitat by 4.6, 5.9, and 8.5 percent, respectively. The greatest decreases in habitat occur under the ARNRC, BIOP, and FWS30 alternatives; these reductions are 15.2, 21.5, and 23.3 percent, respectively.

Physical Habitat for Native Fish

Table 5.7-14 presents the average annual physical habitat index values of the alternatives for seven Tribal Reservations during the full period from 1898 to 1997. The Reservations analyzed include Fort Peck Reservation, downstream of Fort Peck Dam; Yankton Reservation and Ponca Tribal Lands, which are downstream of Fort Randall Dam; and Winnebago Reservation, Omaha Reservation, Iowa Reservation, and Sac and Fox Reservation, all of which are downstream of Gavins Point Dam. See Section 5.7.5 for a discussion of how the physical habitat index was calculated.

An index value was computed for each month based on how closely the velocity and/or depth distributions for a given river reach match the "natural" flow conditions based on pre-Mainstem Reservoir System channel conditions. The index can range from 0 to 1.0 with 1.0 indicating a perfect match. The values for each of the 12 months are summed to compute an annual index for each Reservation or group of Reservations in that reach. The annual index can range as high as 12.0. The total annual index is computed by combining the values from all the Reservations.

Total index values for average annual physical habitat associated with these Reservations is 35.74 for the CWCP. All of the other alternatives result in an increase in total physical habitat values over the CWCP: the MLDDA alternative by 0.1 percent, the ARNRC alternative by 2.1 percent, the MRBA alternative by 0.2 percent, the MODC alternative by 0.5 percent, the BIOP alternative by 0.4 percent, and the FWS30 alternative by 1.0 percent.

Under the CWCP, the average annual index value for physical habitat for the Fort Peck Reservation is 9.03. For this Reservation, all of the other alternatives increase the physical habitat index values over the CWCP. The greatest increase in physical habitat index values occurs under the ARNRC alternative (5.1 percent). The remaining submitted alternatives provide smaller percentage increases over the CWCP: the MLDDA alternative by 0.3 percent, the MRBA alternative by 0.7 percent, the MODC alternative by 1.2 percent, the BIOP alternative by 1.7 percent, and the FWS30 alternative by 1.9 percent.

The CWCP yields an index value of 8.56 for physical habitat for native river fish for the Yankton Reservation and Ponca Tribal Lands. Five of the submitted alternatives decrease physical habitat values from the value of the CWCP, while the MLDDA alternative increases the index value by 0.1 percent and the MODC alternative decreases the index value by 0.1 percent. The remaining submitted alternatives all decrease the physical habitat index value: the MRBA alternative by 0.7 percent, the FWS30 alternative by 1.2 percent, the BIOP alternative by 1.3 percent, and the ARNRC alternative by 1.4 percent.

The CWCP provides a physical habitat index value for native river fish of 10.22 for the reach adjacent to the Winnebago Reservation and Omaha

Table 5.7-14. Average annual physical habitat values for native river fish impact on Reservations (index).

	1898 to 1997						
Reservation	**CWCP**	**MLDDA**	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Fort Peck	9.03	9.06	9.49	90.9	9.14	9.18	9.20
Yankton and Ponca	8.56	8.57	8.44	8.50	8.55	8.45	8.46
Winnebago and Omaha	10.22	10.18	10.27	10.23	10.23	10.08	10.18
Iowa and Sac and Fox	7.93	7.94	8.30	8.00	8.01	8.16	8.27
Total	**35.74**	**35.75**	**36.50**	**35.82**	**35.93**	**35.87**	**36.11**

Reservation. The ARNRC alternative increases (0.5 percent) the physical habitat value as do both the MRBA and MODC alternatives (0.1 percent). Both the MLDDA alternative and the FWS30 alternative decrease physical habitat values by 0.4 percent, while the BIOP alternative decreases habitat values by 1.4 percent.

For the Iowa Reservation and the Sac and Fox Reservation, the CWCP shows a 7.93 index value for native river fish physical habitat. All of the submitted alternatives provide an increase in physical habitat index values over the CWCP. The MLDDA alternative provides the smallest percentage increase over the CWCP, 0.1 percent, and the MRBA and MODC alternatives increase habitat values by 0.9 and 1.0 percent, respectively.

The FWS30 and ARNRC alternatives provide the greatest percentage increase (4.3 and 4.7 percent, respectively). The BIOP alternative provides a 2.9 percent value increase over the CWCP.

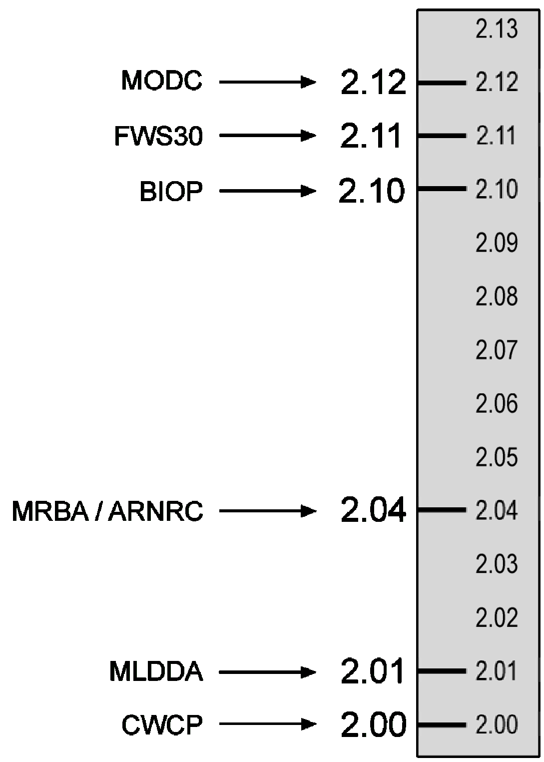

Figure 5.7-1. Average annual young fish production index values for submitted alternatives.

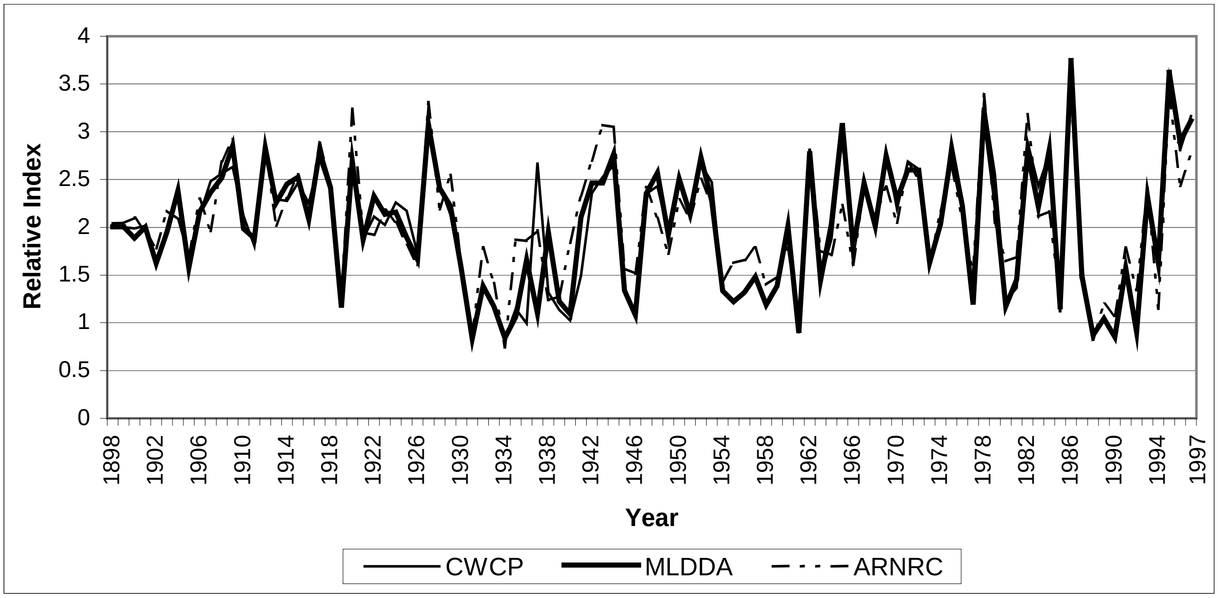

Figure 5.7-2. Annual values for young fish production in mainstem lakes for alternatives CWCP, MLDDA, and ARNRC.

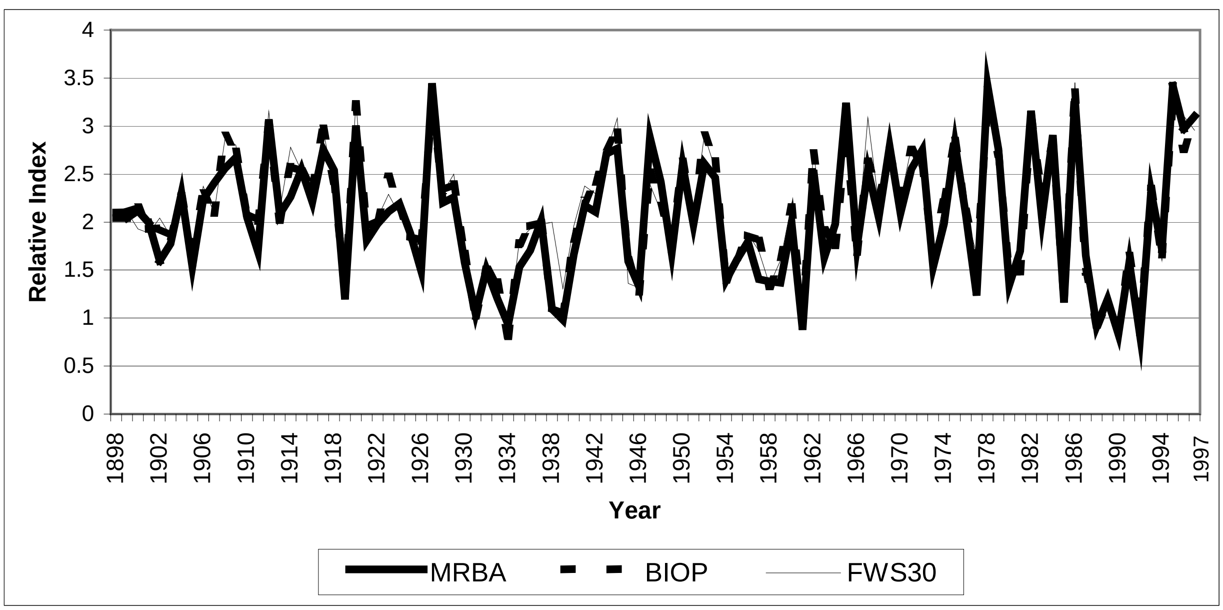

Figure 5.7-3. Annual values for young fish production in mainstem lakes for alternatives MRBA, BIOP, and FWS30.

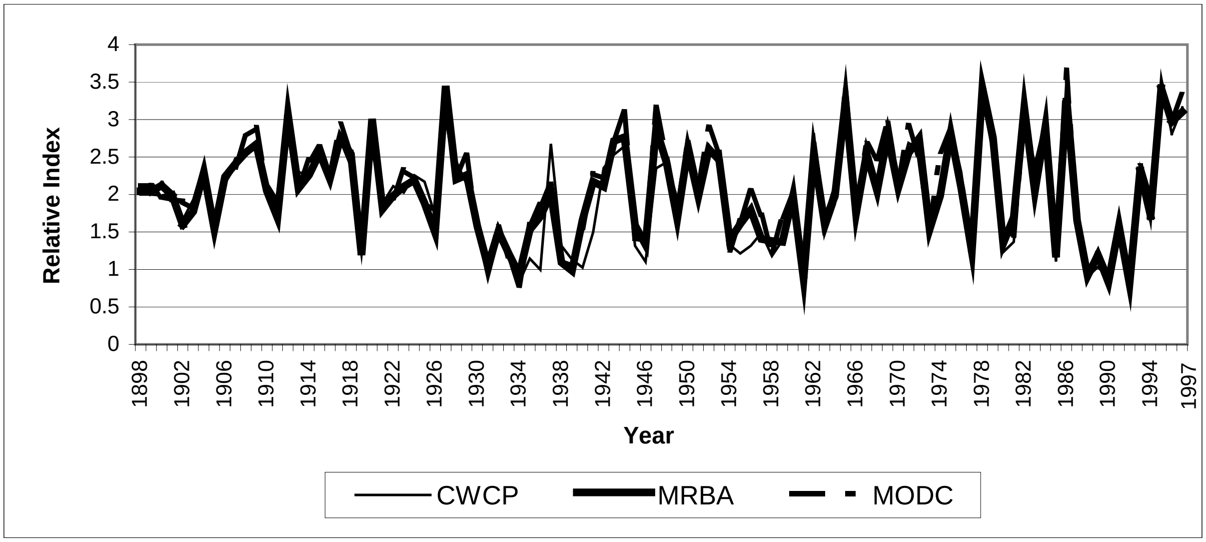

Figure 5.7-4. Annual values for young fish production in mainstem lakes for alternatives CWCP, MRBA, and MODC.

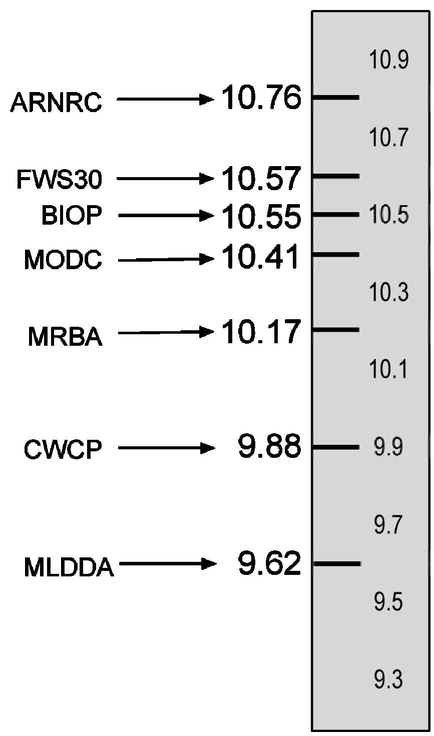

Figure 5.7-5. Average annual coldwater fish habitat in mainstem lakes for submitted alternatives (MAF).

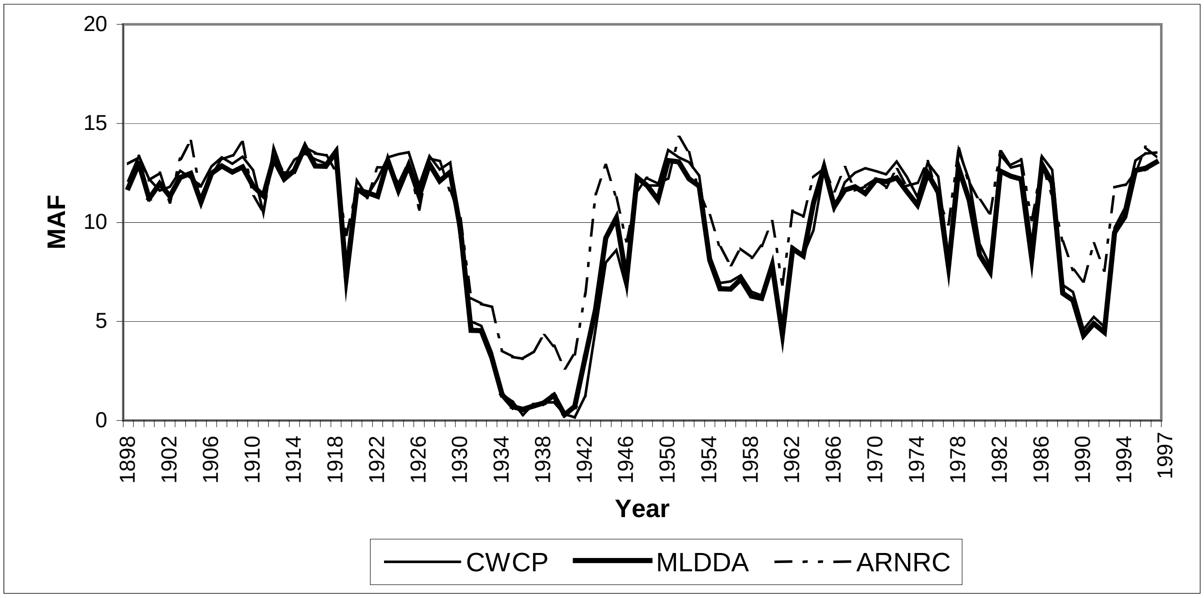

Figure 5.7-6. Annual coldwater fish habitat in mainstem lakes for alternatives CWCP, MLDDA, and ARNRC.

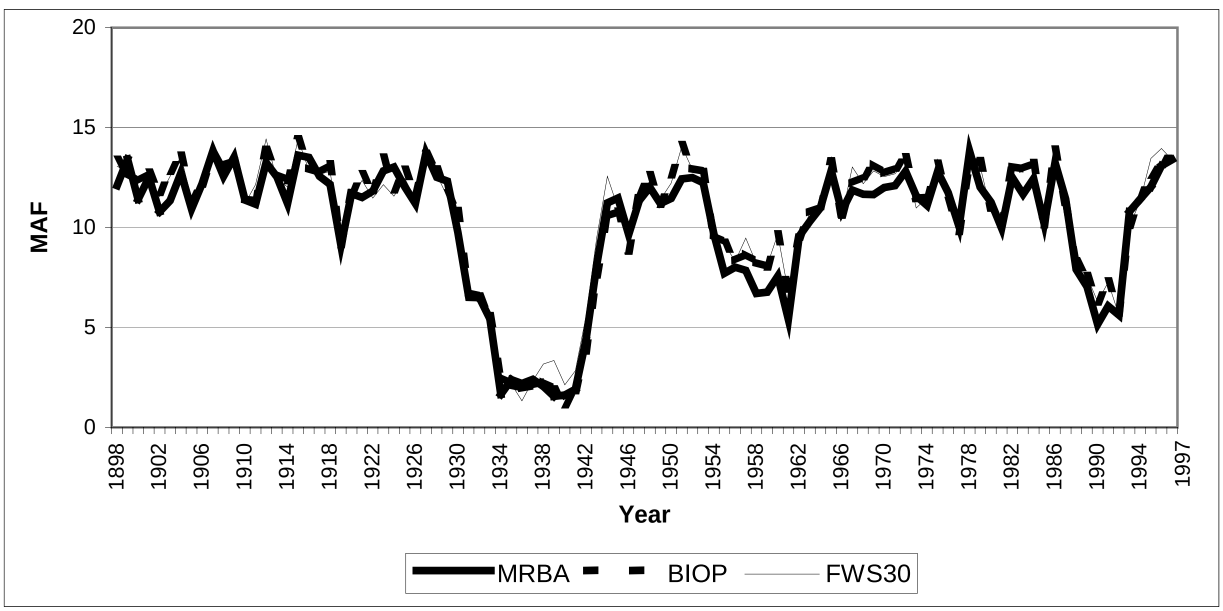

Figure 5.7-7. Annual coldwater fish habitat in mainstem lakes for alternatives MRBA, BIOP, and FWS30.

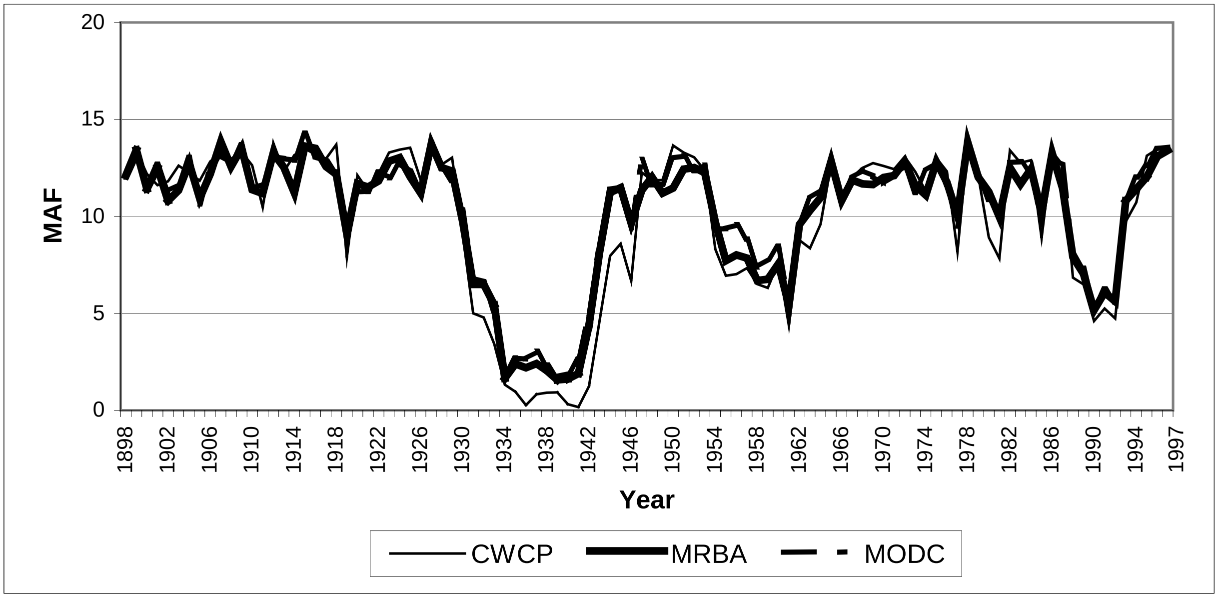

Figure 5.7-8. Annual coldwater fish habitat in mainstem lakes for alternatives CWCP, MRBA, and MODC.

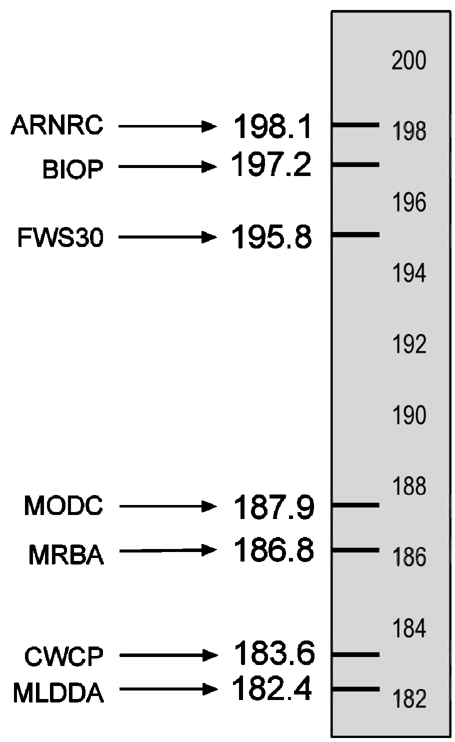

Figure 5.7-9. Average annual coldwater fish habitat in river reaches for submitted alternatives (miles).

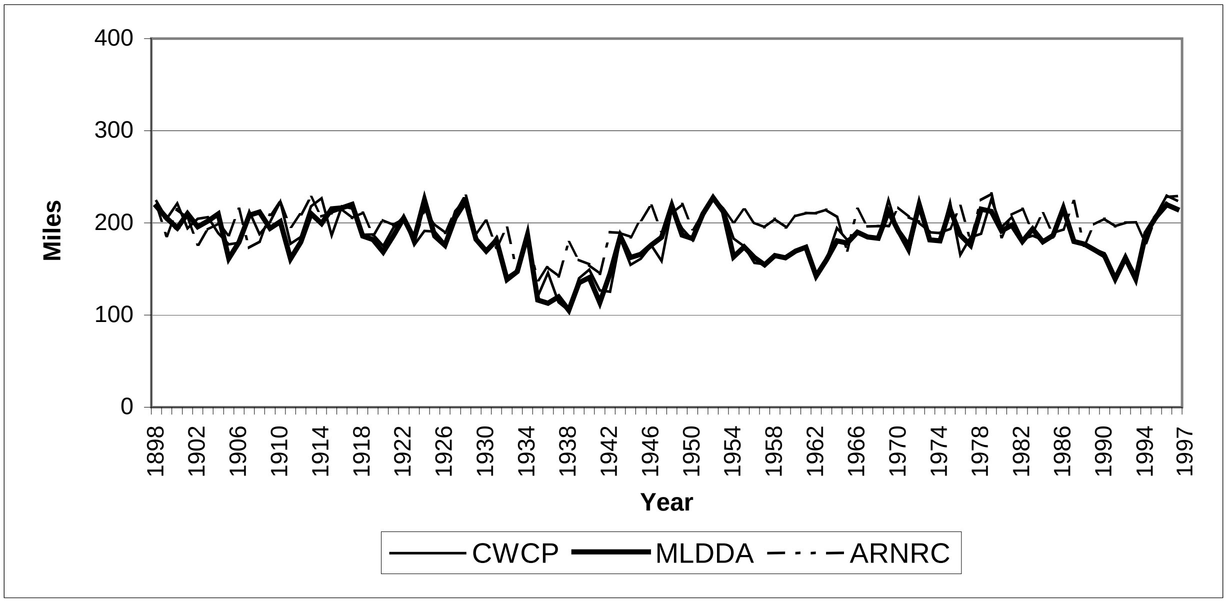

Figure 5.7-10. Annual coldwater fish habitat in river reaches for alternatives CWCP, MLDDA, and ARNRC.

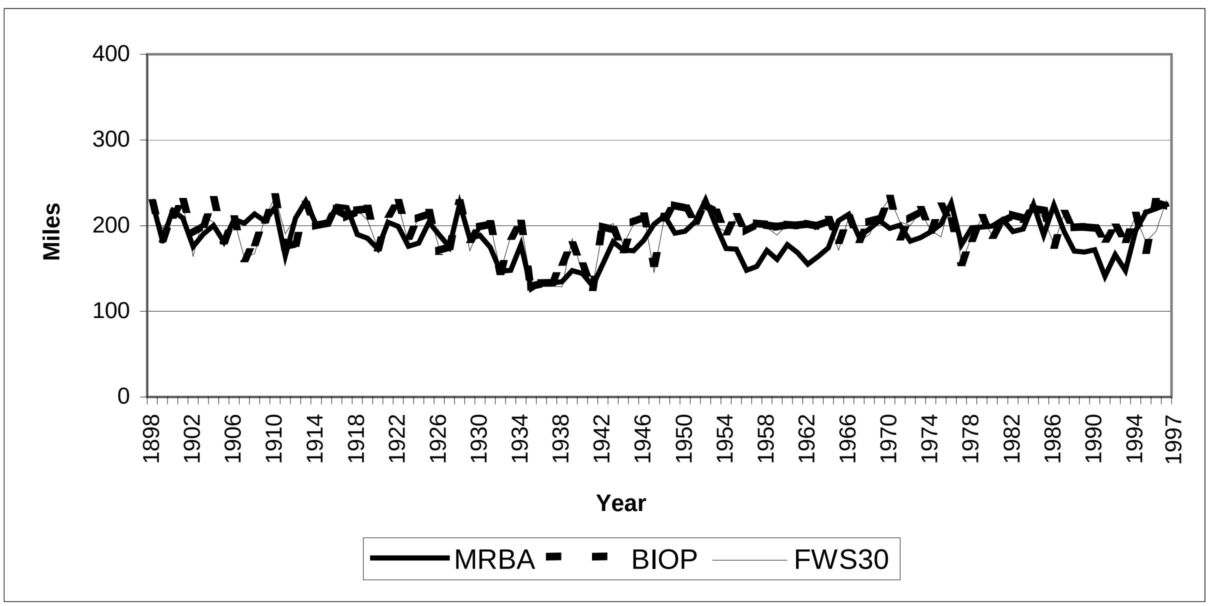

Figure 5.7-11. Annual coldwater fish habitat in river reaches for alternatives MRBA, BIOP, and FWS30.

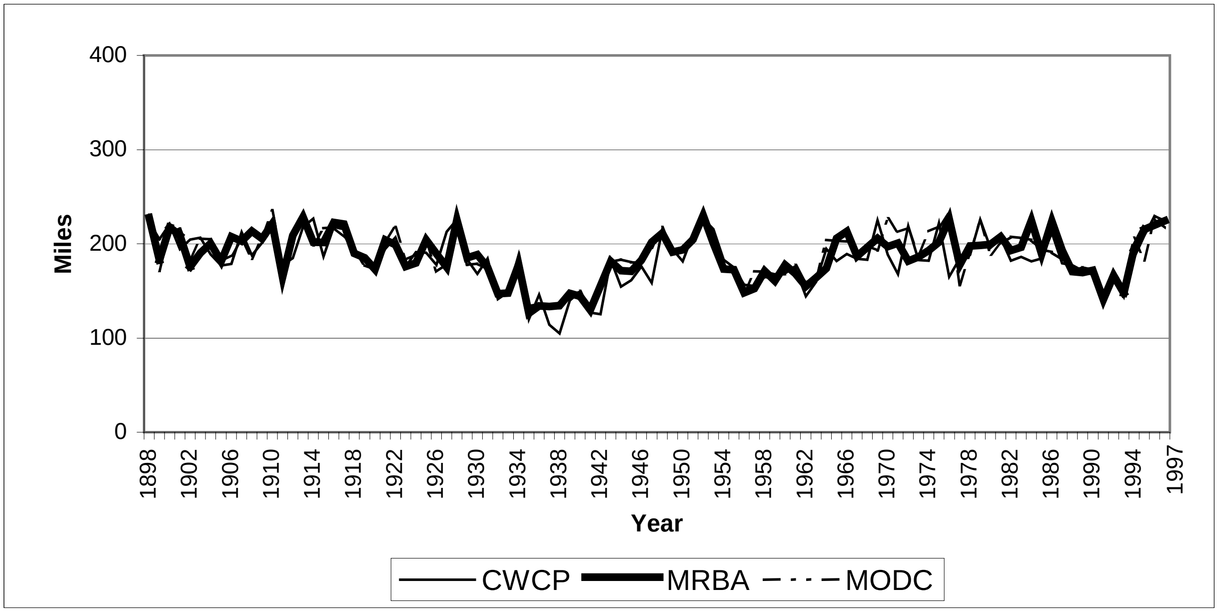

Figure 5.7-12. Annual coldwater fish habitat in river reaches for alternatives CWCP, MRBA, and MODC.

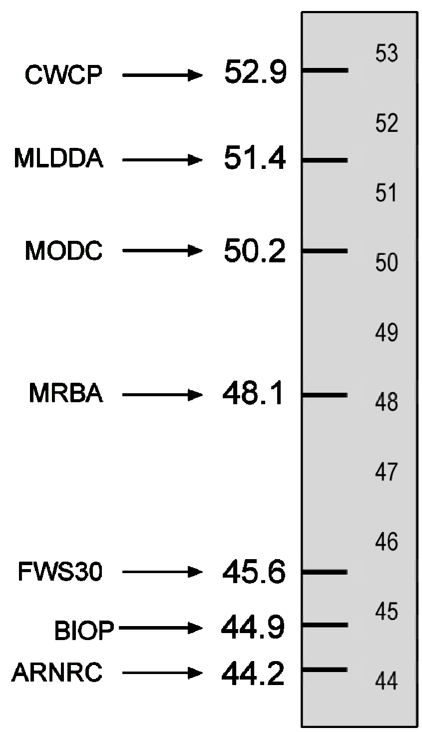

Figure 5.7-13. Average annual warmwater fish habitat in river reaches for submitted alternatives (miles).

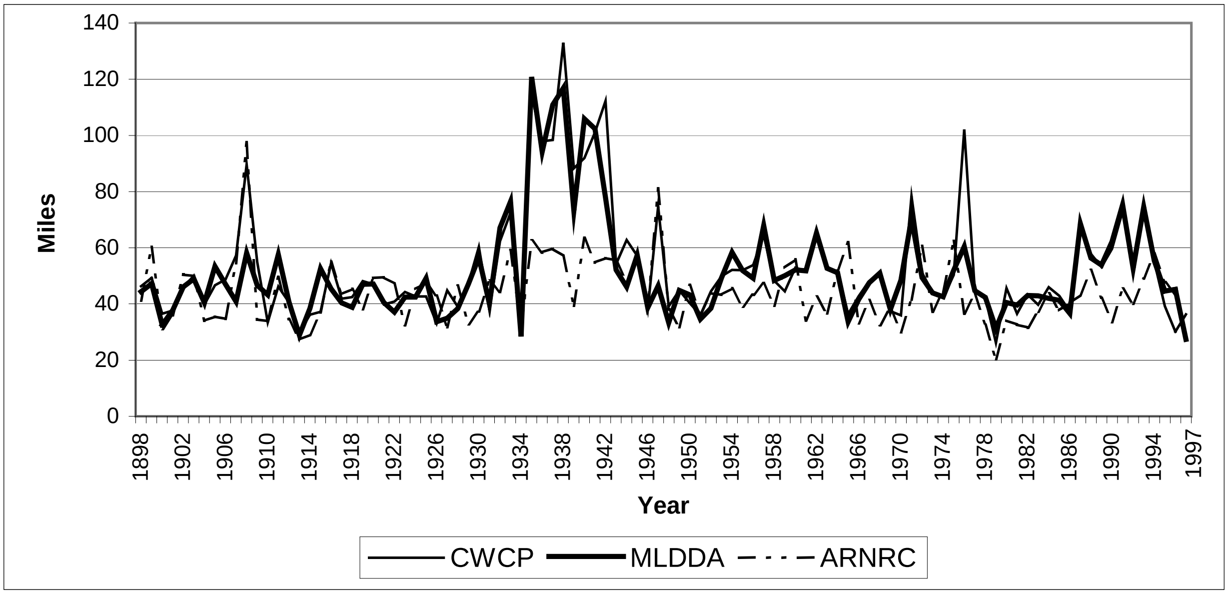

Figure 5.7-14. Average annual warmwater fish habitat in river reaches for alternatives CWCP, MLDDA, and ARNRC.

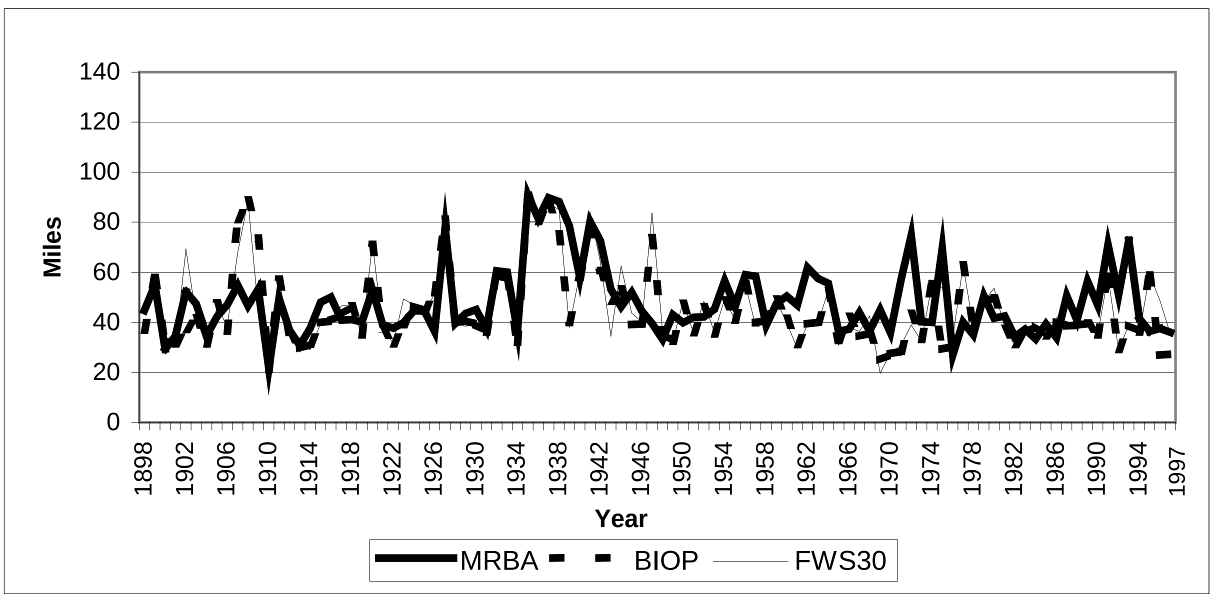

Figure 5.7-15. Annual warmwater fish habitat in river reaches for alternatives MRBA, BIOP, and FWS30.

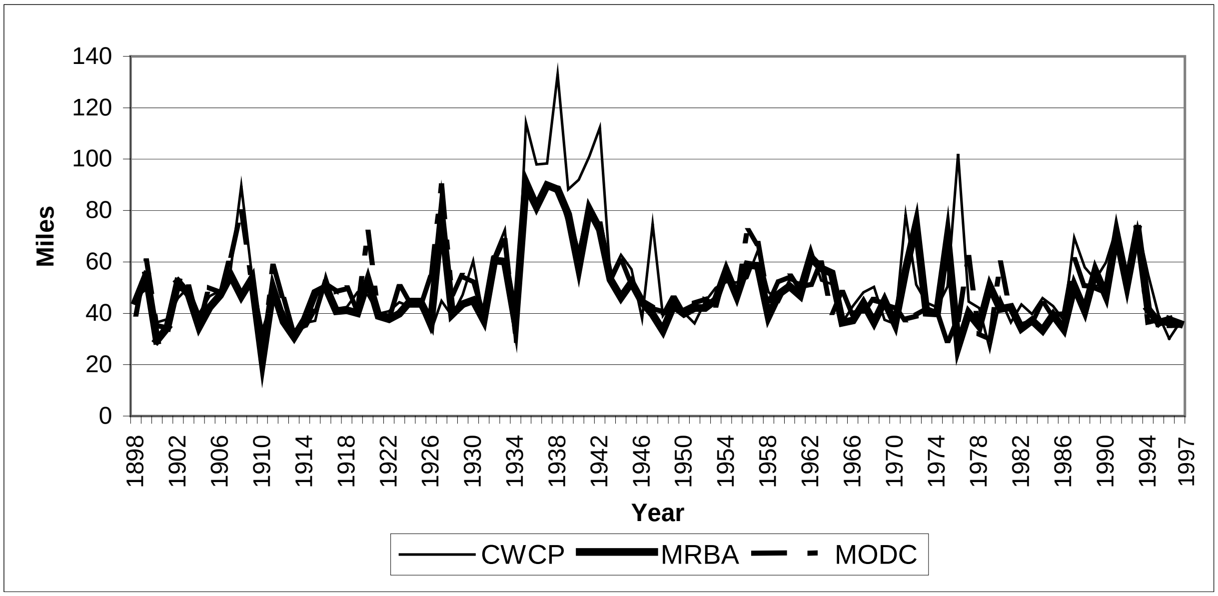

Figure 5.7-16. Annual warmwater fish habitat in river reaches for alternatives CWCP, MRBA, and MODC.

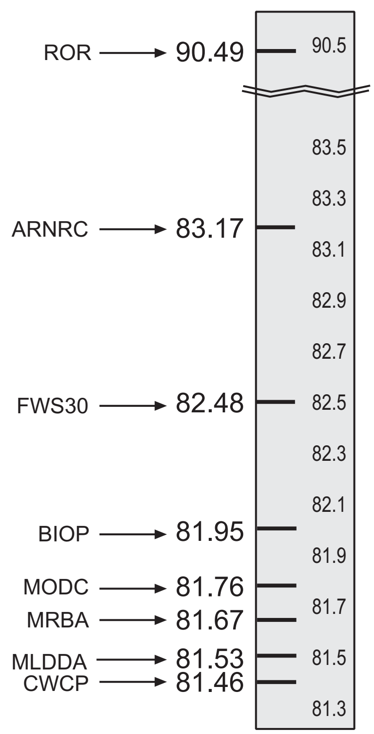

Figure 5.7-17. Average annual river fish physical habitat for submitted alternatives (miles).

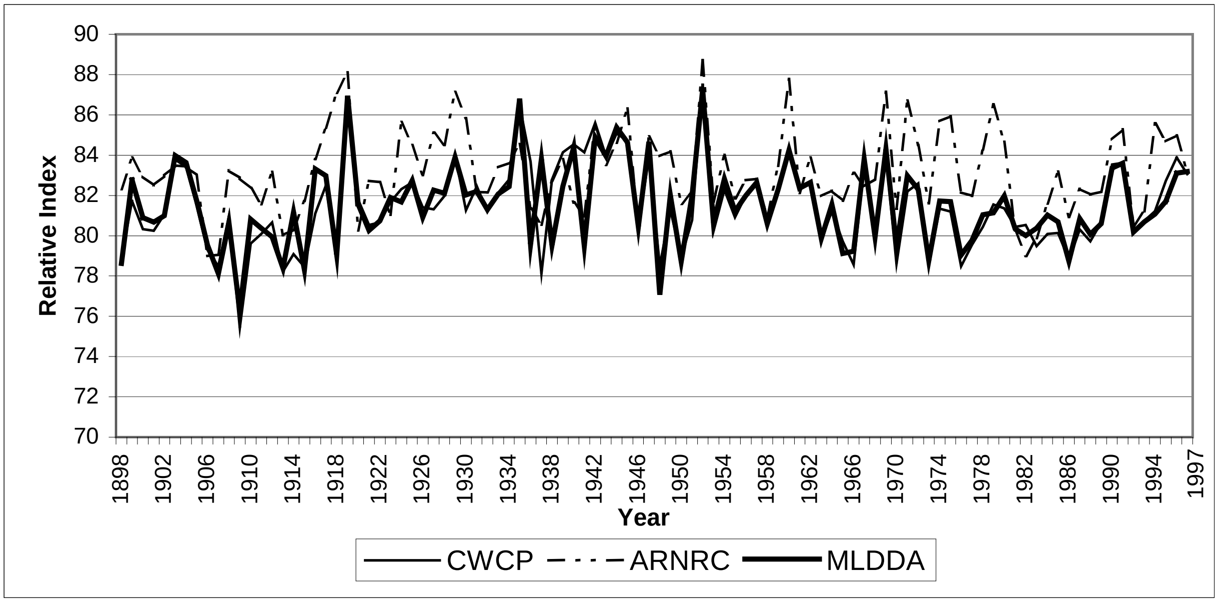

Figure 5.7-18. Annual values for river fish physical habitat for alternatives CWCP, ARNRC, and MLDDA.

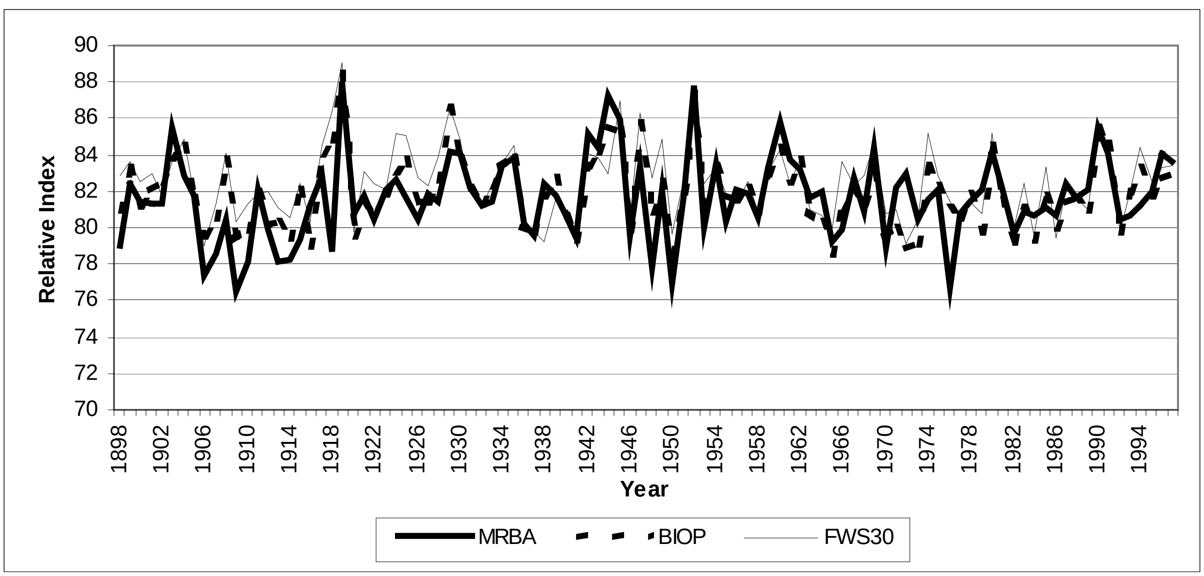

Figure 5.7-19. Annual values for river fish physical habitat for alternatives MRBA, BIOP, and FWS30

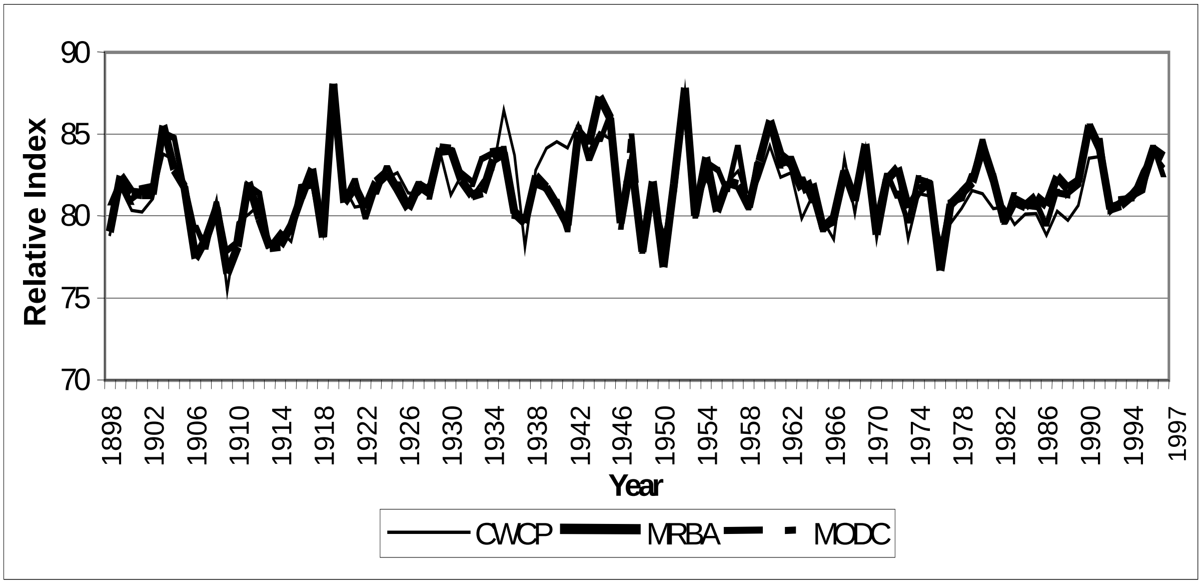

Figure 5.7-20. Average annual values for river fish physical habitat for alternatives CWCP, MRBA, and MODC.

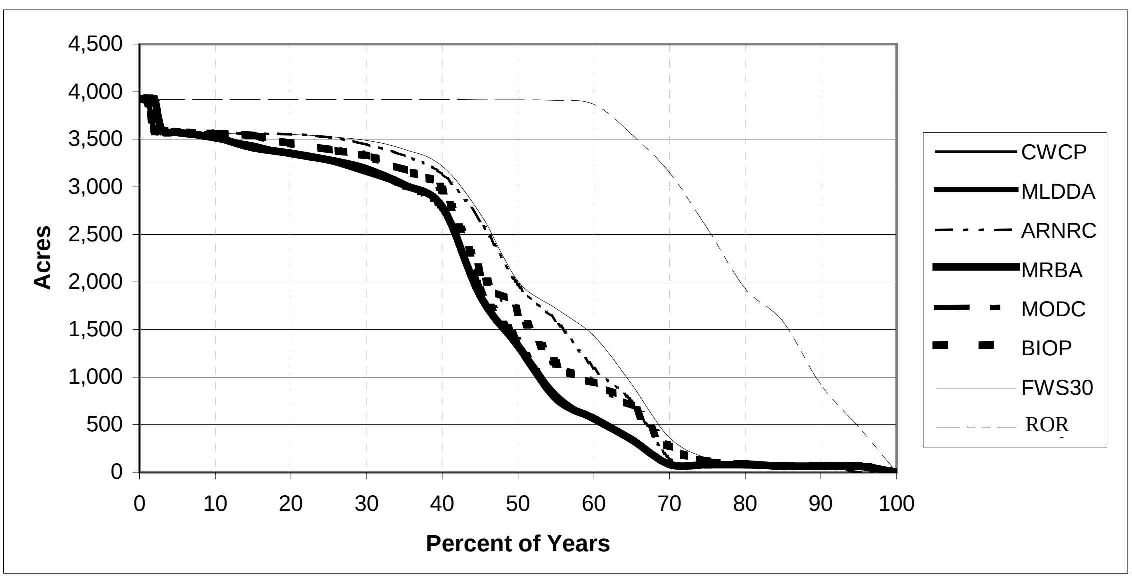

Figure 5.7-21. Acres of connectivity for 2 days during May and June.

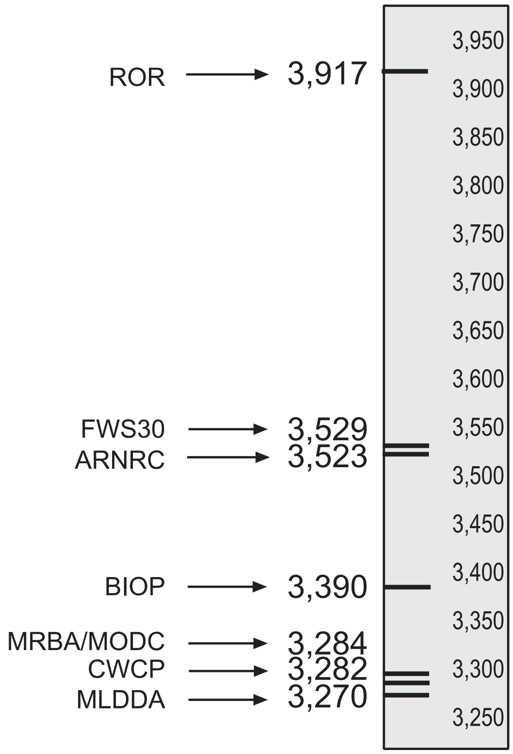

Figure 5.7-22. Acres of connectivity for 2 days in May and June (25th percentile).

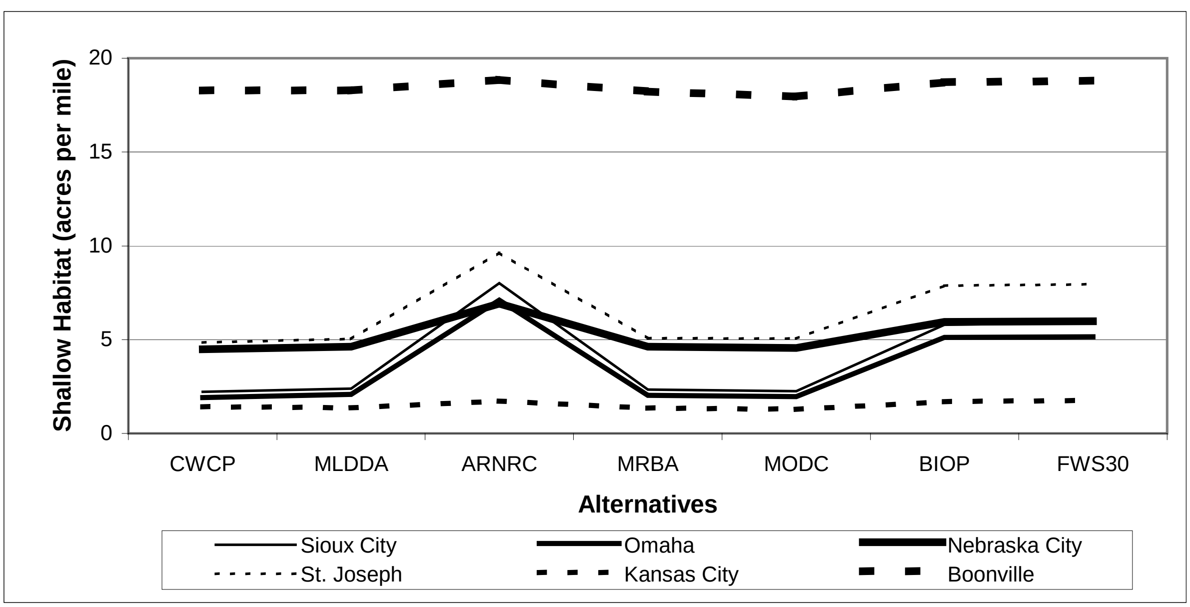

Figure 5.7-23. Expected daily shallow water habitat for river fish.

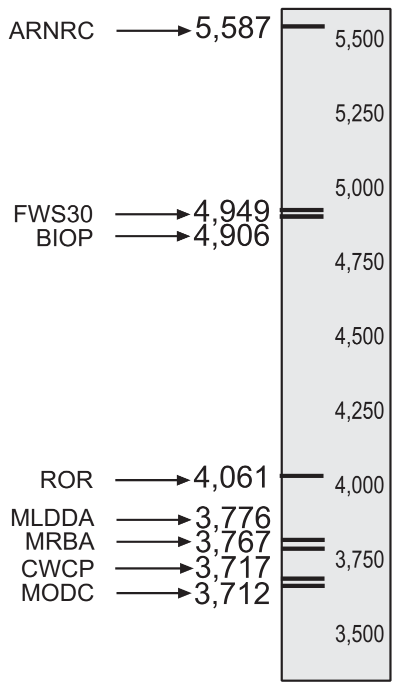

Figure 5.7-24. Total expected daily shallow water habitat available during mid-July to mid-August for submitted alternatives and ROR (acres).

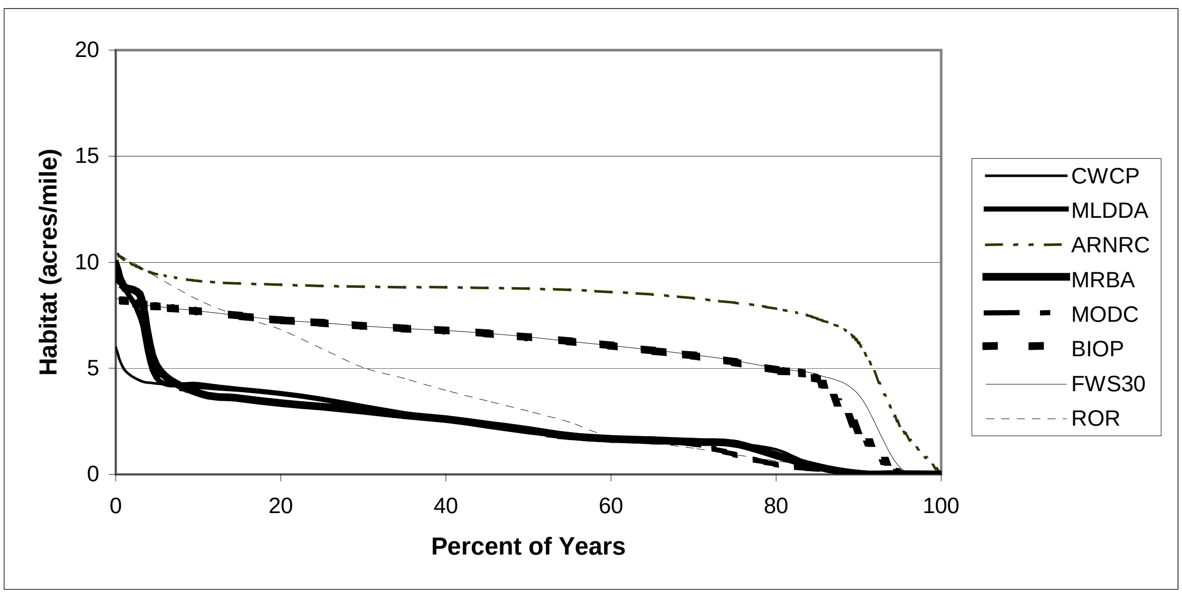

Figure 5.7-25. Duration plot of shallow water habitat during the mid-July to mid-August period – Sioux City reach.

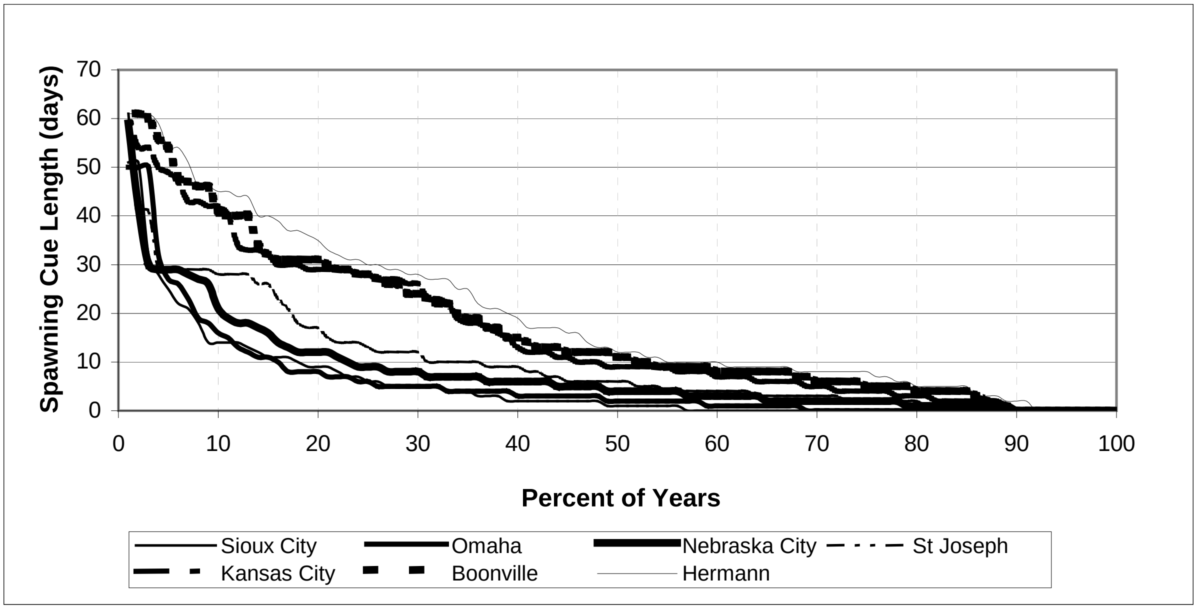

Figure 5.7-26. Duration plot of spawning cue length during May and June for the CWCP.

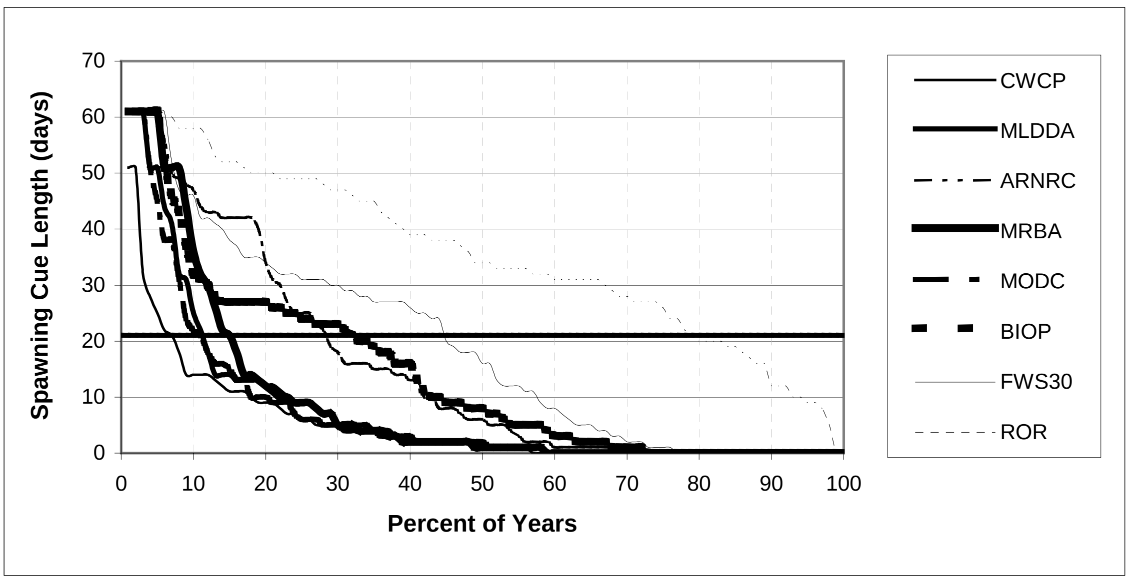

Figure 5.7-27. Duration plot of spawning cue length during May and June at Sioux City.

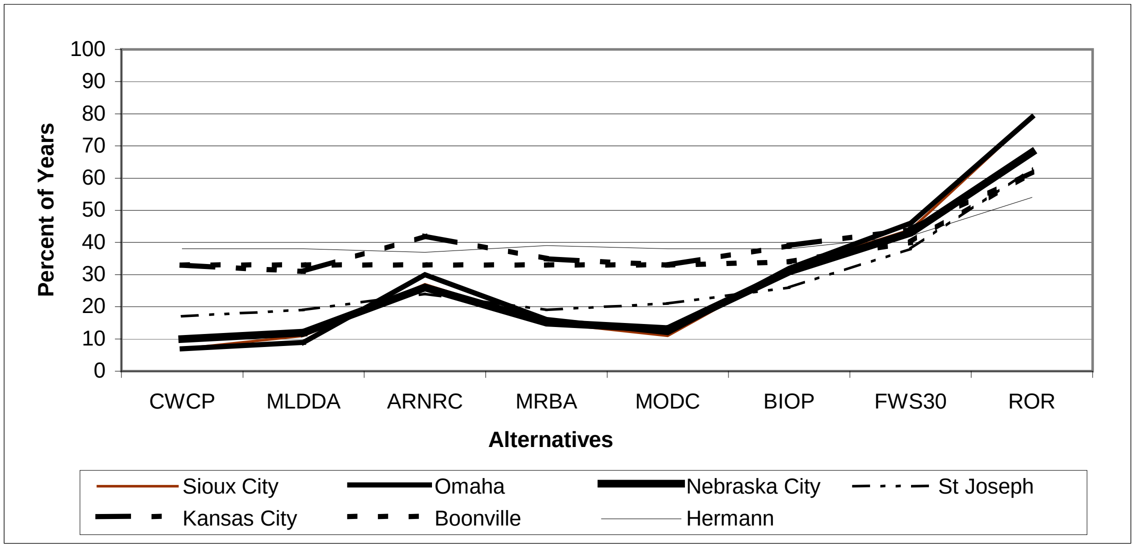

Figure 5.7-28. Percent of years with a 21-day spawning cue at Lower River gaging locations.

5.8 FLOOD CONTROL, INTERIOR DRAINAGE, AND GROUNDWATER IMPACTS

The Mainstem Reservoir System dams, in conjunction with other flood control measures, provide flood control benefits to lands adjacent to the downstream river reaches. The dams store upstream inflow and release flows downstream at a controlled rate. The lower, controlled releases limit impacts to farmlands, buildings, and other floodplain development along the river reaches. The lower river stages facilitate surface water drainage from adjacent lands protected by flood control levees. The lower river stages also allow groundwater levels under adjacent croplands to stay below levels that may not have an adverse effect on the crops.

Three separate analyses were developed to quantify potential impacts on flood control, interior drainage, and groundwater. Hypothetically, a major flood event could damage crops that could also be damaged in the same year by inadequate interior drainage or high groundwater levels. No attempt was made to compute a consolidated damage or benefit to the affected lands. Two major factors limited the possibility for this consolidation. First, the interior drainage and groundwater analyses were done for representative sites. Seven interior drainage sites and four groundwater sites were analyzed instead of all of the land along the river. The complexity of the modeling processes limited these two analyses to these representative sites. Second, each analysis covered a different time period—100 years for flood control, 45 years for interior drainage, and 10 years for groundwater. Again, the complexity of the latter two modeling processes (as well as the availability of data for the interior drainage model) limited the period that could be modeled. Flood control effects were measured in terms of the difference in value (in millions of dollars) of flood control benefits provided by each alternative compared to the run of river (ROR) scenario. The ROR scenario represents natural base inflow with no control placed on the inflow by the dams. Alternatives that include projected lake levels that are higher than the ROR alternative, which had the lake levels held constant at the base of flood control, are reflected by additional damages, or negative benefit values, in the summary tables and figures. The methods applied to get the results presented in this section are described in the Economic Studies—Flood Control, Interior Drainage, Groundwater Technical Report (Corps, 1998d).

5.8.1 Flood Control

Flood control benefits were computed for four mainstem lakes: Fort Peck Lake, Lake Sakakawea, Lake Oahe, and Lake Francis Case. Flood control benefits were also computed for the river reaches downstream from five of the six Mainstem Reservoir System dams, with the Big Bend Dam being the exception. These reaches are Fort Peck Dam downstream, Garrison Dam downstream, Oahe Dam downstream, Fort Randall Dam downstream, and Gavins Point Dam downstream. The Lower River downstream from Gavins Point Dam was divided into seven subreaches. These subreaches are the Sioux City, Omaha, Nebraska City, St. Joseph, Kansas City, Boonville, and Hermann subreaches. Total system flood control benefits and the differences among the alternatives are discussed in this section.

Figure 5.8-1 illustrates the total average annual flood control benefits for the submitted alternatives. These alternatives are clustered into three groups. The CWCP and the MLDDA alternative offer the highest level of flood control benefits. The BIOP, MODC, and MRBA alternatives offer the next highest level, and the ARNRC and the FWS30 alternative offer the lowest level of flood control benefits.

Table 5.8-1 also presents the total average annual flood control benefits for the alternatives. The table also breaks down these benefits into reaches. Total flood control benefits provided by the CWCP are $410.30 million over the 100-year period of analysis. The CWCP has a flat release from Gavins

Table 5.8-1. Average annual flood control benefits ($millions).

Reach Name	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Fort Peck Lake	-0.07	-0.05	-0.06	-0.09	-0.07	-0.07	-0.07
Fort Peck Dam downstream	2.96	2.92	2.95	2.93	2.94	2.89	2.88
Lake Sakakawea	-0.07	-0.04	-0.13	-0.10	-0.11	-0.11	-0.11
Garrison Dam downstream	72.41	72.50	72.16	72.19	72.21	72.14	72.19
Lake Oahe	-0.28	-0.18	-0.54	-0.30	-0.38	-0.52	-0.48
Oahe Dam downstream	14.75	14.76	14.62	14.75	14.73	14.67	14.65
Lake Francis Case	-0.17	-0.11	-0.31	-0.18	-0.18	-0.17	-0.12
Fort Randall Dam downstream	0.70	0.70	0.68	0.70	0.70	0.70	0.69
Gavins Point Dam downstream	15.94	15.91	15.71	15.94	15.93	15.88	15.89
Sioux City	112.51	112.46	111.80	111.96	112.17	112.19	112.08
Omaha	49.30	49.33	49.16	49.18	49.19	49.23	49.33
Nebraska City	41.66	41.72	41.52	41.13	41.10	40.96	40.90
St. Joseph	36.71	36.70	36.08	36.47	36.49	36.34	36.08
Kansas City	37.73	37.68	37.21	37.16	36.48	37.16	37.06
Boonville	9.29	9.26	9.28	9.19	9.13	9.10	8.99
Hermann	16.93	16.93	16.57	16.91	16.96	16.79	16.74
Total	**410.30**	**410.49**	**406.70**	**407.83**	**407.29**	**407.17**	**406.70**

Point Dam in the spring and summer equaling 34.5 kcfs in non-drought periods and 28.5 kcfs during major droughts. The largest portion of the CWCP flood control benefits is provided to the Sioux City subreach, with $112.51 million, or 27.42 percent of the total benefits provided. The reach downstream from Garrison Dam receives $72.41 million, or 17.7 percent of the total protection, and the Omaha and Nebraska City subreaches receives 12.0 percent and 10.2 percent of the total benefit respectively. All other reaches and subreaches receive less than 10 percent of the total benefit. The Sioux City and Garrison Dam downstream reaches will be discussed in some detail at the end of the section.

The MLDDA alternative sets aside an additional 2 MAF of system storage for flood control beyond that provided under the CWCP. This alternative provides total average annual flood control benefits of $410.49 million. The additional 2 MAF of storage increase the benefit level over the CWCP by $0.19 million (0.1 percent), and provide the highest average annual flood control benefits of all the alternatives. Of all of the alternatives analyzed, the MLDDA is the only one that increases annual flood control benefits over the CWCP benefit level.

The ARNRC alternative, with $406.70 million total average annual flood supply benefits, has greater conservation measures than the CWCP, and it includes a 15-kcfs spring rise from mid-May to mid-June followed by an 18-kcfs summer release until September 1 from Gavins Point Dam. This alternative decreases the average annual flood control benefits compared to the CWCP by $3.60 million, or 0.9 percent due to the spring rise and the lower level of summer releases. Of this total, $2.74 million, or 76.1 percent, of the increased damages are from Gavins Point Dam to the mouth. The spring rise increases the flow levels in the river during the time when high flows are most common, resulting in decreases in the flood control benefit. This simulation of this alternative by the DRM did not allow evacuation during the summer low-flow period except in the greater runoff years in the upper basin. This forced the model to move more water in the spring for the ARNRC alternative, which resulted in even greater damages in the spring months in certain years. The ARNRC provides the same flood control benefits as the FWS30 alternative, which is the lowest average annual flood control benefits for the alternatives analyzed in this section.

The MRBA alternative, with $407.83 million total average annual flood control benefits, provides higher drought conservation measures than the CWCP. This alternative includes a 7.1-month navigation season and, typically, a navigation service level that is 3 kcfs lower (relative to full service) in drought years. The increased drought conservation measures maintain the lakes at higher levels through the extended droughts. Unbalancing of the storage among the upper three lakes as part of this alternative results in higher flows in some years in the reaches downstream from Fort Peck and Garrison Dams. Flood control benefits are slightly decreased by $2.47 million, or 0.6 percent, from the level provided by the CWCP. Of this total difference, $2.13 million, or 86.2 percent of the difference occurs on the Lower River. There is no spring rise included in the Gavins Point release. A portion of the damages occurs in 1995, which is a year in which excess releases were made from the Mainstem Reservoir System beyond those that would occur under day-to-day management of the system. The others are spread throughout the 100-year period of analysis, 1898 to 1997, with no clear rationale for the decrease in benefits.

The MODC alternative is like the MRBA alternative except the release under the MODC alternative is extended out to mid-September to allow for continuing low flows for the pallid sturgeon. This alternative also has a spring rise from Fort Peck Dam in about 1 out of 3 years on average. The drought conservation measures and protection for the pallid sturgeon in this alternative decrease the average annual flood control benefits by $3.01 million to $407.29 million, a decrease of 0.7 percent from the CWCP. Of this total difference, $2.62 million, or 87.0 percent, occurs on the Lower River, similar to results for the MRBA alternative.

The alternative prescribed by the 1994 Biological Opinion, the BIOP alternative, includes a 17.5-kcfs spring rise followed by a 25/21 summer low flow, and incorporates the same conservation measures as the MRBA alternative. The combination of the spring rise, the 25/21 summer low flow, and the drought conservation measures in this alternative provides $407.17 million in average flood control benefits. The BIOP alternative benefits are lower by $3.13 million, or 0.8 percent, than the CWCP in flood control benefits. Of this difference, $2.42 million, or 77.3 percent, occurs on the Lower River.

One of the alternatives suggested by the USFWS, the FWS30 alternative, is identical to the BIOP alternative except that the spring rise is 30 kcfs higher than the CWCP. This alternative provides $406.70 million in flood control benefits. As with the ARNRC alternative, the FWS30 alternative provides the lowest average annual flood control benefits, a decrease of $3.60 million, or 0.9 percent, from the benefit level of the CWCP. Of this total difference, $3.00 million, or 83.3 percent, occurs on the Lower River. The decrease in flood protection provided by this alternative can be attributed to the drought conservation measures, the unbalancing of the upper three lakes, the higher spring rise, and the lower level of summer release.

The reach-specific data are addressed by alternative and only address the reaches and subreaches that receive the greatest percentages of the flood control benefits. Most of the average annual flood control benefits occur in the Lower River reach in the subreaches of Sioux City, Omaha, Nebraska City, St Joseph, and Kansas City (Table 5.8.1-1). The CWCP provides the highest level of benefit for the Sioux City, St. Joseph, and Kansas City subreaches. The CWCP provides the second highest level of benefit to the reach downstream from Garrison Dam and the Nebraska City subreach, and the third highest level of benefit to the Omaha subreach. The analysis focuses on the percentage change from the CWCP starting with the greatest percentage first.

The MLDDA alternative provides greater flood control benefits than the CWCP for the Nebraska City subreach, the reach below Garrison Dam, and the Omaha subreach. The percentage increase above the level of the CWCP for all these sections is 0.1 percent.

The ARNRC alternative provides a lower flood control benefit level than the CWCP for all reaches and subreaches analyzed in detail. The percentage decrease below the level of the CWCP for the sections are as follows: 1.7 percent for St. Joseph, 1.4 percent for Kansas City, 0.6 percent for Sioux City, 0.4 percent for the reach downstream of Garrison Dam, 0.3 percent for Nebraska City, and 0.3 percent for Omaha.

The MRBA alternative provides a lower benefit level than the CWCP for all reaches and subreaches analyzed in detail. The percentage decrease for each of the reaches and subreaches are as follows: 1.5 percent for Kansas City, 1.3 percent for Nebraska City, 0.7 percent for St. Joseph, 0.5 percent for Sioux City, 0.3 percent for the reach downstream of Garrison Dam, and 0.2 percent for Omaha.

The MODC alternative provides a lower benefit level than the CWCP for all reaches and subreaches analyzed in detail. The percentage decrease for each of the reaches and subreaches are as follows: 3.3 percent for Kansas City, 1.3 percent for Nebraska City, 0.6 percent for St. Joseph, 0.3 percent for Sioux City, 0.3 percent for the reach downstream of Garrison Dam, and 0.2 percent for Omaha.

The BIOP alternative provides a lower benefit level than the CWCP for all reaches and subreaches analyzed in detail. The percentage decrease for each of the reaches and subreaches are as follows: 1.7 percent for Nebraska City, 1.5 percent for Kansas City, 1.0 percent for St. Joseph, 0.4 percent for the reach downstream of Garrison Dam, 0.3 percent for Sioux City, and 0.1 percent for Omaha.

The FWS30 alternative provides a lower benefit level than the CWCP for all reaches and subreaches analyzed in detail except for the Omaha subreach. The percentage decrease for the reaches and subreaches with lower benefit levels are as follows: 1.8 percent for Nebraska City, 1.8 percent for Kansas City, 1.7 percent for St. Joseph, 0.4 percent for Sioux City, and 0.3 percent for the reach downstream of Garrison Dam. The Omaha subreach receives increased protection by 0.1 percent over the level of the CWCP.

Figures 5.8-2 through 5.8-4 graphically illustrate the very slight differences between all alternatives during the 100-year study period. There are no obvious trends for any of the alternatives. An in-depth analysis found that major differences in flood control benefits in certain years were due to a multitude of differences in the simulation runs; however, not once in the years examined was the major difference due to the Gavins Point spring rise.

Flood Control for Tribal Reservations

In terms of Reservation impacts, each Reservation identified within one of the five reaches analyzed is considered within the analysis of that particular reach. The reach downstream from Fort Peck Dam includes benefits to Fort Peck Reservation. The reach downstream from Fort Randall Dam includes the benefits to Yankton Reservation, Ponca Tribal Lands, and Santee Reservation. The Sioux City reach includes the benefits to both the Winnebago and Omaha Reservations while the St. Joseph reach includes benefits to Sac and Fox and Iowa Reservations.

Table 5.8-2, Average annual flood control benefits for Reservations, provides the data for comparing the alternatives for flood control benefits to the Reservations. The data for Fort Peck Reservation show that the CWCP and the ARNRC, MRBA, and MODC alternatives provide the same average annual flood control benefit of $0.85 million. The MLDDA alternative provides slightly lower benefits of $0.84 million. The BIOP and FWS30 alternatives also provide slightly lower flood control benefits of $0.83 million.

The benefits provided to Fort Berthold Reservation are highest under the MLDDA alternative with a 33 percent increase over the CWCP, which provides the next highest benefit level. The ARNRC alternative provides a 100.0 percent decrease in flood control benefits from the level of the CWCP.

Table 5.8-2. Average annual flood control benefits for Reservations ($millions).

Reservation	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Fort Peck	0.85	0.84	0.85	0.85	0.85	0.83	0.83
Fort Berthold	-0.03	-0.02	-0.06	-0.04	-0.05	-0.05	-0.05
Standing Rock	-0.05	-0.03	-0.09	-0.05	-0.06	-0.08	-0.08
Cheyenne River	-0.05	-0.03	-0.10	-0.06	-0.07	-0.09	-0.09
Lower Brule	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Crow Creek	-0.01	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Yankton and Ponca Tribal Lands	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Santee	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Winnebago	8.52	8.52	8.47	8.48	8.50	8.50	8.49
Omaha	7.96	7.95	7.91	7.92	7.93	7.93	7.92
Iowa, Sac and Fox	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**17.30**	**17.34**	**17.08**	**17.20**	**17.20**	**17.14**	**17.12**

Standing Rock Reservation receives the highest benefit level from the MLDDA alternative at $0.03 million in damages over the ROR alternative. This benefit level is a 40.0 percent increase over the level of the CWCP. The lowest flood control benefits for this Reservation are provided by the ARNRC alternative with an 80.0 percent decrease from the level of the CWCP.

The highest benefits for Cheyenne River Reservation is provided by the MLDDA alternative with $0.03 million in damages over the ROR, a 40.0 percent increase over the benefits of the CWCP. The CWCP provides $0.05 million in damages over the ROR. The ARNRC alternative provides the lowest benefits with a 100.0 percent decrease below the CWCP.

The benefits provided to Lower Brule Reservation are the same for all submitted alternatives. The level of benefit for Crow Creek Reservation is also the same for all submitted alternatives except for the MLDDA alternative, which provides a slight increase in flood control benefits over the other alternatives.

The data for the Fort Randall reach, which includes Yankton Reservation, Ponca Tribal Lands, and Santee Reservation, indicate no change in flood control benefits for any alternative during any period of analysis.

The Sioux City subreach includes Winnebago and Omaha Reservations. This subreach receives about 95 percent of the total flood control benefits under all alternatives. The CWCP and the MLDDA alternative provide $8.52 million in average annual flood control benefits to Winnebago Reservation, $0.05 million more than the lowest benefit level under the ARNRC alternative. The ARNRC alternative also provides the least amount of average annual flood control benefits to the Omaha Reservation at $7.91 million, which is lower than those provided by the CWCP by $0.05 million. The CWCP provides the largest annual flood control benefits to Omaha Reservation at $7.96 million. The largest percentage change for the Sioux City subreach is a decrease of 0.6 percent between the CWCP and the ARNRC alternative.

There is no difference in the benefits among the submitted alternatives for the St Joseph reach, which includes Sac and Fox Reservation and Iowa Reservation.

5.8.2 Interior Drainage

Analysis of interior drainage impacts was completed for six representative sites downstream of Gavins Point Dam along the Missouri River from Nebraska City to Hermann. The sites are levee unit L575 around Hamburg, Iowa; levee unit L536 near Corning, Missouri; levee unit L488 north of St. Joseph, Missouri; levee unit R351 east of Independence, Missouri; levee unit L246 near Boonville, Missouri; and the Tri-County levee unit, across the river from Hermann, Missouri. The sites represent combinations of the non-flow factors that contribute to interior drainage damage such as topography, drainage structure size and placement, rainfall, etc. that may be found at leveed areas along the river

With the exception of L575, all of the basins that exited directly to the Missouri River or the lower reaches of a tributary adjacent to each levee unit were modeled. For L575, the portion of the levee unit that drains into Main Ditch 6 was not modeled. Simulation runs of the alternatives were made for a 45-year period from October 1, 1949 through September 30, 1994 (Water Years 1950 through 1994). The simulation runs, completed using an adapted version of a model developed for the Corps' Hydrologic Engineering Center called HEC-IFH, computed the size of the ponding areas within the six levee units on a daily basis for this period.

These files were input to an economic model that was an adapted version of a model that was also developed for the Corps' Hydrologic Engineering Center called HEC-PBA. This model computed the damages to the potential crops raised in the areas where the water ponded. Each ponding site had an assumed area that stored water often enough that the farmer did not plant a crop in this portion of the site. This area was input to the HEC-PBA model as a "zero-damage" acreage that was subtracted from the total ponding area for each of the modeled basins within the levee unit. The resulting damages to the crops were not converted to benefits for this report because the primary interest is on the relative differences among the alternatives. A negative difference between two alternatives is a relative benefit. Figure 5.8-5 presents graphically the total average annual damage for each alternative. Table 5.8-3 presents the average annual data for each area modeled.

The CWCP does not have a spring rise or summer low-flow period. The flat release from mid-May through late August is 34.5 kcfs in non-drought periods and goes to 28.5 kcfs in major droughts. Over the 45-year simulation period, the total interior drainage damages for the CWCP average $1.34 million per year. This is the alternative with the lowest damages. Due to the differences in sites, there can be significant variation in the interior damages for the same alternative. For example, for the 45-year period, the damages for the CWCP range from a low of $0.06 million at site R351 to a high of $0.52 million at the L246 site. Both of these sites are downstream from Kansas City, and have major inflows entering the Missouri River from upstream tributaries. The primary difference between the two sites is the amount of "zero-damage" acreage. The R351 has a number of very large ditches that drain the site. These ditches provide considerable storage space for the runoff from the interior of the levee should the outlets to the Missouri River be blocked by high river stages.

The range of interior drainage damage is from $1.51 million for the FWS30 alternative to $1.34 million for the CWCP, a difference of $0.17 million per year. As Figure 5.8-5 shows, the alternatives can be grouped according to the amount of total interior drainage damage for the six sites analyzed. Four of the alternatives are grouped close to the CWCP, ranging from 40 million, a difference of only $0.06 million. Three of the alternatives, MLDDA, MODC and MRBA, are similar to the CWCP in that they do not have increased spring or reduced summer releases from Gavins Point Dam. The ARNRC alternative, with a spring rise but lower summer releases, is also grouped with these lower damage alternatives. The second grouping includes the BIOP and FWS30 alternatives that have a spring rise and low summer flow from Gavins Point Dam. They show the highest damages at $1.46 and $1.51 million per year, respectively.

Table 5.8-3 shows that the effect of moderating releases from Gavins Point Dam declines significantly at the sites further down river from the dam. As one moves further downstream from Gavins Point Dam, there are more outside influences on interior drainage damages, such as tributary inflow. This reduces the effect of controlling releases on sites further from the dam. Site L575 is closest to the dam and accounts for the majority of changes in total damages for each alternative.

The MLDDA alternative is like the CWCP with balanced intrasystem regulation and no additional spring and summer release, but sets aside an additional 2 MAF of storage for flood control. It has $0.01 million higher damages per year than the CWCP, only a 0.7 percent difference. Compared to the CWCP, the MLDDA alternative has the smallest difference in damages in total and at each of the sites.

The ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season that mimic the natural flow of the Lower River, unlike the CWCP. From Gavins Point Dam there is a spring rise of 15 kcfs above full navigation service in many years and a lower summer release of 18 kcfs. The combination of an additional spring and a lower summer release creates average interior drainage damages of $1.40 million per year, $0.06 million more damages per year than the CWCP. This is a 4.4 percent increase overall. Essentially, all the difference in damages occurs at site L575, where the damages are $0.06 million more than the CWCP, for a 14.0 percent increase.

Although the MRBA alternative has unbalanced intrasystem regulation and an increase in conservation slightly less than the ARNRC alternative, a major difference between these two alternatives is that under the MRBA alternative, a steady flow is maintained through the late spring and summer, as with the CWCP. A spring rise is not included in the MRBA alternative. The damages average $1.38 million per year, which is an increase of $0.04 million per year or 3.0 percent higher than the CWCP. The majority of the increase occurs at site L575 with a $0.03 million (7.0 percent) per year increase over the CWCP.

Table 5.8-3. Average annual interior drainage damages for 1950 to 1994 ($millions).

Alternative	Total	L575	L536	L488	R351	L246	Tri-County
CWCP	**1.34**	0.43	0.12	0.15	0.06	0.52	0.07
MLDDA	**1.35**	0.44	0.12	0.15	0.06	0.51	0.07
ARNRC	**1.40**	0.49	0.12	0.15	0.06	0.51	0.07
MRBA	**1.38**	0.46	0.12	0.15	0.06	0.52	0.07
MODC	**1.37**	0.45	0.12	0.15	0.06	0.52	0.07
BIOP	**1.46**	0.52	0.13	0.16	0.06	0.52	0.07
FWS30	**1.51**	0.55	0.14	0.16	0.06	0.53	0.07

The MODC alternative is identical to the MRBA alternative except there is a Fort Peck spring rise and the flat release from Gavins Point was extended out to mid-September to allow for continuing low flows for the pallid sturgeon. The MODC alternative shows average annual interior drainage damages of $1.37 million, $0.03 million more per year than the CWCP, or a 2.2 percent increase.

There is virtually no change in damages at five of the six sites, but site L575 shows a $0.02 million (4.7 percent) increase.

The BIOP and FWS30 alternatives also have most of the components of the MRBA and MODC alternatives; however, there is variation with the spring/summer release criteria compared to the CWCP. The BIOP alternative, prescribed in the 1994 Biological Opinion, includes a 17.5-kcfs increased spring release from Gavins Point Dam, followed by a 25-kcfs low flow from June 21 to July 15, and then a 21-kcfs flow from July 16 to August 15. The Gavins Point Dam release then goes back up to 25 kcfs until September 1 to restore service to navigation targets. This alternative is among the alternatives with the highest damages, at $1.46 million per year, a $0.12 million increase in damages over the CWCP, which is a 9.0 percent increase. Most of the increase in total damages is due to the increase at L575. It shows $0.09 million per year higher damages than the CWCP, a 20.9 percent increase.

The FSW30 alternative, submitted by USFWS, is identical to the BIOP alternative except that it has a higher spring rise of 30 kcfs. It has the largest interior drainage damages of the alternatives. The average annual damages for FWS30 are $1.51 million, $0.17 million more than CWCP for a 12.7 percent increase. As with the other alternatives, most of the increase in damages is attributable to L575. The damages at L575 are $0.12 million per year higher than for the CWCP, an increase of 27.9 percent.

Figures 5.8-6 through 5.8-8 show that there can be considerable variance through the years. For example, the CWCP shows average damages of $1.34 million, but yearly damages range from $0.03 million in 1956 to $0.11 million in 1993, a flood year. In all but 7 years though, the damages are less than $2.00 million. Only 2 years, 1984 and 1993, have damages above $3.00 million. The other alternatives follow a similar pattern as the CWCP, with the same low damage years and the same high damage years. In 1993, a major flood year, all submitted alternatives are greater than $11.0 million in damages and are within $0.05 million of the CWCP.

The MLDDA, MRBA, and MODC alternatives have the least annual variability from the CWCP and only show an increase of greater than $0.20 million over the CWCP in 1965, 1983, and 1986. The ARNRC, BIOP, and FWS30 alternatives, with the spring rise and summer low flows, show considerable more variability than the CWCP. They have many more years with increases of more than $0.20 million higher than the CWCP. The ARNRC alternative is more than $0.20 million higher than the CWCP in 10 of the 45 years of analysis, while the BIOP alternative and the FWS30 alternatives are more than $0.20 million higher than the CWCP in 13 and 18 years, respectively. The ARNRC alternative also has 3 years where the damages are at least $0.20 million less than the CWCP while the BIOP and FWS30 alternatives do not have years showing that level of damage reduction. Thus, while the ARNRC alternative shows variability like the BIOP and FWS30 alternatives, its average damages are lower and more like alternatives without the spring rise and summer low flows, as shown in Figure 5.8-4.

Interior Drainage for Tribal Reservations

The sites included for interior drainage analysis did not include any Tribal Reservation land; therefore, damage estimates for interior drainage damages on Reservation land were not developed.

The Reservations located within this reach are Sac and Fox Reservation and Iowa Reservation. The nearest site analyzed to the Reservations is the L488 site, which is downstream and across the Missouri River from the Reservations. In terms of Reservation lands, it must be noted that Sac and Fox Reservation and Iowa Reservation floodplain land is protected by non-Federal levees that may or may not have non-flow factors similar to L488. To the extent that they are similar, they will have similar damages. For Iowa Reservation and Sac and Fox Reservation, about 1,000 acres are located in the Missouri River floodplain. The value of the crops that could be damaged is $0.30 million. Four residential buildings are located in the floodplain and subject to flooding. Their value is estimated to be $0.40 million.

If the Reservation lands respond similarly to that of the L488 lands, the ARNRC alternative creates the least damage. The most damage is indicated under the FWS30 alternative. At site L488, only $0.01 million average annual damages separates the ARNRC damages from the FWS30 damages, a relatively small variance. If the Reservations are more similar to the total of all the sites, CWCP would sustain the least interior drainage damage and FWS30 would sustain the most.

5.8.3 Groundwater Effects

Analyses of groundwater effects were computed for four representative sites along the Missouri River from Onawa, Iowa to Hermann, Missouri. These four sites are designated as RM691, an unleveed site near Onawa; levee unit L575 near Hamburg, Iowa (across the river from Nebraska City); levee unit L488/L497 north of St. Joseph, Missouri; and the Tri-County levee unit across the river from Hermann, Missouri.

Simulation runs were made of the submitted alternatives and the CWCP for the 10-year period of October 1, 1969 through September 30, 1979 (Water Years 1970 through 1979). The results of the groundwater model simulation runs were in terms of percent of the modeled area that had groundwater levels at 1-foot increments from zero feet deep up to 9 feet deep. These files were input to another adapted version of the HEC-PBA model, which is the same model used for the interior drainage analysis. This economics model computed the annual crop damages associated with the shallow groundwater levels on the crops raised at each representative site. These damages were not converted to benefits for this report because the primary interest is on the relative differences among the alternatives. A negative difference between two alternatives is a relative benefit. Table 5.8-4 and Figure 5.8.3-1 present the average annual groundwater damages for the submitted alternatives and the CWCP. The table also presents the damages by area modeled.

Over the 10-year simulation period, the total damages for the modeled sites for the CWCP average $4.52 million per year. At individual sites it ranges from a low of $0.30 million per year at the Tri-County site near Hermann to a high of $2.18 million per year at the L575 site near Hamburg, Iowa. Two factors contribute to differences in the damages. First, there is a difference in the relative size of the sites (RM 691 and L575 are much larger than Tri-County and L488/497). Second, there is a difference in the lay of the farmable land with respect to the river. Although the RM691 site is larger than the L575 site, it has only 34 percent of the damages of the L575 site, which has more land with elevations closer to the river water surface.

Figure 5.8-9 shows the average annual damages by alternative. Groundwater damages for the alternatives range from $4.31 million for the MODC alternative to $5.20 million for the ARNRC alternative, compared to the CWCP at $4.52 million. This range is 4.6 percent lower annual groundwater damages for the MODC alternative to 15.0 percent increased damages for the ARNRC alternative when compared to the CWCP. The alternatives with the changes in the annual release patterns from Gavins Point Dam show the largest increases in damages. Of these, the ARNRC and FWS30 alternatives show essentially the same increase ($5.20 and $5.18 million), with the BIOP alternative ($4.96 million) being somewhat lower. The other three alternatives show much smaller changes from the CWCP. The MLDDA alternative, with more steady year-round flows, shows a small increase in damages to $4.58 million. The MRBA and MODC alternatives, also with more steady year-round flows, actually show a reduction in damages to $4.50 and $4.31 million, respectively.

Table 5.8-4. Average annual groundwater damages, 1970 to 1979 ($millions).

Alternative	Total	RM691	L575	L488/497	Tri-County
CWCP	**4.52**	0.74	2.18	1.30	0.30
MLDDA	**4.58**	0.74	2.19	1.35	0.29
ARNRC	**5.20**	0.85	2.64	1.36	0.35
MRBA	**4.50**	0.74	2.17	1.29	0.30
MODC	**4.31**	0.72	2.10	1.20	0.29
BIOP	**4.96**	0.86	2.48	1.30	0.32
FWS30	**5.18**	0.89	2.62	1.34	0.33

In some cases, the reduction or increase in damages may look small. It should be noted that even a small difference of $0.02 million per year translates to $0.20 million for the 10-year period. Also, the damages may be limited to a small area and affect only a few individuals. In that case, the effect could be relatively high to a small number of individuals.

The MLDDA alternative sets aside 2 MAF for flood control. This results in total average groundwater damage for the four sites of $4.58 million. That is $0.06 million or only 1.3 percent more than the CWCP. At three of the four sites, the change from the CWCP is less than 2 percent, but at site L488/497, MLDDA is among the alternatives with the highest annual damages, at 4 percent, or $0.053 million, more per year than the CWCP.

The ARNRC alternative, with an average annual groundwater damage of $5.20 million, has the highest groundwater damages of the alternatives. The ARNRC alternative has an unbalanced intrasystem regulation and a split navigation season that mimics the natural flow of the Lower River. From Gavins Point Dam there is a spring release increase of 15 kcfs and a lower summer release of 18 kcfs. The combination of an additional spring and a lower summer release creates groundwater damages that are $680,000 or 15.0 percent higher than computed for the CWCP. This alternative has the highest increase over the CWCP. It also has the highest increase at three of the four sites, ranging from a 4.6 percent increase at L488/497 to a 21.1 percent increase at L575.

Although the MRBA alternative has unbalanced intrasystem regulation and an increase in drought conservation similar to the ARNRC alternative, a major difference between these two alternatives is that in the MRBA alternative, a flat release is maintained from Gavins Point Dam during the summer, as with the CWCP. A spring rise is not included in the MRBA alternative. Thus, the MRBA alternative shows essentially no change from the CWCP with damages of $4.50 million, $21,000 less than the CWCP or a 0.5 percent decrease in damages. There is also essentially no effect at three of the four sites. The fourth site, L488/497, shows a small (1.1 percent) decrease in damages.

The MODC alternative is identical to the MRBA alternative except the flat release from Gavins Point Dam is extended to mid-September to allow for continuing low flows for the pallid sturgeon. This low-flow extension decreases damages from the MRBA alternative by an average of $0.19 million per year. At $4.31 million annual groundwater damage to crops, it shows the largest decrease in damages from the CWCP. The average annual groundwater damages are $0.21 million, 4.6 percent below those of the CWCP.

The BIOP and FWS30 alternatives also have most of the basic components of the MRBA and MODC alternatives; however, there is variation in the additional spring/summer release criteria compared to the CWCP. The BIOP alternative, prescribed in the 1994 USFWS Biological Opinion, includes a 17.5-kcfs increased spring release from Gavins Point Dam, followed by a 25-kcfs low flow from June 21 to July 15, followed by a 21-kcfs flow from July 16 to August 15. The Gavins Point Dam release then goes back up to 25 kcfs until September 1 when it meets navigation targets. This alternative is among the alternatives with the highest damages. It shows average groundwater damages of $4.91 million per year, $0.44 million more than the CWCP or a 9.8 percent increase. Although the BIOP alternative shows no increase in damages at site L488/497, it shows significant increases at the other sites: between a 7.6 percent increase at Tri-County to 16.2 percent at RM691.

The FWS30 alternative, submitted by the USFWS, is identical to the BIOP alternative except there is a higher spring rise of 30 kcfs. The damages are very close to the highest groundwater damages to crops per year at $5.18 million, an increase from the CWCP of $0.66 million per year, or 14.6 percent. By including the higher spring rise, average annual crop damages increase by $0.22 million over the BIOP alternative. At each of the individual sites, the FWS30 alternative is among those with the highest increases.

Figures 5.8-10 to 5.8-12 show that there can be considerable variance in damages per year. Although the CWCP has average damages of $4.52 million, the range is from $2.37 million in 1976 to $6.92 million in 1978. The highest groundwater damages occur in 1978 because it was a very wet year in the upper Missouri River basin (highest runoff year in the period of analysis). All of the alternatives follow a similar pattern, but there are differences. The MRBA and MODC alternatives follow the CWCP most closely except in 1978 and 1979. In the wet year, 1978, the

MRBA alternative shows damages that are much higher than the CWCP ($1.32 million higher), but the extended flat release of the MODC alternative keeps damages below the CWCP ($0.25 million lower). In the following year, 1979, both MRBA and MODC are much lower than the CWCP ($1.15 and $1.36 million lower).

Damages for the MLDDA alternative are very close to the CWCP with an increase of $0.06 million per year, but it shows more variance. Although the increased set aside for flood control was focused on reducing flooding, it results in increased groundwater damages of $1.31 million in 1978, a very wet year, but then shows decreased damages of $0.87 million in 1979.

The alternatives with the changed releases from Gavins Point Dam show the largest increases in damages and are fairly consistently higher than the CWCP. The ARNRC, BIOP and FWS30 alternatives have lower damages than the CWCP in only 2 of the 10 years. Of the three, the FWS30 alternative shows the greatest differences in individual years, ranging from $1.71 million higher in 1976 to $0.53 lower than the CWCP in 1979.

Groundwater Effects for Tribal Reservations

The sites included for groundwater analysis did not include any Reservation land; therefore, damage estimates for excessive groundwater on Reservations were not developed.

Sac and Fox Reservation and Iowa Reservation are in the vicinity of the L488/L497 site that is downstream and across the Missouri River from the Reservation. If groundwater damage on the Reservation land responds similarly to that of the L488/497 site, a decrease in crop damage from the CWCP would be expected with the MRBA and MODC alternatives. An increase in crop damage over the CWCP would be expected for the MLDDA, ARNRC, and FWS30 alternatives. An estimated $150,000 per year separates the groundwater damages of the ARNRC, MLDDA, and FWS30 alternatives from the damages of the MODC alternative at L488/497. If groundwater levels cause a damage response on the Reservations more like that of the total damages, higher damages would result from all alternatives except the MRBA and MODC alternatives.

Winnebago and Omaha Reservations are located primarily across the river and upstream from RM 691. To the extent that these Reservation floodplain lands have similar characteristics to the RM 691 site, a reduction in damages from the CWCP can be expected from the MODC alternative. If instead they respond more like total damages, a decrease in crop damages from the CWCP can be expected from the MRBA and MODC alternatives. Increases in damages would occur for the ARNRC, BIOP, and FWS30 alternatives under either the similarity to the RM691 or the total damages conditions.

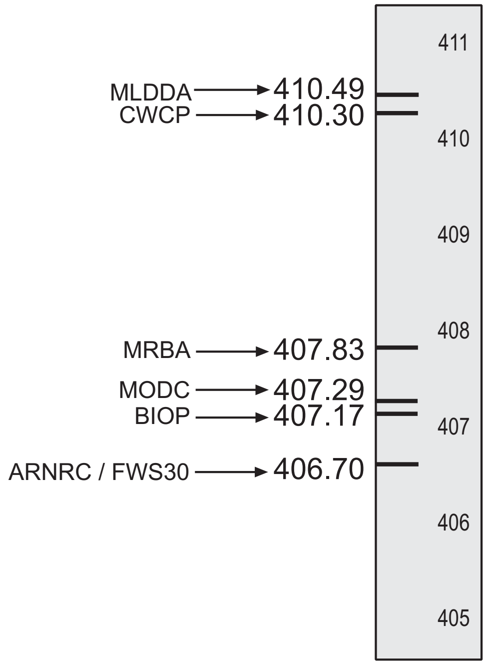

Figure 5.8-1. Average annual flood control benefits for submitted alternatives ($millions).

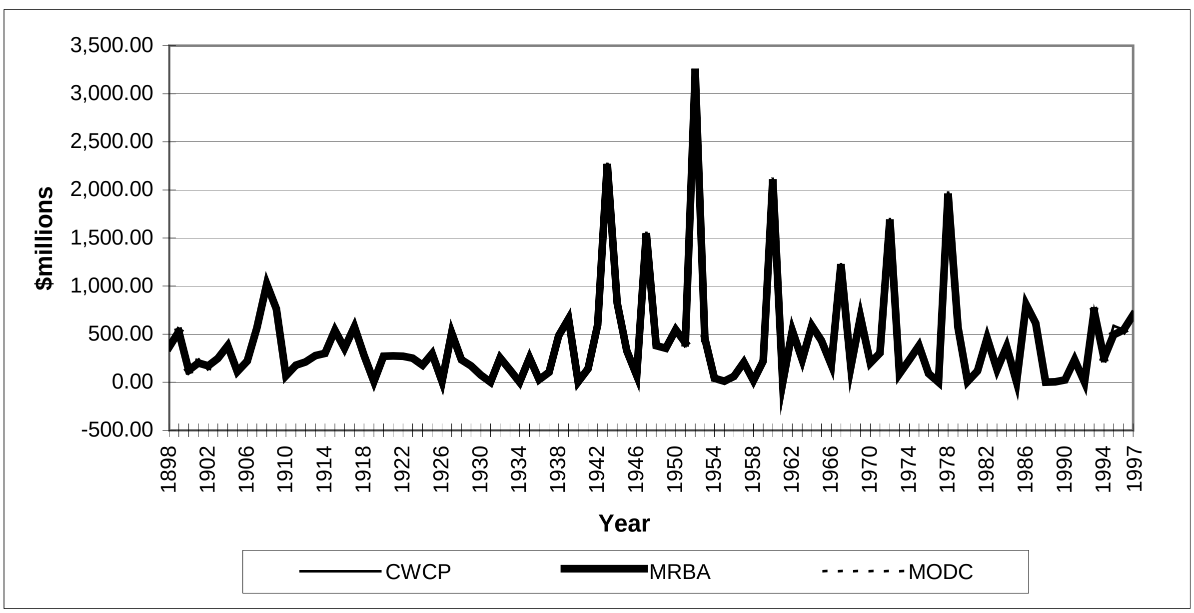

Figure 5.8-2. Annual flood control benefits for alternatives CWCP, MRBA, and MODC ($millions).

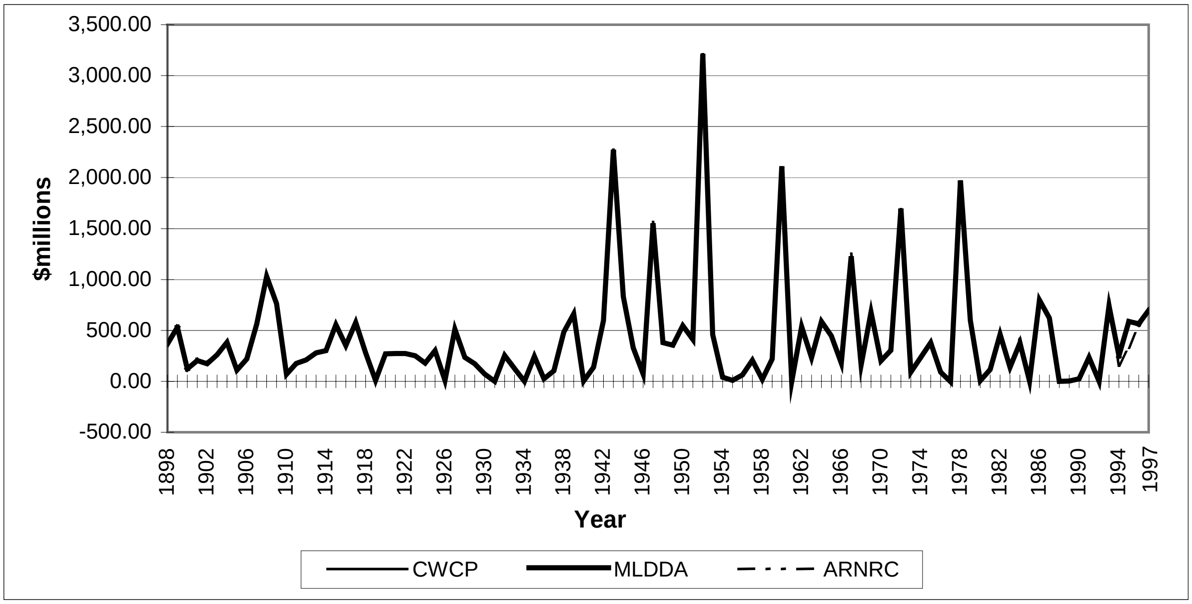

Figure 5.8-3. Annual flood control benefits for alternatives CWCP, MLDDA, and ARNRC ($millions).

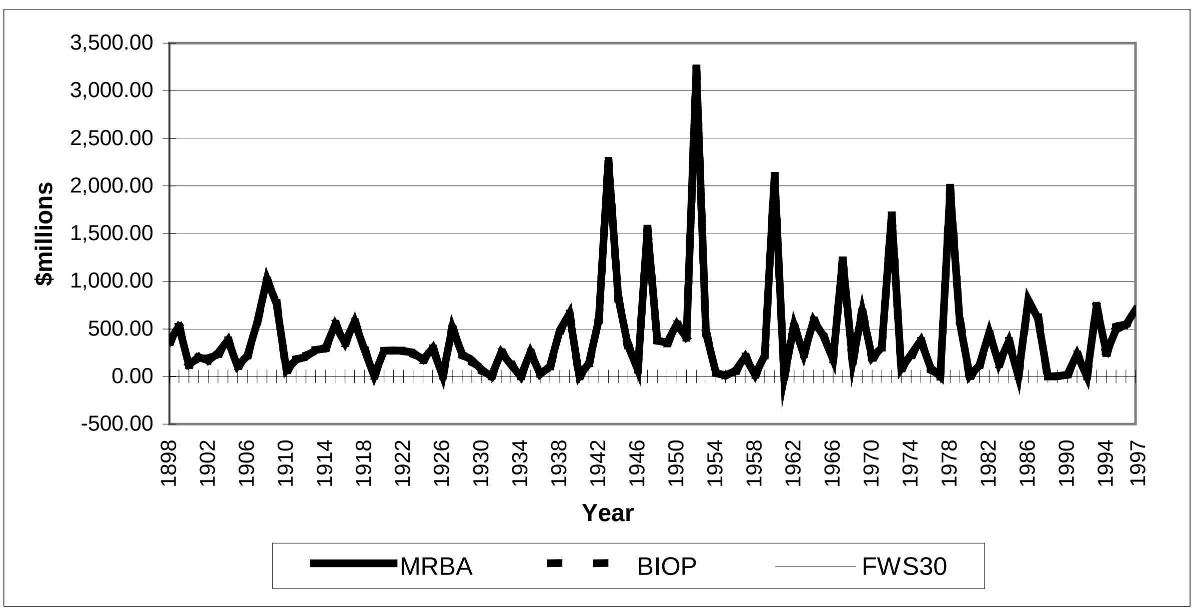

Figure 5.8-4. Average annual flood control benefits for alternatives MRBA, BIOP, and FWS30 ($millions).

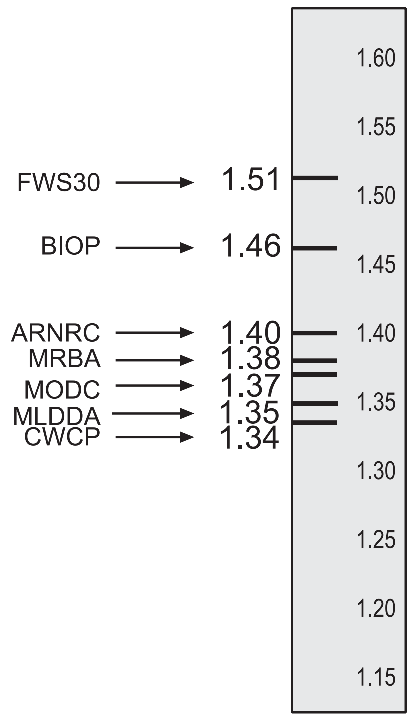

Figure 5.8-5. Average annual interior damages for submitted alternatives ($millions).

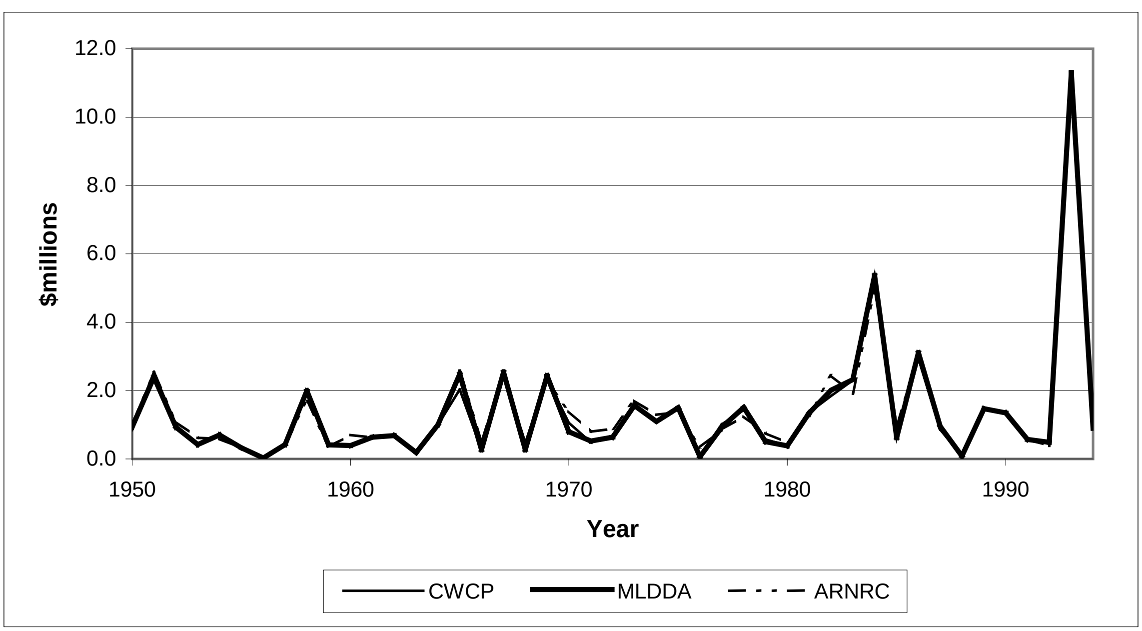

Figure 5.8-6. Average annual interior drainage damages for alternatives CWCP, MLDDA, and ARNRC.

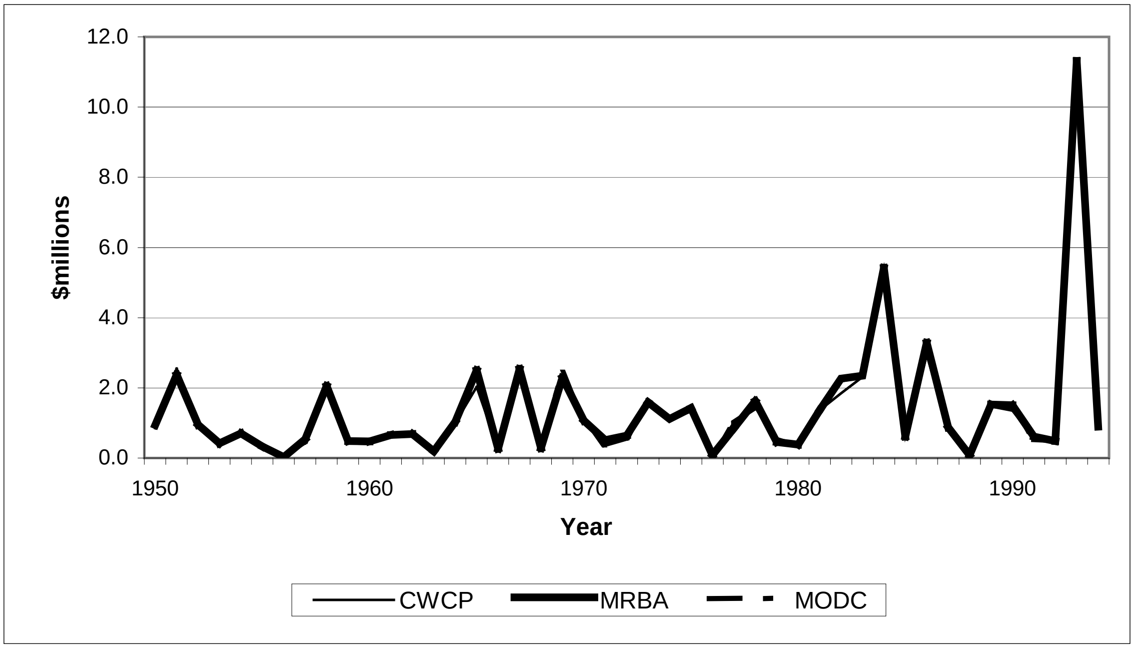

Figure 5.8-7. Average annual interior drainage damages for alternatives CWCP, MRBA, and MODC.

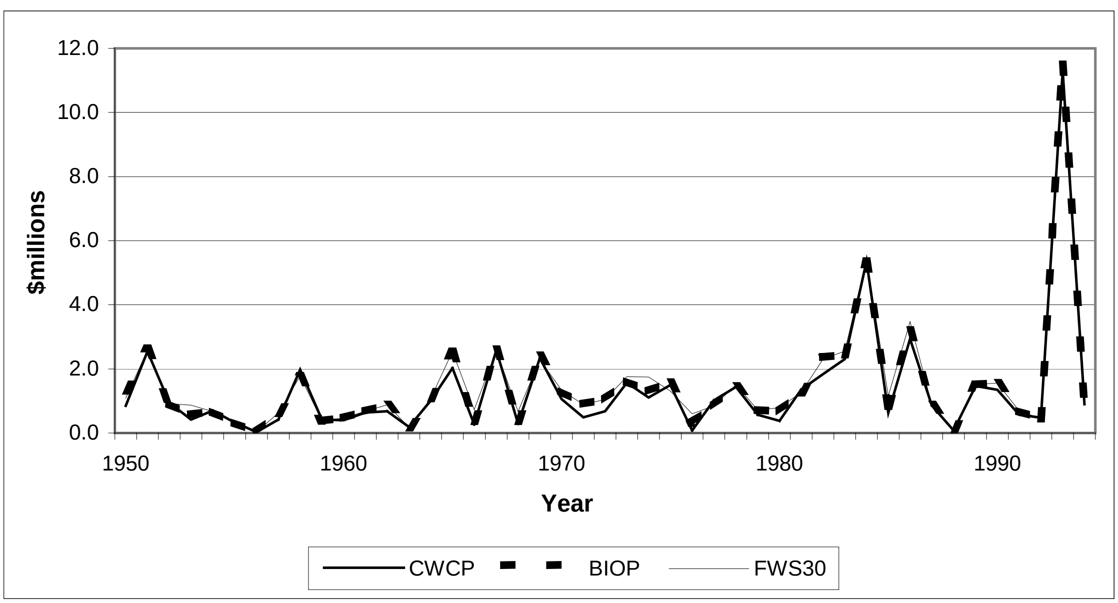

Figure 5.8-8. Average annual interior drainage damages for alternatives CWCP, BIOP, and FWS30.

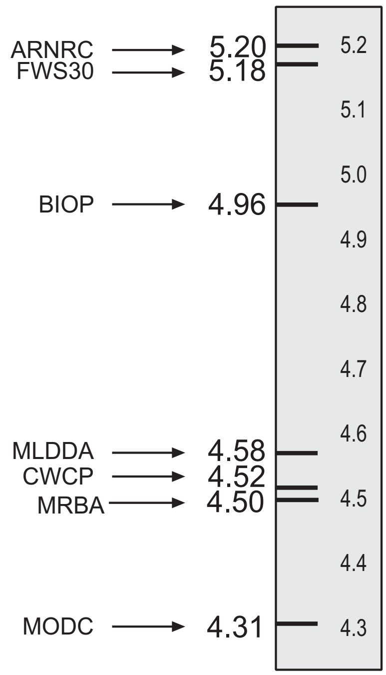

Figure 5.8-9. Average average annual groundwater damages for submitted alternatives ($millions).

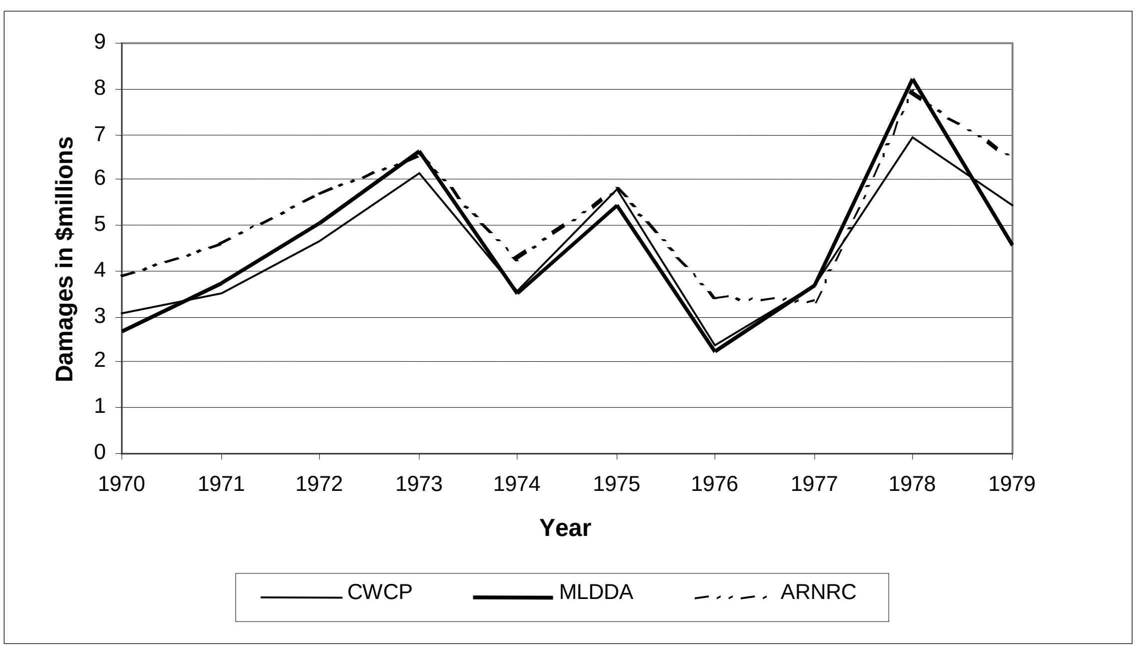

Figure 5.8-10. Average annual groundwater damages for alternatives CWCP, MLDDA, and ARNRC.

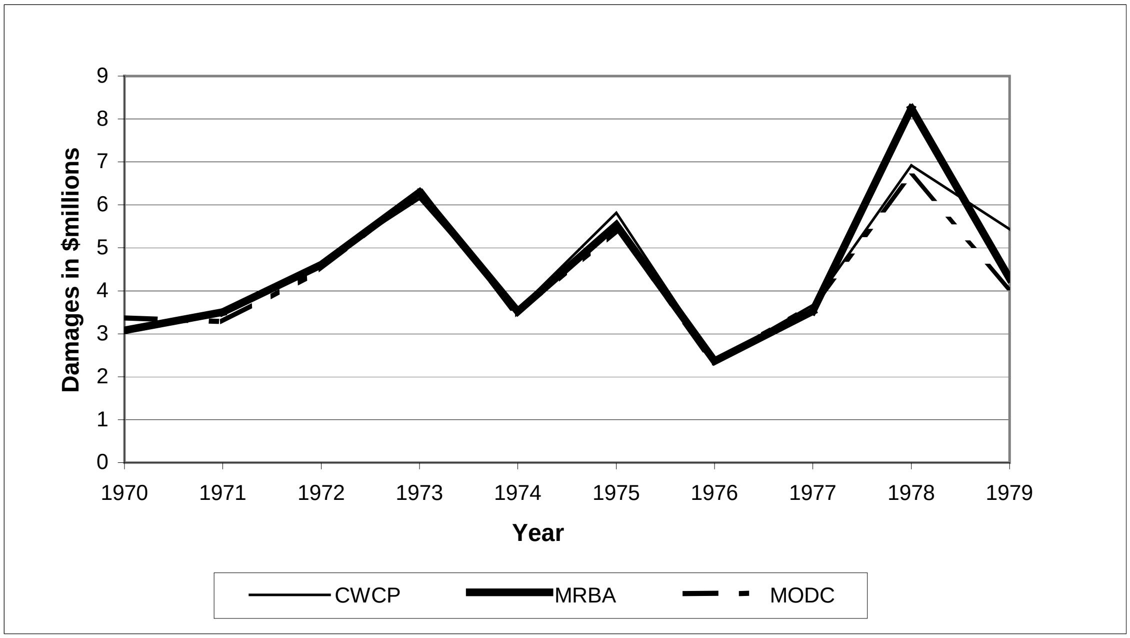

Figure 5.8-11. Average annual groundwater damages for alternatives CWCP, MRBA, and MODC.

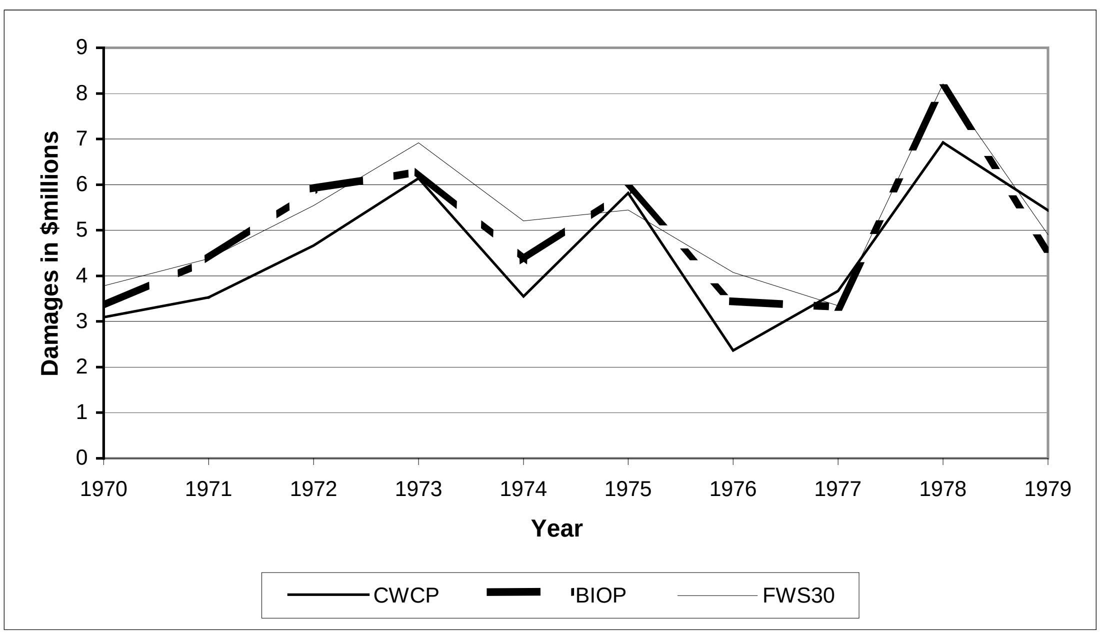

Figure 5.8-12. Average annual groundwater damages for alternatives CWCP, BIOP and FWS30.

5.9 WATER SUPPLY

Water supply benefits were analyzed for the intake facilities along all of the lake and river reaches between the headwaters of Fort Peck Lake and the mouth of the Missouri River at St. Louis. This analysis comprehensively addressed economic benefits, measured in terms of millions of dollars, and is documented in the Water Supply Economics technical report (Corps, 1994g). The analysis includes benefits for the powerplants along the lake and river reaches that are dependent on the Mainstem Reservoir System for cooling water. The powerplant benefits are associated not only with the intake of water to the powerplants, but also with the discharge of the water back to the river for those powerplants that do not have alternative cooling technologies. The water supply analysis, therefore, includes a water quality benefits analysis for these powerplants based on limits on the thermal discharge of the water after use for cooling. In some cases, the effects can be water supply-related, and in other cases, water quality-related. The two effects have been combined to eliminate any potential for "double counting" benefits for a single facility.

Table 5.9-1 and Figure 5.9-1 present the average annual Missouri River water supply benefits for the alternatives. The table also presents the average annual water supply benefits for each reach evaluated. In each of the submitted alternatives about 81 percent of the benefits occur along the Lower River reach. About 16 percent of the benefits occur along the Upper River (downstream from Fort Peck, Garrison, and Fort Randall Dams) reaches, and the remaining 3 percent occurs along the lake reaches of the Mainstem Reservoir System.

Figure 5.9-1 graphically illustrates the average annual water supply benefits of all the alternatives discussed in Chapter 5. One alternative, the MLDDA alternative, at $611.38 million, stands out

Table 5.9-1. Average annual water supply benefits ($millions).

Lake/Reach	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Fort Peck Lake	0.57	0.57	0.55	0.58	0.58	0.56	0.56
Lake Sakakawea	6.28	6.25	6.74	6.62	6.61	6.54	6.69
Lake Oahe	5.97	5.82	6.21	5.94	6.01	6.09	6.08
Lake Sharpe	4.74	4.74	4.74	4.74	4.74	4.74	4.74
Lake Francis Case	2.34	2.34	2.38	2.32	2.33	2.38	2.37
Lewis and Clark Lake	0.65	0.65	0.66	0.65	0.66	0.66	0.66
Lake Subtotal	**20.55**	**20.37**	**21.26**	**20.86**	**20.93**	**20.97**	**21.09**
Fort Peck	1.39	1.38	1.40	1.40	1.42	1.49	1.48
Garrison	92.37	94.36	94.27	94.25	94.28	94.23	94.23
Fort Randall	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Upper River Subtotal	**93.77**	**95.76**	**95.68**	**95.66**	**95.71**	**95.72**	**95.72**
Gavins Point	1.53	1.53	1.53	1.53	1.53	1.53	1.53
Sioux City	32.15	32.15	32.17	32.14	32.11	32.14	32.14
Omaha	198.76	198.46	190.71	197.69	197.29	196.24	196.00
Nebraska City	145.44	145.23	141.69	144.89	144.88	144.29	144.23
St. Joseph	24.26	24.25	24.28	24.25	24.23	24.25	24.24
Kansas City	49.18	49.20	49.11	49.03	49.01	49.05	49.03
Boonville	0.64	0.64	0.64	0.64	0.63	0.64	0.64
Hermann	43.81	43.79	43.77	43.76	43.74	43.76	43.74
Lower River Subtotal	**495.77**	**495.25**	**483.88**	**493.92**	**493.43**	**491.89**	**491.55**
Total	**610.08**	**611.38**	**600.82**	**610.43**	**610.07**	**608.58**	**608.36**

from the other alternatives. Three of the alternatives are closely grouped together between $610.07 and $610.43 million, a difference of $0.36 million. Two alternatives, the BIOP and FWS30 alternatives, are more closely aligned with a difference of $0.22 million. At the lower end of the range, the ARNRC alternative also stands out at $600.82 million. Because the three alternatives with reduced summer flows in all years have the lowest benefits, the summer low-flow value appears to be the primary factor causing the reduction in water supply benefits.

The CWCP has a flat release from Gavins Point Dam in the spring and a summer release of 34.5 kcfs in non-drought periods and 28.5 kcfs in major droughts. Estimated average annual benefits for the CWCP total $610.08 million. Setting aside an additional 2 MAF of system storage for flood control, as with the MLDDA alternative, increases the total average annual water supply benefits over the CWCP by 0.2 percent, or $1.30 million. Under the MLDDA alternative, the average annual water supply benefits decrease for the lakes by $0.18 million, or 0.9 percent, increase for the Upper River by $1.99 million, or 2.1 percent, and decrease for the Lower River by $0.52 million, or 0.1 percent.

The ARNRC alternative, with its higher conservation measures and a 15-kcfs spring rise from mid-May to mid-June followed by an 18-kcfs summer release until September 1 from Gavins Point Dam, decreases the total average annual water supply benefits from the CWCP by 1.5 percent, or $9.26 million. The average annual benefits increase by 3.5 percent, or $0.71 million, for the lakes and by 2.0 percent, or $1.91 million, for the Upper River. Under the ARNRC alternative, average annual water supply benefits decrease for the Lower River by 2.4 percent, or $11.89 million. This dramatic decrease for the Lower River is due primarily to the reduced capability to discharge thermal wastes from the powerplants dependent on the Missouri River for cooling water. Under the ARNRC alternative, replacement power from alternative sources will be required to make up for the lost generation associated with the cutbacks in generation to limit thermal waste discharges during the summer months.

The MRBA alternative provides higher drought conservation measures than the CWCP. It includes a 7.1-month navigation season and, typically, a decrease of 3 kcfs in the navigation service level (relative to full service) in drought years. Under this alternative, total water supply benefits increase over those benefits provided by the CWCP by about 0.1 percent, or $0.35 million. The average annual benefits increase for the lakes by $0.31 million, or 1.5 percent, and for the Upper River by $1.89 million, or 2.0 percent. Compared to the CWCP, the MRBA alternative results in a 0.4 percent, or $1.85 million, decrease in water supply benefits for the Lower River subtotal.

The MODC alternative's flat release, which is extended out to mid-September to allow for continuing low flows for the pallid sturgeon, results in a minimal decrease ($0.01 million and less than 0.1 percent) in the total average annual water supply benefits compared to the CWCP. The lakes and the Upper River show an overall increase in water supply benefits while the Lower River shows a decrease in benefits. Under the MODC alternative, the increase for the lakes is $0.38 million, or 1.8 percent, and the increase for the Upper River is $1.94 million, or 2.1 percent. The Lower River benefits decrease by $2.34 million, or 0.5 percent. These lost benefits are primarily due to the lost powerplant benefits during the 1930 to 1941 drought when navigation is suspended in several years.

The BIOP alternative has a 17.5-kcfs spring rise followed by a 25/21-kcfs summer low flow. It also has the same drought conservation measures as the MRBA alternative. The BIOP alternative results in a decrease in the total average annual water supply benefits from those of the CWCP (a decrease of 0.2 percent, or $1.5 million); however, as with the MODC alternative, there is an increase in benefits for the lakes and Upper River and a decrease for the Lower River. The average annual benefits increase for the lakes is 2.0 percent, or $0.42 million, and for the Upper River, the benefits increase by 2.1 percent, or $1.95 million. Under the BIOP alternative, the decrease for the Lower River would be 0.8 percent, or $3.88 million, which is less than for the CWCP.

The FWS30 alternative, also suggested by the USFWS, is identical to the BIOP alternative except that the spring rise is 30 kcfs. Its water supply benefits are similar to those for the BIOP alternative. Compared to the CWCP, the FWS30 alternative decreases the total average annual water supply benefits by 0.3 percent, or $1.72 million. It provides an increase in benefits for the lakes

(2.6 percent, or $0.54 million) and the Upper River (2.1 percent, or $1.95 million). The average annual benefits decrease by 0.9 percent, or $4.22 million, for the Lower River under the FWS30 alternative. The loss of benefits for the Lower River under both the BIOP and FWS30 alternatives is primarily a result of the thermal powerplant discharge restrictions. The 21-kcfs summer low flow in most years and the 18-kcfs summer flow in the non-navigation years (during the 1930 to 1941 drought) require generation cutbacks at some of the powerplants along the Missouri River.

The annual values of total water supply benefits for the alternatives are shown in Figures 5.9-2 through 5.9-4. These figures show that there is little difference among the alternatives except for the lower summer flow alternatives. Noticeable reduced values occur in most years for the ARNRC, BIOP, and FWS30 alternatives. There are noticeable differences during the years included in the 1930 to 1941 drought for all of the alternatives. These differences show up in the non-navigation years, which are the years with the lowest summer flows (9 or 18 kcfs, depending on the alternative), and the non-navigation years vary among the alternatives. The four major dips in the annual values occur in the years 1898, 1928, 1958, and 1988. Major capital improvements are assumed to be made in those years to the thermal powerplants and the water intakes included in the water supply analysis. The fourth dip is smaller as fewer than 30 years are included in the remainder of the water supply economic computations.

5.9.1 Water Supply for Tribal Reservations

Currently, there are approximately 302 intakes and intake facilities along the mainstem Missouri River that are identified for American Indian Tribes. The total water supply benefits provided to the Tribes are $5.37 million. Only the MLDDA alternative reduces the total benefits (0.7 percent, or $0.04 million) provided to the Tribes on a combined basis relative to those provided under the CWCP. The increases for the other five alternatives range from 2.6 percent (BIOP alternative) to 6.9 percent (ARNRC alternative).

The alternatives have different impacts to individual Reservations, depending upon the location along the Missouri River. Currently, there are 109 water supply intakes and intake facilities located on the Missouri River serving Fort Peck Reservation. The data from Table 5.9-2 indicate that the CWCP provides $0.21 million of water supply benefits to this Reservation. All of the alternatives except the MLDDA and MRBA alternatives increase the water supply benefits to this Reservation. The MLDDA and MRBA alternatives do not result in a benefit change from the CWCP for Fort Peck Reservation. The BIOP and FWS30 alternatives both provide the maximum average annual water supply benefits, a 14.3 percent increase in benefits over those of the CWCP, while the ARNRC and MODC alternatives provide a 9.5 and 4.8 percent increase in water supply benefits, respectively.

Fort Berthold Reservation has 79 water supply intakes and intake facilities along Lake Sakakawea.

Table 5.9-2. Average annual reservation water supply benefits ($millions).

Reservation	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Fort Peck	0.21	0.21	0.23	0.21	0.22	0.24	0.24
Fort Berthold	1.75	1.74	1.96	1.86	1.87	1.77	1.87
Standing Rock	0.67	0.63	0.79	0.73	0.74	0.75	0.74
Cheyenne River	0.08	0.09	0.09	0.09	0.08	0.08	0.09
Lower Brule	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Crow Creek	1.98	1.98	1.99	1.99	1.99	1.99	1.99
Yankton	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Santee	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Winnebago	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Omaha	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total	**5.37**	**5.33**	**5.74**	**5.56**	**5.58**	**5.51**	**5.61**

The CWCP provides $1.75 million of benefits to this Reservation on an average annual basis. The ARNRC alternative provides the greatest increase in average annual water supply benefits (12.0 percent) and the MODC and FWS30 alternatives both provide the second largest benefits increase (6.9 percent) to this Reservation. The MRBA alternative increases the water supply benefit for this Reservation by 6.3 percent, while the BIOP alternative yields only a 1.1 percent increase over the CWCP. Of the alternatives, the MLDDA alternative is the only one that results in lost water supply benefits compared to the CWCP (0.6 percent decrease). Standing Rock Reservation has 14 water supply intakes along Lake Oahe on Reservation land. Under the CWCP, these benefits average $0.67 million per year. As with Fort Berthold Reservation, the ARNRC alternative provides the greatest average annual water supply benefits to the Reservation (17.9 percent increase) compared to those of the CWCP. The BIOP alternative results in an increase in water supply benefits to this Reservation (11.9 percent), as do both the MODC and FWS30 alternatives (10.4 percent). The MRBA alternative shows a slightly lower increase than the above alternatives (9.0 percent). The MLDDA alternative is the only one that provides lower average annual water supply benefits to Standing Rock Reservation, with lost benefits of 6.0 percent compared to those of the CWCP.

Nine water supply intakes have been identified along Lake Oahe on Cheyenne River Reservation. Average annual benefits to the Reservation under the CWCP total $0.08 million. None of the alternatives decrease water supply benefits to this Reservation. The MLDDA, ARNRC, MRBA, and FWS30 alternatives all provide the greatest average annual water supply benefits to the Reservation, with a 12.5 percent increase in benefits for each over the CWCP. The MODC and BIOP alternatives do not result in a change in water supply benefits from the CWCP.

Lower Brule Reservation has 22 water supply intakes identified along Lake Sharpe. Average annual benefits for these intakes total $0.54 million under the CWCP. Compared to the CWCP, all of the other alternatives provide the same benefits because the level of Lake Sharpe does not vary under any of the alternatives.

There are 55 water supply intakes serving the Crow Creek Reservation from Lake Sharpe and Lake Francis Case. Average annual benefits to these intakes under the CWCP total $1.98 million. All but one of the alternatives, the MLDDA alternative, slightly increase the average annual water supply benefits to the Reservation (0.5 percent increase) and provide additional benefits over those of the CWCP. This Reservation is located along both Lake Sharpe and the headwaters of Lake Francis Case, and the differences arise for those intakes located on the Lake Francis Case reach. The MLDDA alternative does not result in a change in water supply benefits compared to those of the CWCP.

Four irrigation intakes pulling water from Lake Francis Case are located on Yankton Reservation. None of the alternatives increase water supply benefits to these intakes compared to the CWCP. Santee Reservation has seven water supply intakes located on Lewis and Clark Lake. All of the alternatives provide average annual benefits of $0.11 million to these intakes.

Of the 49 water supply intakes located on the Missouri River in the Sioux City reach, there is one irrigation intake on Winnebago Reservation and two irrigation intakes on Omaha Reservation. For Winnebago and Omaha Reservation irrigation intakes, all of the alternatives provide $0.01 million and $0.02 million, respectively, in average annual water supply benefits to these Reservations. Compared to the CWCP, there is no change in water supply benefits under any of the remaining alternatives.

None of the nine water supply intakes located on the St. Joseph reach of the Missouri River are on Iowa Reservation or Sac and Fox Reservation.

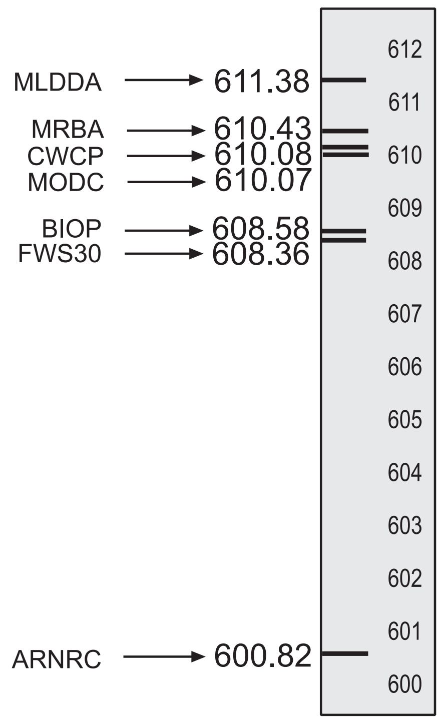

Figure 5.9-1. Average annual water supply benefits for submitted alternatives ($millions).

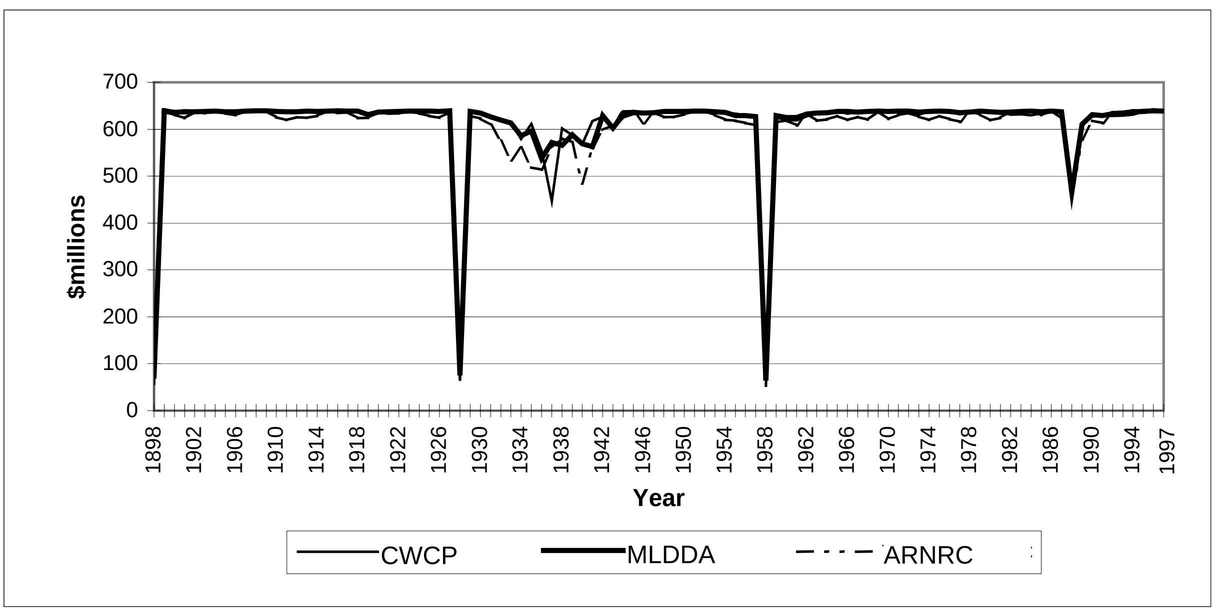

Figure 5.9-2. Average annual water supply benefits for alternatives CWCP, MLDDA, and ARNRC.

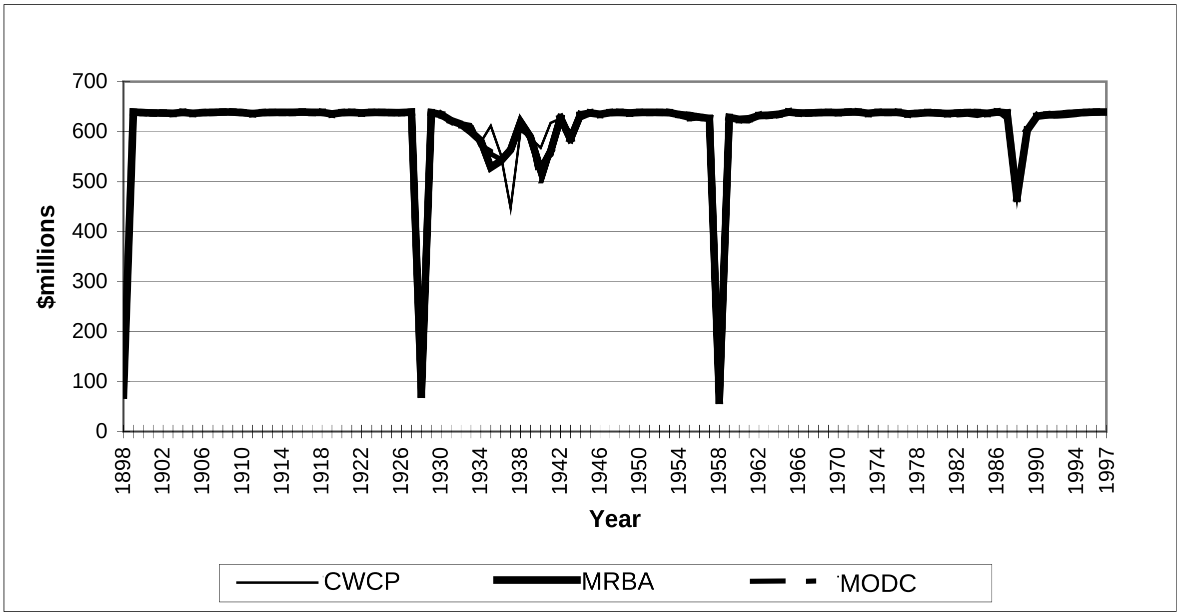

Figure 5.9-3. Average annual water supply benefits for alternatives CWCP, MRBA, and MODC.

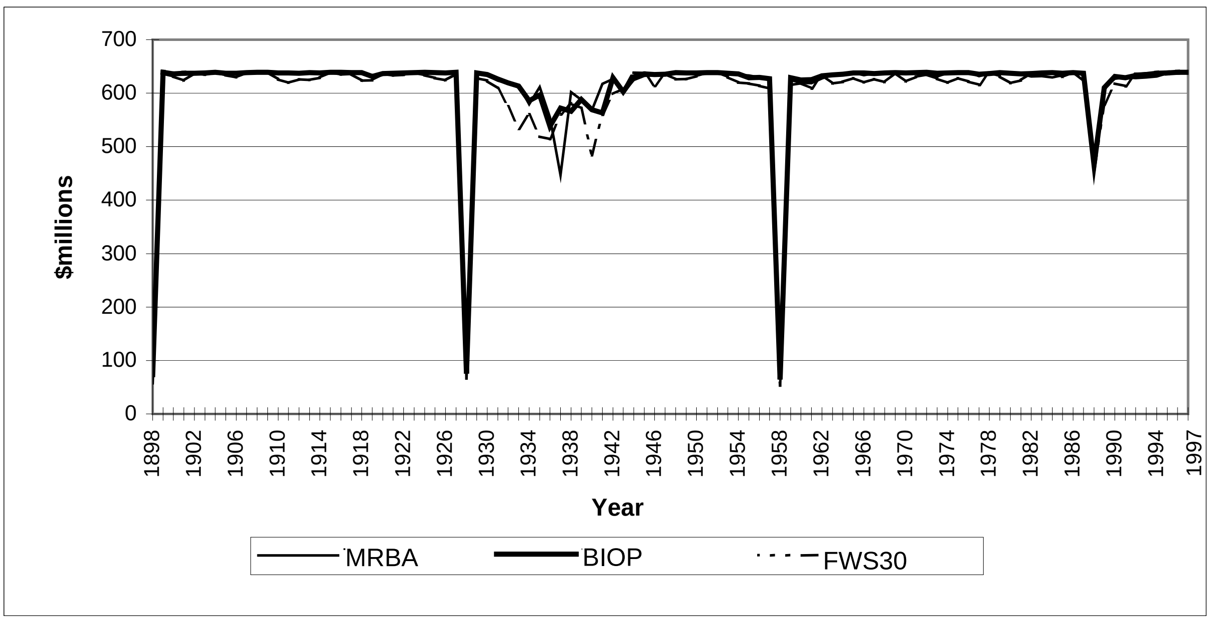

Figure 5.9-4. Average annual water supply benefits for alternatives MRBA, BIOP, and FWS30.

5.10 HYDROPOWER

The impacts to hydropower were estimated by evaluating the total value of hydropower production for both the capacity and energy components with respect to alternative replacement costs, as discussed in the Hydropower Economics technical report for the DEIS (Corps, 1994i). Differences in the hydropower benefits for the alternatives are reviewed from different perspectives, including a breakdown of capacity and energy values. The capacity value represents the amount of generation capacity available from the hydropower units in light of various constraints. The energy value is the amount of power generated during a specified time period.

It should be noted that the numbers presented in this FEIS are different from those included in the RDEIS, whose numbers reflected a recent re-analysis of the basic unit values for capacity and energy. The basic application of these values in the hydropower economic impact model has not changed from that discussed in the

Hydropower Economics technical report (Corps 1994i); only the monetary amounts assigned to these values have been adjusted. The numbers presented below are corrected from those included in the RDEIS to correct some hydropower model parameters that were not revised appropriately when the RDEIS values were hurriedly revised prior to its completion. Basically the numbers are about 20 percent lower for the capacity portion of the total hydropower value (capacity plus energy benefits). The total hydropower trends among the alternatives are essentially the same with these revised numbers and the RDEIS numbers.

The total economic hydropower benefits for the alternatives are presented in Table 5.10-1 and Figure 5.10-1. Table 5.10-1 also includes data for each of the six mainstem dams. The greatest total average annual benefits for the 100-year period of analysis occur under the FWS30 alternative ($679.18 million), and the least occur under the MLDDA alternative ($664.35 million), a difference of approximately 2.2 percent.

The CWCP has a flat release of 34.5 kcfs from Gavins Point Dam during spring and summer of most years; during major droughts, this release is reduced to 28.5 kcfs. This operational pattern results in $668 million of total average annual benefits for the Mainstem Reservoir System hydropower production. The majority of the hydropower benefit comes from two dams, Oahe (29.6 percent) and Garrison (20.9 percent). The contributions of the remaining four dams are as follows: Big Bend (17.2 percent), Fort Randall (16.8 percent), Fort Peck (9.3 percent), and Gavins Point (6.0percent).

Figure 5.10-1 depicts the distribution of the total benefits of the alternatives. Two alternatives—BIOP and FWS30—are grouped at the top of the distribution, separated by only $0.07 million. The MLDDA alternative results in the least average annual benefits, $3.65 million (0.5 percent) below the CWCP. The other alternatives all result in greater average annual benefits than the CWCP. The greatest increase occurs under the FWS30 alternative, closely followed by the BIOP alternative. The ARNRC, MODC, and MRBA (in descending order) form a loose grouping between the CWCP and the FWS30 and BIOP alternatives.

Table 5.10-1. Average annual hydropower benefits ($millions).

Alternative	Total	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point
CWCP	**668.00**	63.62	139.67	197.60	115.14	111.98	40.00
MLDDA	**664.35**	63.48	138.54	195.44	115.44	111.56	39.89
ARNRC	**674.98**	64.15	146.28	202.16	113.43	110.17	38.79
MRBA	**672.57**	64.29	142.27	199.74	114.93	111.52	39.83
MODC	**674.52**	64.21	143.10	200.62	114.91	111.83	39.86
BIOP	**679.11**	64.47	144.37	202.45	115.61	111.56	40.65
FWS30	**679.18**	64.55	144.99	202.27	115.73	111.15	40.48

The MLDDA alternative differs from the CWCP by setting aside an extra 2 MAF of system storage for flood control. The resulting decrease in capacity produces a slight (0.5 percent) reduction in total average annual hydropower benefits compared to the CWCP. Total hydropower benefit reductions, ranging from 0.2 percent to 1.1 percent, occur at five of the six dams. A 0.3 percent increase in average annual hydropower benefits occurs at Big Bend Dam.

The combination of increased drought conservation measures, periodic spring rise, and annual decreased summer releases under the ARNRC alternative results in a 1.0 percent increase in total average annual hydropower benefits, compared to the CWCP. The bulk of this increase comes from Garrison and Oahe Dams, which show increases of 4.7 percent and 2.3 percent, respectively. At the three lower dams (Big Bend, Fort Randall, and Gavins Point), the ARNRC alternative results in decreases in average annual hydropower benefits ranging from 1.5 to 3.0 percent.

Similar to the CWCP, the MRBA and MODC alternatives maintain a flat release from Gavins Point Dam during the summer; however, intrasystem regulation is unbalanced under these alternatives, and drought conservation in the upper three lakes is increased. These changes result in small increases in total average annual hydropower benefits, 0.7 percent for MRBA and 1.0 percent for MODC. For both alternatives, increases in hydropower benefits come from the three upper dams, while decreases occur at the three lower dams.

The greatest average annual hydropower benefits occur under the BIOP and FWS30 alternatives, which feature increased drought conservation measures and spring rises at Gavins Point and Fort Peck Dams, but higher summer flows than the ARNRC alternative. Both of these alternatives result in 1.7 percent increases in total average annual hydropower benefits compared to the CWCP. Under both alternatives, increases occur at all dams except Fort Randall.

The annual values of total hydropower benefits for the alternatives are shown in Figures 5.10-2 through 5.10-4. Hydropower benefits are highly variable during the entire period of analysis, and none of the alternatives performs consistently better or worse than any of the others. For all alternatives, the lowest total hydropower benefit values occur during the 1930 to 1941 drought. Additional low points occur during the late 1950s and late 1980s. The figures indicate that the alternatives featuring drought conservation measures (i.e., all except the MLDDA alternative) generally provide higher benefits than the CWCP during drought periods.

Figure 5.10-2 shows that the MRBA and the MODC alternatives, with essentially the same increased drought conservation measures, exhibit very similar patterns, producing higher annual hydropower benefits than the CWCP during most of the 1930s and 1940s. In Figure 5.10-3, the ARNRC alternative, with its highest drought conservation measures, results in higher benefits than the CWCP during and after the 1930 to 1941 drought, as well as during the 1960s and 1990s. In contrast, the MLDDA alternative remains very close to the CWCP, showing higher values only for brief periods during the 1930s and 1940s (Figure 5.10-3). As shown in Figure 5.10-4, the BIOP and FWS30 alternatives, with the same increased drought conservation measures as the MRBA alternative, match each other almost exactly and are very similar to the MRBA alternative. The most noticeable differences occur during the 1940s, 1950s, and 1990s, when the BIOP and FWS30 alternatives produce greater benefits than the MRBA alternative (as well as the CWCP).

The month-to-month distributions of the average annual generating capacity values for the full 100-year period of analysis are presented in Table 5.10-2 and Figures 5.10-5 through 5.10-7. In general, the total generating capacity at the mainstem dams is at its highest level in the summer months. Under most alternatives, the lowest levels of generating capacity occur during spring and fall and an intermediate peak occurs during winter. The exception to this pattern occurs under the two alternatives that maximize benefits to fish and wildlife (BIOP and FWS30), both of which lack the capacity drop-offs during spring and fall, showing instead a gradual increase in capacity from winter to summer. The relative effects of the other five alternatives remain consistent throughout the year. The MLDDA results in slightly lower monthly average peaking capacities than the CWCP, and the MRBA, MODC, and ARNRC alternatives result (in increasing order) in higher levels. During autumn, winter, and spring, the BIOP and FWS30 alternatives result in the highest peaking capacities, but they fall slightly below the level of the ARNRC alternative during the summer.

Table 5.10-2. Monthly average hydropower peaking capacity (MW).

Alternative	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CWCP	2,146	2,148	2,053	2,009	2,130	2,244	2,270	2,255	2,089	2,071	2,150	2,141
MLDDA	2,132	2,134	2,037	1,995	2,117	2,231	2,259	2,243	2,069	2,050	2,133	2,127
ARNRC	2,210	2,213	2,112	2,058	2,179	2,292	2,322	2,322	2,158	2,139	2,220	2,206
MRBA	2,179	2,183	2,085	2,035	2,162	2,276	2,299	2,286	2,118	2,095	2,180	2,174
MODC	2,190	2,194	2,093	2,041	2,166	2,282	2,307	2,295	2,127	2,103	2,190	2,185
BIOP	2,224	2,226	2,238	2,255	2,253	2,279	2,313	2,312	2,295	2,270	2,237	2,219
FWS30	2,229	2,231	2,243	2,261	2,259	2,280	2,315	2,315	2,298	2,274	2,242	2,224

The energy distributions, in thousands of megawatt-hours, or gigawatt-hours (GWh), are presented in Table 5.10-3 and in Figures 5.10-8 through 5.10-10. Overall, the annual patterns of the alternatives fall into two groups. Under most alternatives, the values are lowest in March, increasing each month to peak during the summer, and then gradually returning to the low value in March. In contrast, the three alternatives with a Gavins Point spring rise followed by summer flows lower than those of the CWCP (the ARNRC, BIOP, and FWS30 alternatives) have two peaks (in May and September), separated by a secondary low during the summer months.

Compared to the CWCP, the lower base of flood control under the MLDDA alternative results in slightly lower energy values throughout the year, except in February and March. As a result of the Gavins Point Dam spring rise and summer low releases, the ARNRC alternative results in higher energy values than the CWCP during the spring and fall, but considerably lower values during late summer. The increased drought conservation measures of the MRBA and MODC alternatives generally result in lower energy values during the winter months, but higher values during spring, summer, and autumn, relative to the CWCP. The BIOP and FWS30 alternatives follow a pattern similar to that of the ARNRC, although they do not fall as far below the CWCP during the month of July.

For the region in which the Mainstem Reservoir System hydropower facilities operate, Federal hydroelectric generating capacity is marketed based on the peak season firm demand in both the summer and winter seasons. In the early 1980s, the marketing agency, the Western Area Power Administration (WAPA), chose to use 1961 water conditions to determine adverse-year capability for the sale of firm capacity. The lowest peak capacities in the summer and winter periods for the Corps' 1961 annual operating year (March 1961 through February 1962) represent the criteria that determine the capacities that WAPA marketed. Table 5.10-4 presents the summer and winter values for dependable capacity in 1961 for all the alternatives. This table also presents the currently marketed capacities in both seasons.

Under current depletion levels, the CWCP does not meet the currently marketed levels identified in the early 1980s at depletion levels assumed at that time. The CWCP almost meets the level in the summer (-2 MW), but falls much shorter of meeting the level in the winter (-37 MW). Five of the alternatives to the CWCP exceed the currently marketed level both in summer and winter. Only the MLDDA alternative does not meet that level, falling short both in summer (-9 MW) and winter

Table 5.10-3. Monthly average hydropower energy values (GWh).

Alternative	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CWCP	729	637	554	711	928	912	1023	1053	973	928	857	722
MLDDA	727	638	593	708	922	893	1022	1047	945	923	854	714
ARNRC	723	623	568	827	1048	980	732	901	1039	971	892	719
MRBA	710	611	550	739	931	920	1030	1049	1020	976	776	727
MODC	715	603	591	752	932	913	1047	1025	988	968	799	723
BIOP	723	615	555	797	1031	907	882	887	1060	998	876	710
FWS30	719	611	557	795	1086	934	859	876	1044	985	864	704

(-42 MW). All of the other alternatives have greater drought conservation measures than the CWCP and MLDDA alternative; this is the primary factor resulting in hydropower capacity increases above currently marketed levels. The ARNRC alternative, which has the greatest drought conservation measures, goes the furthest, exceeding currently marketed levels by 157 MW in summer and 113 MW in winter.

Table 5.10-4. Marketable capacity from the Mainstem Reservoir System hydropower facilities (MW).

	1961 Operating Year Minimum Capacity	
Alternative	**Summer Season**	**Winter Season**
Currently marketed	2,070	2,010
CWCP	2,068	1,973
MLDDA	2,061	1,968
ARNRC	2,227	2,123
MRBA	2,102	2,015
MODC	2,118	2,042
BIOP	2,177	2,100
FWS30	2,173	2,096

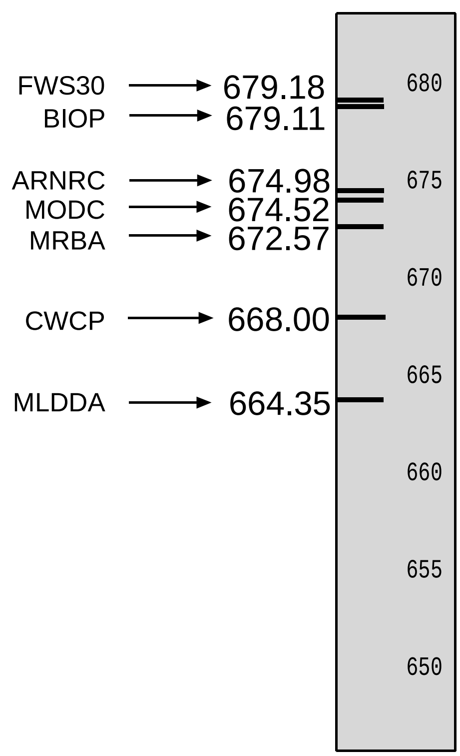

Figure 5.10-1. Average annual hydropower benefits for submitted alternatives ($millions).

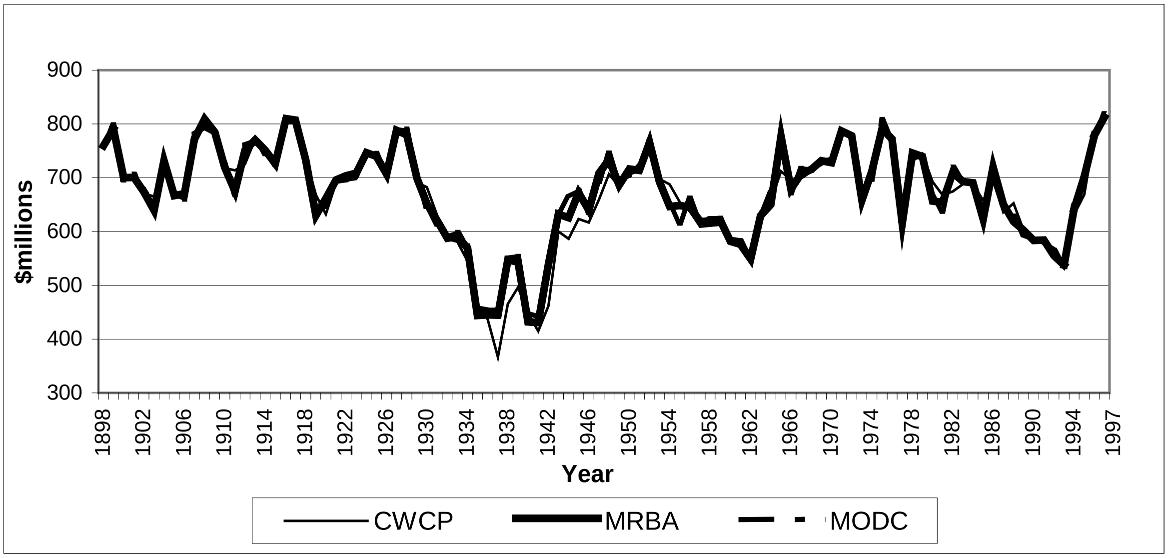

Figure 5.10-2. Annual hydropower benefits for alternatives CWCP, MRBA, and MODC.

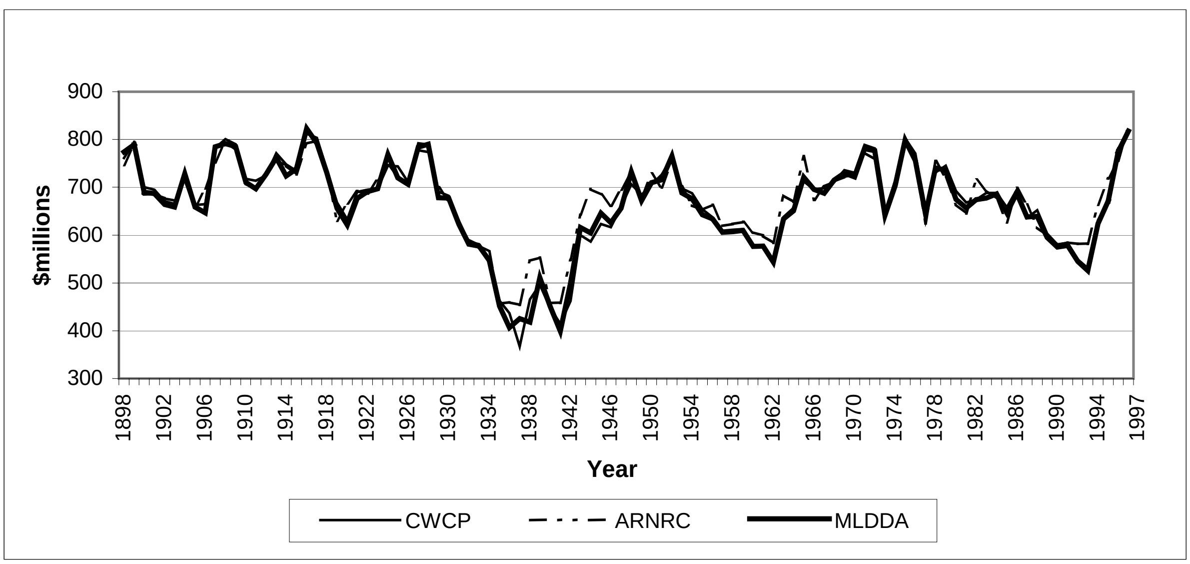

Figure 5.10-3. Annual hydropower benefits for alternatives CWCP, ARNRC, and MLDDA

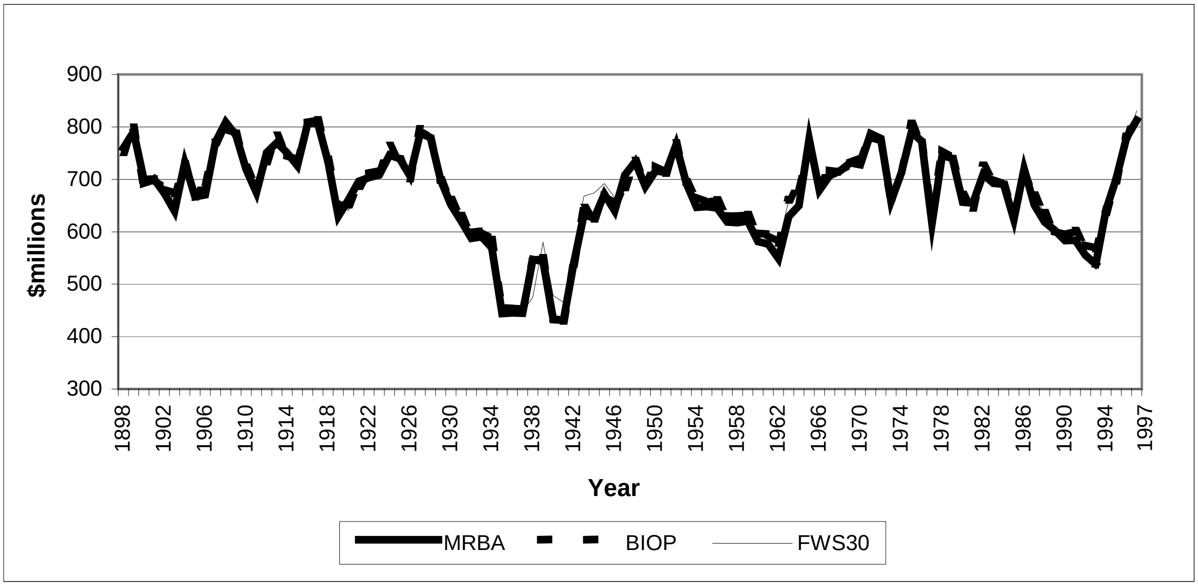

Figure 5.10-4. Annual hydropower benefits for alternatives MRBA, BIOP, and FWS30.

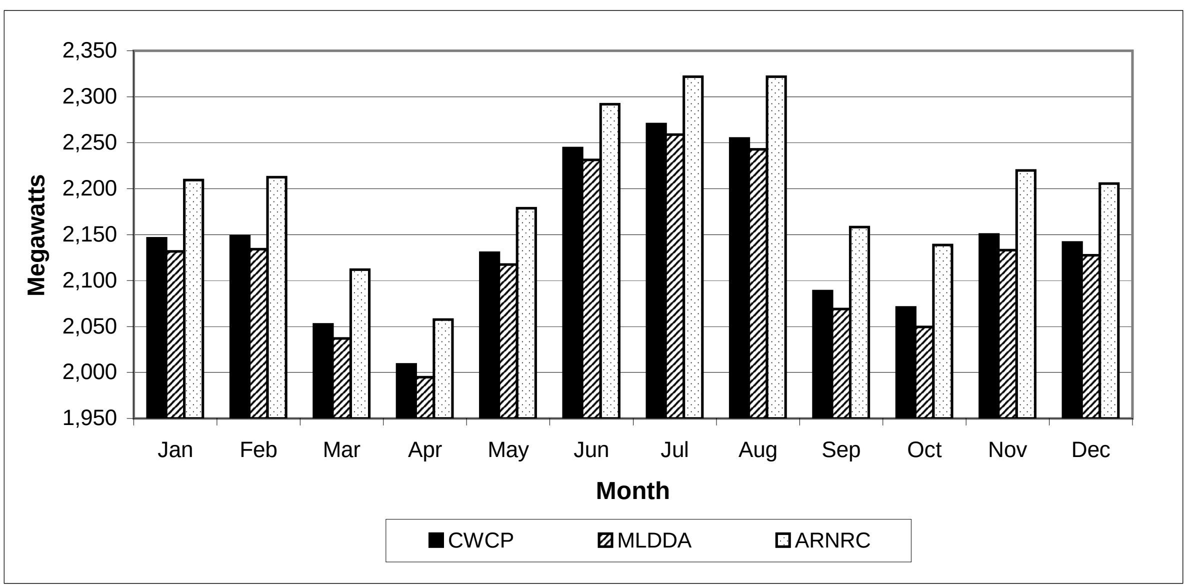

Figure 5.10-5. Monthly average hydropower peaking capacity for alternatives CWCP, MLDDA, and ARNRC.

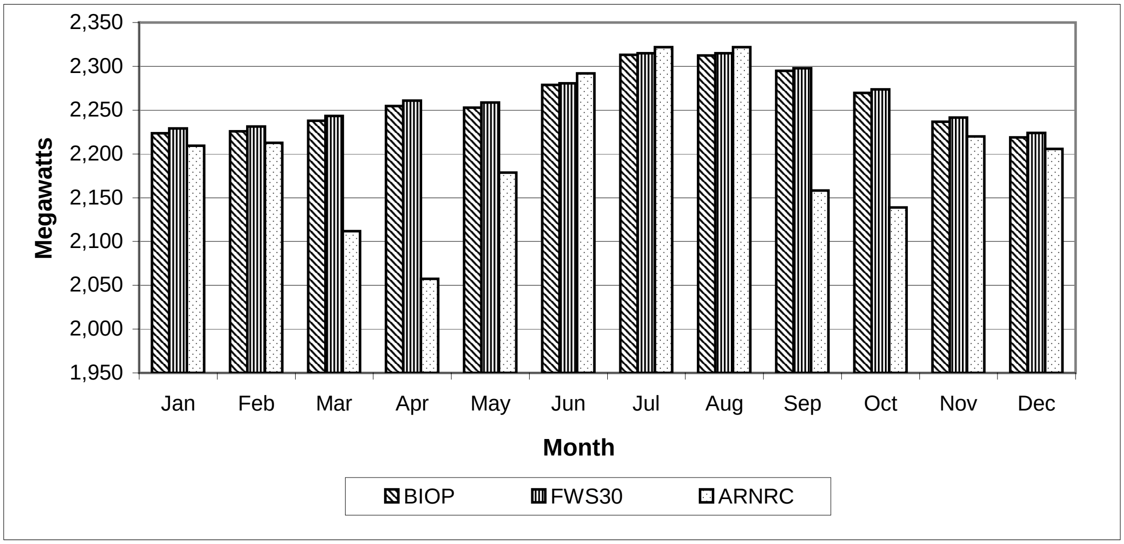

Figure 5.10-6. Monthly average hydropower peaking capacity for alternatives BIOP, FWS30, and ARNRC.

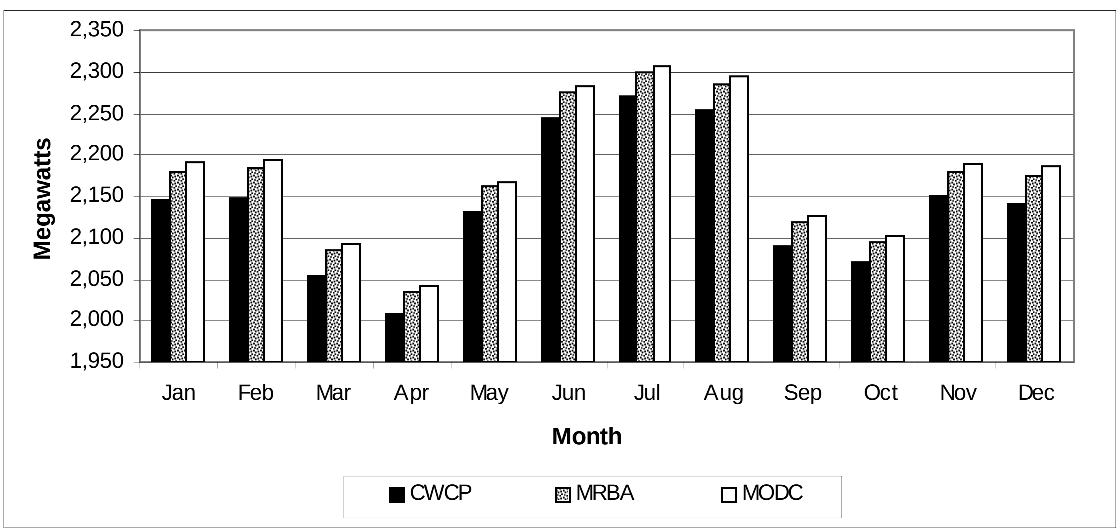

Figure 5.10-7. Monthly average hydropower peaking capacity for alternatives CWCP, MRBA, and MODC.

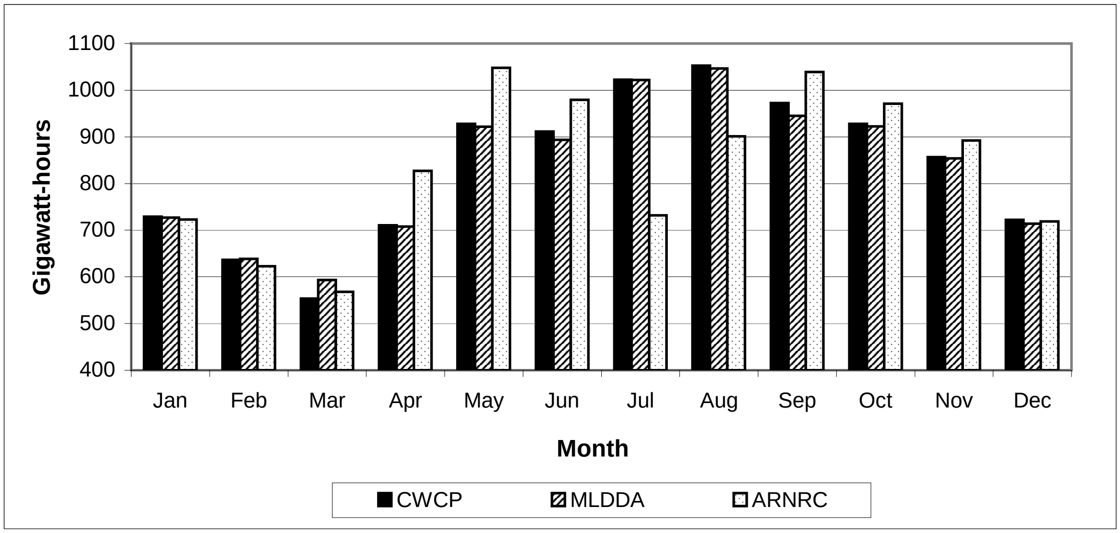

Figure 5.10-8. Monthly average hydropower energy for alternatives CWCP, MLDDA, and ARNRC.

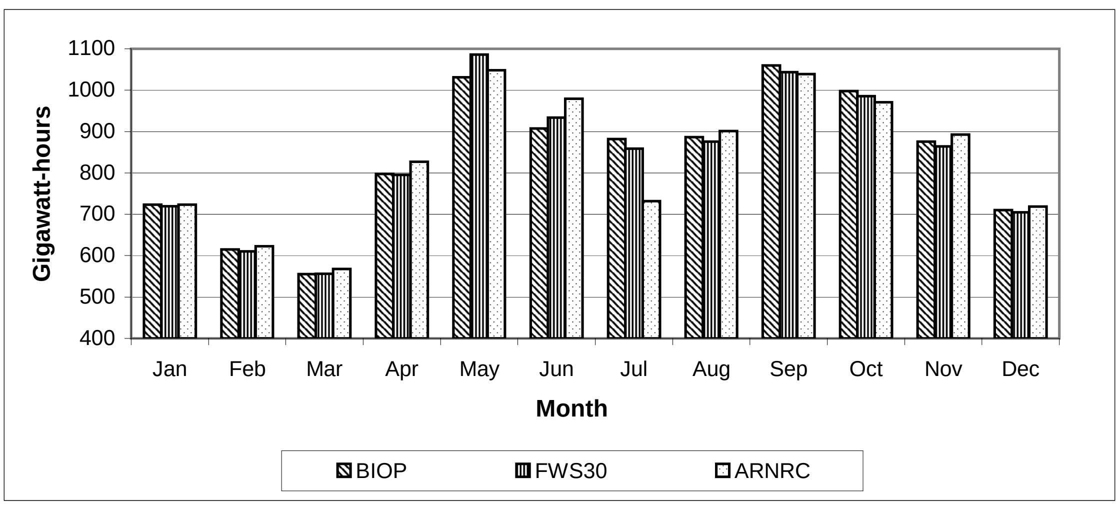

Figure 5.10-9. Monthly average hydropower energy for alternatives BIOP, FWS30, and ARNRC.

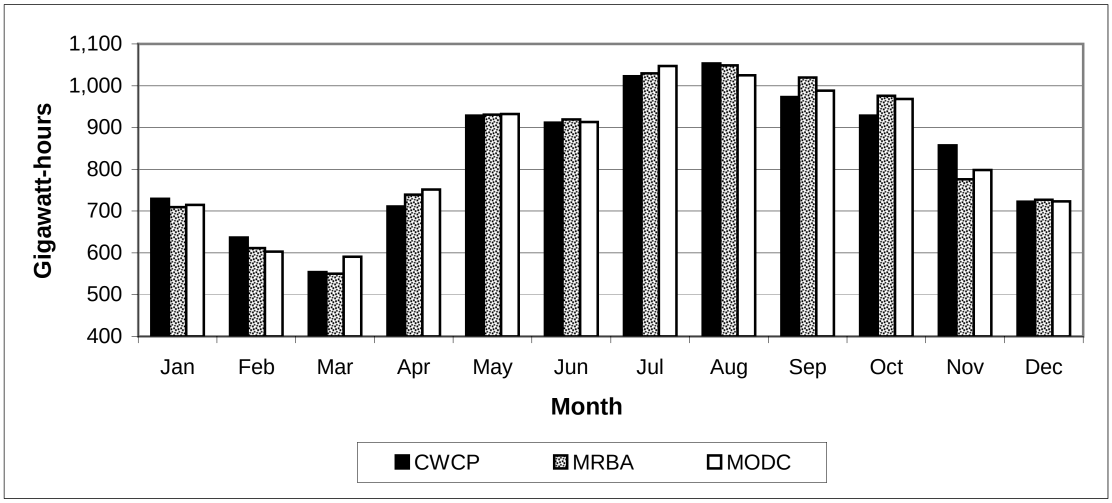

Figure 5.10-10. Monthly average hydropower energy for alternatives CWCP, MRBA, and MODC.

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5.11 RECREATION

Recreation is an important beneficial use of water along the entire Missouri River. Each of the six lakes and the river reaches between the lakes on the Lower River has recreational development. Recreation is also one of the many uses of the Lower River downstream from Gavins Point Dam. This section discusses the effects to recreation benefits from operating the Mainstem Reservoir System under each of the submitted alternative plans and the CWCP.

Recreation benefits (measured in millions of dollars) under the alternatives were estimated using the Daily Routing Model (DRM) and the Economic Impacts Model (EIM). The DRM (Corps, 1998b) is a hydrologic model that estimates lake surface elevation and river flow at 23 reaches using the alternative operation strategies and the historic runoff levels between 1898 and 1997. The EIM (Corps, 1994r) uses the output from the DRM and economic value functions (Corps 1994h) to estimate the economic benefit. The economic value functions for recreation benefits are computed by identifying changes in potential visitation, multiplying this visitation times composite values per visitation (one or more activities are usually associated with a visit), and subtracting any capital costs that may be incurred for facilities in each reach. Visitation computations are based on visitation surveys completed in the early 1990s (to determine changes in visitation based on lake-level and river-flow changes) and measured visitation in 1993. Capital costs are those that are incurred when facilities reach the end of their useful life and require replacement. Also included with the capital costs are the costs for boat ramp repairs and extensions required when lake levels drop. Finally, the resulting benefits were inflated by 12 percent to account for changes in visitation and costs since the early 1990s when the methodology was developed.

Recreation benefits presented in this section of Chapter 5 are National Economic Development (NED) benefits that reflect the willingness of users to pay and include only entry and use fees. Consequently, the resulting values are somewhat less than if the values were Regional Economic Development benefits, which include the NED benefits plus other expenditures that are associated with recreation activities, such as boat and equipment purchases, motel expenses, restaurant costs, etc. It is important to recognize that the estimated economic benefits are used for comparative purposes only and may not represent actual economic returns under the different alternatives. The models were designed expressly for comparing the effects of changing from the CWCP and not to forecast the future.

Figure 5.11-1 and Table 5.11-1 present the average annual benefits of the alternatives during the 100-year analysis period. These benefits are also broken down for each of the reaches analyzed in Table 5.11-1. Total average annual recreation benefits for the alternatives range from $84.69 million (under the CWCP) to $88.00 million (under the MRBA alternative), a difference of 3.9 percent.

The CWCP results in $84.69 million in average annual recreation benefits. Approximately 71.3 percent of the recreation benefits come from the mainstem lakes. Another 23.3 percent of the benefits come from the Lower River reaches, and the remaining 5.4 percent come from the Upper River reaches (downstream from Fort Peck, Garrison, and Fort Randall Dams). All of the submitted alternatives result in greater total average annual benefits than the CWCP. Looking at individual lakes and river reaches, average annual recreation benefits from the alternatives range between about 9.4 percent lower and 15.0 percent higher than the average annual benefits calculated for the CWCP. With the exception of Lake Sakakawea, each of the lakes has increases in recreation benefits relative to the CWCP; benefits from the river reaches, except for the Fort Peck reach, generally decline relative to the CWCP.

As depicted in Figure 5.11-1, all of the submitted alternatives result in greater recreation benefits than the CWCP. The lowest increase occurs under the MLDDA alternative, which is grouped with the CWCP at the bottom of the scale. The remaining alternatives are grouped in the $86 to $88 million range, with the greatest increase occurring under the MRBA alternative. The recreation benefits of the MODC and FWS30 alternatives are near those

Table 5.11-1. Average annual recreation benefits ($millions).

Lake/River Reach	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Fort Peck Lake	2.92	3.08	3.13	3.15	3.25	3.11	3.19
Lake Sakakawea	13.81	13.50	15.70	15.75	15.26	15.14	15.88
Lake Oahe	14.90	15.43	16.41	15.94	16.08	15.85	16.30
Lake Sharpe	7.97	7.97	7.97	7.97	7.97	7.97	7.97
Lake Francis Case	10.58	10.81	10.84	10.85	10.83	10.87	10.88
Lewis and Clark Lake	10.20	10.20	10.20	10.20	10.20	10.20	10.20
Lake Subtotal	**60.38**	**60.99**	**64.25**	**63.86**	**63.59**	**63.14**	**64.42**
Fort Peck	0.35	0.35	0.38	0.36	0.36	0.39	0.38
Garrison	3.24	3.25	3.18	3.16	3.16	3.16	3.14
Fort Randall	0.99	0.99	0.94	0.99	0.99	0.97	0.97
Upper River Subtotal	**4.58**	**4.59**	**4.50**	**4.51**	**4.51**	**4.52**	**4.49**
Gavins Point	5.10	5.05	4.62	5.06	5.05	4.85	4.79
Sioux City	11.45	11.37	10.52	11.39	11.36	10.93	10.81
St. Joseph	0.61	0.61	0.60	0.61	0.61	0.60	0.60
Kansas City	0.90	0.90	0.89	0.90	0.90	0.89	0.89
Boonville	0.71	0.71	0.70	0.71	0.71	0.71	0.71
Hermann	0.96	0.96	0.95	0.96	0.96	0.96	0.96
Lower River Subtotal	**19.73**	**19.60**	**18.28**	**19.63**	**19.59**	**18.94**	**18.76**
Total	**84.69**	**85.18**	**87.03**	**88.00**	**87.69**	**86.60**	**87.67**

of the MRBA alternative and are separated from one another by only $0.02 million. The ARNRC and BIOP alternatives (in descending order) are at the bottom of the upper grouping. Increased drought conservation measures appear to have the greatest influence on total average annual recreation benefits. The five alternatives that feature these measures (i.e., all except the MLDDA alternative) result in the greatest increases over the CWCP.

Under the MLDDA alternative, river operations are similar to those under the CWCP except that 2 MAF of storage is used for annual flood control and multiple use rather than as carryover multiple use (i.e., the base of the flood control zone is 55.1 MAF rather than 57.1 MAF). Total average annual recreation benefits under the MLDDA alternative ($85.18 million) are slightly higher (0.6 percent) than under the CWCP. Average annual benefits from each of the lake reaches except for Lake Sakakawea increase slightly (up to 5.5 percent) relative to the CWCP. In contrast to the other submitted alternatives, the MLDDA alternative results in a slight (2.2 percent) decline in benefits at Lake Sakakawea. In the Upper River reaches, the only difference from the CWCP occurs in the Garrison reach, where the MLDDA alternative results in a very slight increase in benefits, from $3.24 million to $3.25 million. As a result, the MLDDA differs from the other submitted alternatives by resulting in a slight increase in recreation benefits in the Upper River reaches; all of the other alternatives result in decreases relative to the CWCP. In contrast to the Upper River reaches (and consistent with the other submitted alternatives), benefits from the Lower River reaches decrease slightly under the MLDDA alternative. Declines in the Gavins Point (1.0 percent decrease) and Sioux City (0.7 percent decrease) reaches result in average annual recreation benefits for these two reaches of $0.13 million less than those for the CWCP.

The ARNRC alternative includes a 15-kcfs rise in the spring; however, spring flows are often higher than this amount because no summer evacuation of flood flows is allowed. Consequently, spring flows are increased during wet years to reduce the amount of water in flood storage. The ARNRC alternative includes summertime flows of 18 kcfs between July 1 and August 20. Finally, the ARNRC alternative has the highest level of drought conservation of the submitted alternatives. Total average annual recreation benefits under the ARNRC alternative ($87.03 million) are about 2.8 percent higher than under the CWCP. Each of the lakes has benefits ranging from no change (Lewis and Clark Lake and Lake Sharpe) to 13.7 percent higher (Lake Sakakawea) when compared to those of the CWCP. All of the river reaches except Fort Peck have decreases in recreation benefits, ranging from 1.0 percent (Hermann) to 9.4 percent (Gavins

Point) below the CWCP values. Within the Fort Peck reach, the ARNRC alternative results in an 8.6 percent increase in recreation benefits. The largest increase in benefits occurs at Lake Sakakawea ($1.89 million), while the greatest decrease is in the Sioux City reach of the Lower River ($0.93 million decrease).

The MRBA alternative provides higher drought conservation measures than the CWCP. Total average annual recreation benefits ($88.00 million) under the MRBA alternative are the highest of the submitted alternatives, about $3.31 million (3.9 percent) higher than the CWCP. Recreation benefits from the mainstem lakes are approximately $3.48 million (5.8 percent) higher under the MRBA alternative than under the CWCP. In contrast, recreation benefits from the Upper River and Lower River reaches are $0.17 million (0.7 percent) less under the MRBA alternative than under the CWCP. Similar to the other submitted alternatives except the MLDDA alternative, the MRBA provides Lake Sakakawea with the highest increase in recreation benefits ($1.94 million, or 14.0 percent) relative to the CWCP. Most river reaches have no change in recreation benefits relative to the CWCP, although three reaches have slight decreases ranging from $0.04 million (Fort Randall) to $0.08 million (Garrison), and the Fort Peck reach shows a very slight ($0.01 million) increase.

Operationally, the MODC alternative is similar to the MRBA alternative except that the summer flat release for navigation from Gavins Point Dam is extended to mid-September for pallid sturgeon as a result of delaying evacuation of water from flood storage. The extension results in an average annual recreation benefit of $87.69 million, which is slightly lower ($0.31 million) than the MRBA alternative, but higher ($3.00 million, or 3.5 percent) than the CWCP. Changes in benefits for the mainstem lakes relative to the CWCP range from none (Lewis and Clark Lake and Lake Sharpe) to $1.45 million, or 10.5 percent higher (Lake Sakakawea). In contrast, changes in the river reaches range from a $0.01 million increase (Fort Peck) to a $0.09 million (Sioux City) decline in benefits relative to the CWCP. Most of the river reaches have no change in recreation benefits relative to the CWCP.

The BIOP alternative includes a 17.5-kcfs rise in the spring, on average, once every 3 years. The BIOP alternative also includes a provision for low summer flows at 21 kcfs during July 15 to August 15 (the “25/21” summer flow option). During the periods June 21 to July 15 and August 15 to August 31, flow releases are set to 25 kcfs. This alternative also has the same drought conservation measures as the MRBA alternative. The BIOP alternative has an average annual recreation benefit of $86.60 million, which is $1.91 million (2.3 percent) higher than for the CWCP. Overall, benefits from the mainstem lakes are about 4.6 percent ($2.76 million) over the CWCP value; the greatest increase ($1.33 million) comes from Lake Sakakawea. Except for the Fort Peck ($0.04 million increase), Boonville (no change), and Hermann (no change) reaches, the river reaches have declines in recreation benefits under the BIOP alternative, as compared to the CWCP. The greatest decline occurs in the Sioux City reach, where average annual recreation benefits are $0.52 million (4.5 percent) lower than under the CWCP.

The FWS30 alternative is similar to the BIOP alternative except that the spring rise is 30 kcfs rather than 17.5 kcfs. The FWS30 alternative has total average annual recreation benefits of $87.67 million, which is about $2.98 million (3.5 percent) higher than the CWCP. Of the submitted alternatives, the FWS30 alternative has the largest increase in benefits ($4.04 million, or 6.7 percent) for the mainstem lakes relative to the CWCP. This increase is offset somewhat by decreases in benefits from the river reaches, however. The FWS30 alternative has the largest decrease in benefits for the Upper River reaches ($0.09 million, or 2.0 percent), and the second largest decrease for the Lower River reaches ($0.97 million, or 4.9 percent). Lake Sakakawea has the largest increase in average annual benefits ($2.07 million, or 15.0 percent), while the Sioux City reach has the largest reduction in benefits ($0.64 million, or 5.6 percent) relative to the CWCP.

The major differences among the alternatives for recreation benefits occur during periods of drought. Figures 5.11-2 to 5.11-4 provide a graphical depiction of recreation benefits over the 100-year analysis period. Recreation benefits are generally higher for the other five alternatives relative to those of the CWCP and MLDDA alternative during the three major droughts because the higher drought conservation measures result in higher levels in the upper three lakes. The greatest difference is noted during the 1930 to 1941 drought and subsequent recovery period from the lake level declines.

5.11.1 Recreation for Tribal Reservations

Tables 5.11-2 and 5.11-3 allow comparison of how the different alternatives influence average annual recreation benefits for the affected Tribal Reservations during the 100-year period of analysis. Different data are available depending on the location of the Reservations. Effects to Reservations along river reaches are presented as an index of average annual recreation benefits, relative to the CWCP (Table 5.11-2). Effects to Reservations on the lakes are presented as average annual recreation benefits, measured in millions of dollars (Table 5.11-3). Changes in recreation benefits are discussed for each Reservation, starting with Fort Peck Reservation in Montana and proceeding downstream.

Fort Peck Reservation, downstream of Fort Peck Dam, currently has one boat ramp. No recreation areas identified along the Missouri River serve the Reservation. With future economic development in mind, the data from Table 5.11-2 indicate that, for the 100-year period analysis, the ARNRC, BIOP, and FWS30 alternatives provide the maximum average annual recreation benefits to the Fort Peck Reservation. Compared to the CWCP, the BIOP alternative provides a 10.0 percent increase, the FWS30 a 9.0 percent increase, and the ARNRC an 8.0 percent increase. The MLDDA alternative provides no increase in average annual recreation benefits to the Fort Peck Reservation, while the MRBA and MODC alternatives provide slight increases of 1.0 and 2.0 percent, respectively.

Fort Berthold Reservation, which is located on Lake Sakakawea, has 15 recreation areas identified on Reservation land. These areas include two cabin developments, the McKenzie Marine Club and the New Town Marine Club. The CWCP provides $2.91 million in average annual recreation benefits. The data in Table 5.11-3 indicate that the FWS30 alternative provides the highest recreation benefits to Fort Berthold Reservation at $3.35 million, a 15.1 percent increase over the CWCP. The MRBA and ARNRC alternatives also provide increased recreation benefits, at 14.1 percent and 13.7 percent, respectively. The MODC and BIOP alternatives provide a middle range increase of recreation benefits to Fort Berthold Reservation, with a 10.7 percent and 10.0 percent increase, respectively. The MLDDA provides the lowest average annual recreation benefits, with a $0.06 million (2.1 percent) decrease in average annual recreation benefits compared to the CWCP.

Table 5.11-2. Index values of average annual recreation impacts to Reservations adjacent to Upper and Lower River reaches.

Reservation	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Upper River							
Fort Peck	1.00	1.00	1.08	1.01	1.02	1.10	1.09
Yankton/Ponca Tribal Lands	1.00	1.00	0.95	0.99	0.99	0.98	0.97
Lower River							
Winnebago	1.00	0.99	0.92	0.99	0.99	0.95	0.94
Omaha	1.00	0.99	0.92	0.99	0.99	0.95	0.94
Iowa and Sac and Fox	1.00	1.00	0.98	1.00	1.00	0.98	0.98

Table 5.11-3. Average annual recreation benefits for Reservations adjacent to lakes ($millions).

Reservation	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Fort Berthold	2.91	2.85	3.31	3.32	3.22	3.20	3.35
Standing Rock	0.42	0.43	0.46	0.45	0.45	0.44	0.46
Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower Brule	2.94	2.94	2.94	2.94	2.94	2.94	2.94
Crow Creek	1.41	1.41	1.41	1.41	1.41	1.41	1.41
Yankton	1.38	1.40	1.40	1.40	1.40	1.40	1.41
Santee	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Total	**9.23**	**9.20**	**9.69**	**9.69**	**9.59**	**9.56**	**9.74**

Four recreation sites have been identified on Standing Rock Reservation lands along Lake Oahe. The ARNRC and FWS30 alternatives provide the largest increase in recreation benefits over the CWCP, which has a $0.42 million annual benefit (Table 5.11-3). The ARNRC and FWS30 alternatives both provide $0.04 million (9.5 percent) increase over the CWCP. The MRBA and MODC alternatives both have an intermediate increase of $0.03 million (7.1 percent) in average annual recreation benefits compared to the CWCP.

The smallest increase occurs with the MLDDA alternative, with an increase of only $0.01 million (2.4 percent) in average annual recreation benefits.

One recreation site has been identified on Cheyenne River Reservation. The average annual recreation benefits under any of the alternatives for Cheyenne River Reservation are less than $5,000. Recreation benefits less than $0.01 million are not shown in Table 5.11-3 due to rounding off to the nearest $10,000.

Lower Brule and Crow Creek Reservations, which are located on Lake Sharpe, have no change in average annual recreation benefits under any alternative (Table 5.11-3). For the 100-year period of analysis, there are roughly $2.94 million in benefits for Lower Brule Reservation and $1.41 million in average annual recreation benefits for Crow Creek Reservation. Lower Brule Reservation has 10 existing recreation facilities identified on Reservation land, with one identified future site. There are seven existing recreation facilities located on Crow Creek Reservation.

Yankton Reservation has five recreation areas located on Lake Francis Case. The CWCP provides $1.38 million in average annual recreation benefits for Yankton Reservation (Table 5.11-2). The FWS30 alternative provides the largest increase in average annual recreation benefits compared to the CWCP, with an increase of $0.03 million (2.2 percent). The other alternatives increase average annual recreation benefits by about $0.02 million (1.4 percent) compared to the CWCP.

The data for the Fort Randall reach, which includes the majority of Yankton Reservation banks, indicate that all of the alternatives except the MLDDA alternative produce a decrease in average annual recreation benefits compared to the CWCP (Table 5.11-2). The MLDDA alternative has the same benefits as the CWCP. The ARNRC alternative has the largest decrease in impacts to recreation potential for the Reservation compared to the CWCP, with a 5.0 percent decrease in benefits. The smallest decrease in benefits comes from the MRBA and MODC alternatives, both of which produce a 1.0 percent decrease in average annual recreation benefits compared to the CWCP.

Ponca Tribal Lands are located near the headwaters of Lewis and Clark Lake, and the Tribe currently has no recreation facilities on the lake or along the upstream river reach. If the Tribe were to develop facilities along the river, it could expect to have effects similar to that described above for Yankton Reservation banks along the Fort Randall reach. Ponca Tribal Lands were, therefore, included in Table 5.11-2 with the Yankton Reservation.

Santee Reservation, located on the headwaters of the Lewis and Clark Lake, has two identified recreation areas. No change in average annual recreation benefits occurs under any alternative (Table 5.11-3). For the 100-year period of analysis, all alternatives result in roughly $0.17 million in average annual recreation benefits for Santee Reservation.

Potential recreation development and use along Winnebago Reservation or Omaha Reservation are included in Table 5.11-2. The CWCP offers the greatest benefits for recreation development. On both Reservations, the ARNRC alternative has the largest decrease in average annual recreation benefits with an 8.0 percent decrease compared to the CWCP. The MLDDA, MRBA, and MODC alternatives, with a 1.0 percent decrease in recreation benefits compared to the CWCP, have the smallest decrease. The BIOP and FWS30 alternatives provide intermediate decreases in recreation benefits, with decreases of 5.0 percent and 6.0 percent, respectively.

Along the St. Joseph reach, recreation development on either Iowa or Sac and Fox Reservations is affected by the Water Control Plans. The recreation benefits index from Table 5.11-2 indicates no change from the CWCP with the MLDDA, MRBA, and MODC alternatives. A decrease of 2.0 percent in average annual recreation benefits occurs with the ARNRC, BIOP, or FWS30 alternatives.

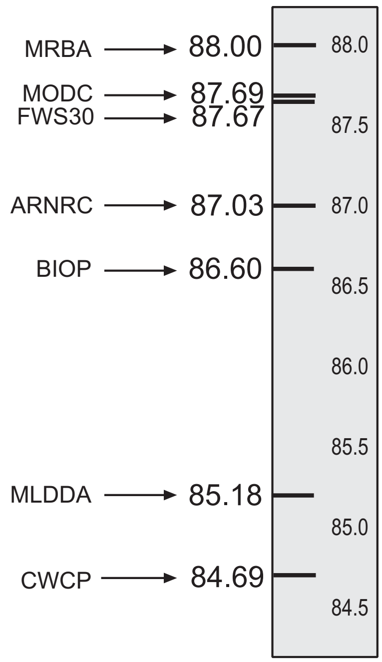

Figure 5.11-1. Average annual recreation benefits for submitted alternatives ($millions).

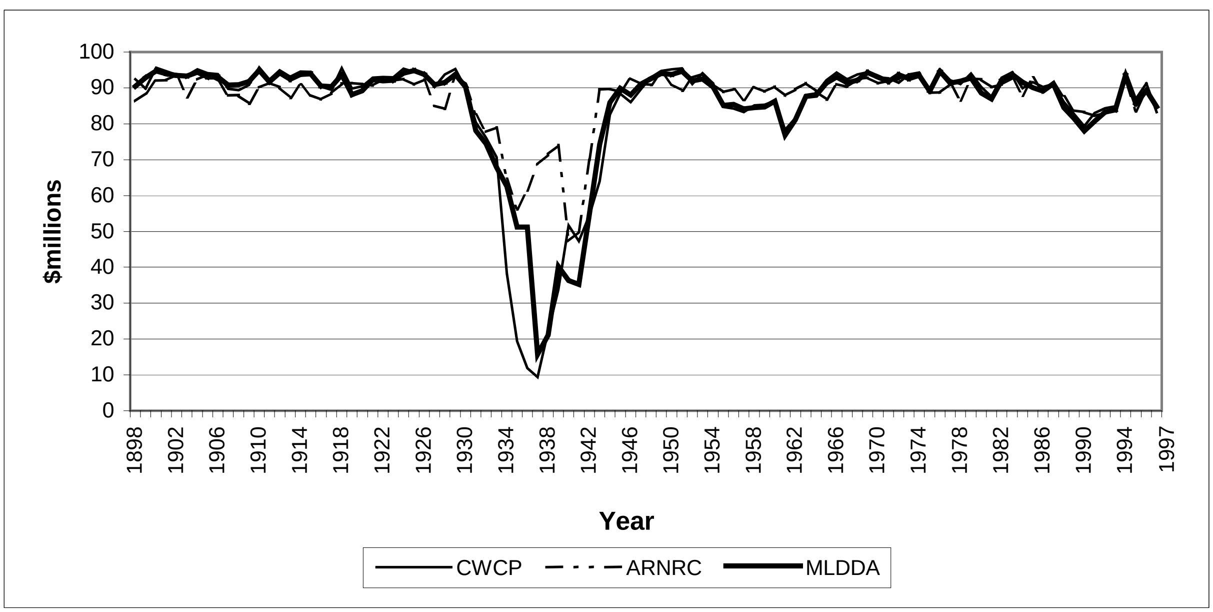

Figure 5.11-2. Annual recreation benefits for alternatives CWCP, ARNRC, and MLDDA.

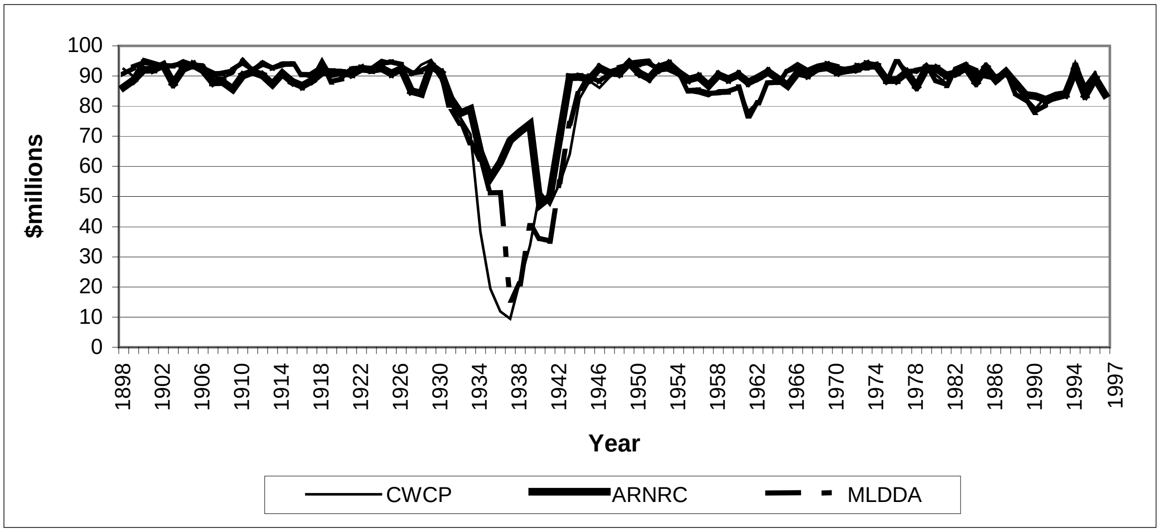

Figure 5.11-3. Annual recreation benefits for alternatives CWCP, MRBA, and MODC.

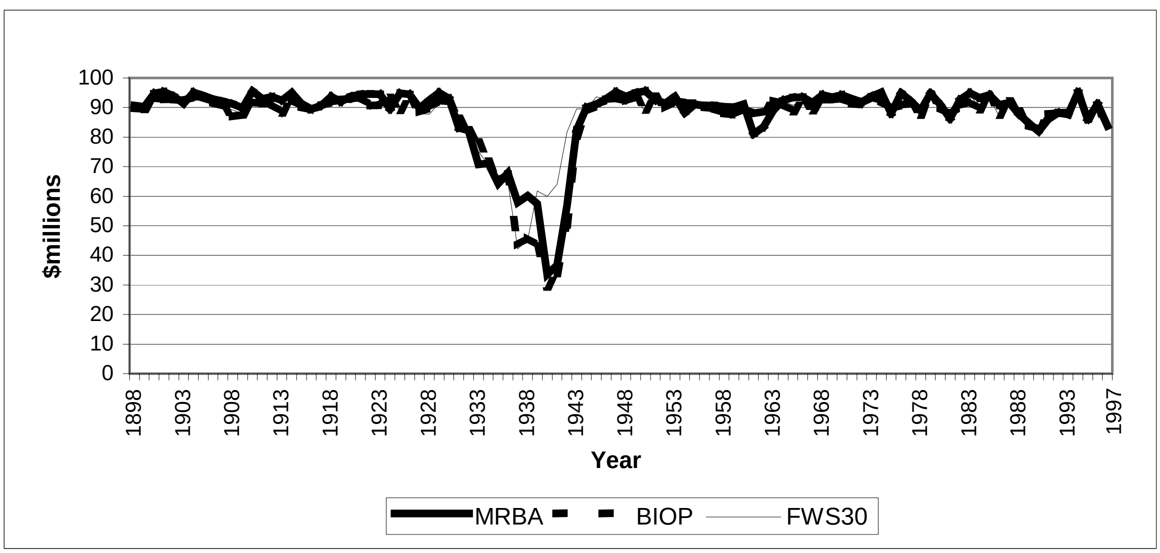

Figure 5.11-4. Annual recreation benefits for alternatives MRBA, BIOP, and FWS30.

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5.12 NAVIGATION

Navigation is served on the Lower River from Sioux City to St. Louis. Changes in several of the criteria making up the set of submitted alternatives affect navigation in differing ways. The drought conservation criteria change how navigation service would be affected during droughts in terms of level of service (flow support) and in minimum season lengths. The changes in Gavins Point releases for endangered species affect how navigation would be served in the non-drought periods. Three of the submitted alternatives would eliminate service to navigation for 2 months or longer in the June through August timeframe. This section of Chapter 5 describes the changes in navigation benefits that occur for these changes to the CWCP.

Navigation benefits are computed based on the cost reduction the navigation industry provides to the Nation. Alternative modes of transportation can move the commodities that the industry moves on the Missouri River; however, these other modes of transportation would move these commodities at a higher cost. The navigation benefits are computed by taking the difference in cost between the next highest costs and the costs of moving the various commodities by barge on the Missouri River from their various origins to the destinations for the commodities moved in 1999. The Tennessee Valley Authority developed these data for the Corps in 2002; therefore, the values in this section of Chapter 5 are different than those presented in Chapter 7. This analysis derived the value per ton of each commodity moved that year that was provided by the navigators on the Missouri River. The details of how these unit values were determined and the breakdown of the annual tonnage moved among the commodities are detailed in the Navigation Economics (Revised) technical report (Corps, 1998c). This technical report also discusses how the operation and maintenance costs were deducted from the cost savings benefits to arrive at the navigation benefits presented in this section of Chapter 5. This chapter describes the impacts of submitted alternatives compared to the CWCP.

The average annual navigation benefits for the Missouri River under the CWCP and the submitted alternatives are listed in Table 5.12-1 and displayed in Figure 5.12-1. Table 5.12-1 shows the total benefits for the system and the breakdown of those benefits by river reach. The CWCP total annual economic benefits outperform all of the submitted alternatives with an average annual benefit of $8.80 million. The bulk of the navigation benefits occur in the Kansas City reach, which extends from Kansas City to the mouth ($6.03 million).

Figure 5.12-1 also shows that the CWCP economically outperforms four of the submitted alternatives, and the average annual values cluster into two basic groupings. The highest benefits cluster includes the CWCP and the MODC, MRBA, and MLDDA alternatives with benefits ranging from a high of $8.19 million for the MLDDA alternative to $9.02 million for the MODC alternative. The next cluster includes the benefits for the three alternatives with summer releases from Gavins Point Dam that do not serve navigation during the summer. These are the BIOP, ARNRC, and FWS30 alternatives, and the benefits ranges from a high of $5.75 million to a low of $5.46 million, a difference of only $0.29 million. The submitted alternatives are discussed individually below.

Briefly summarized, the MLDDA alternative is based on the CWCP and primarily focuses on increasing flood control storage compared to the CWCP by increasing the amount of flood control

Table 5.12-1. Average annual navigation benefits ($millions).

Alternative	Total	Sioux City	Omaha	Nebraska City	Kansas City
CWCP	**8.80**	1.20	0.91	0.66	6.03
MLDDA	**8.19**	1.11	0.85	0.59	5.64
ARNRC	**5.64**	0.61	0.26	0.19	4.57
MRBA	**8.92**	1.31	0.81	0.76	6.04
MODC	**9.02**	1.32	0.83	0.81	6.06
BIOP	**5.75**	0.68	0.25	0.18	4.64
FWS30	**5.46**	0.69	0.22	0.14	4.41

storage in the system of dams. To accomplish this, the MLDDA alternative includes an additional 2 MAF of flood control storage (base of flood control at 55.1 instead of the 57.1 MAF level of CWCP).

The MLDDA alternative also has a higher non-navigation summer service level of 18 kcfs instead of the 9 kcfs of the CWCP, and this would increase the number of non-navigation years for the MLDDA alternative to 3 years instead of 1 year for the CWCP. The MLDDA benefits are slightly lower than those for the CWCP, with an average annual benefit of $8.19 million. The MLDDA changes in operation would reduce total annual benefits to navigation by 7.0 percent compared to the CWCP (Table 5.12-1). By reach, these reductions average from 6.5 to 9.7 percent, with the greatest loss occurring in the Nebraska City reach. The MLDDA average annual benefits place it in the cluster of submitted alternatives highest in benefits compared to the CWCP (Figure 5.12-1).

The ARNRC alternative recommends a series of flow adjustments that "…mimic the timing, magnitude, duration, and variability of the river's natural annual hydrograph…." The ARNRC alternative has a 15 kcfs spring rise over releases required to serve navigation in the May through June timeframe. This rise is followed by releases of 18 kcfs from Gavins Point Dam in the July and August period. The navigation benefits for the ARNRC alternative total $5.64 million per year. This value represents a 35.9 percent reduction in the navigation benefits under the ARNRC alternative.

The MRBA alternative includes higher drought conservation measures than the CWCP, but slightly less than the ARNRC alternative. The MRBA alternative would increase total annual benefits by only 1.4 percent compared to the CWCP with an average annual benefit of $8.19 million. By reach, these changes would range from a 15.9 percent increase in the Nebraska City reach to an 11.6 percent reduction in the Omaha reach.

The MODC alternative follows the MRBA alternative exactly except evacuations of water from the flood control zones of the system are delayed until mid-September to accommodate environmental needs of the endangered pallid sturgeon. The MODC alternative would increase total annual benefits by 2.5 percent compared to the CWCP with an average annual benefit of $9.02 million. By reach, these changes would range from a 23.4 percent increase in the Nebraska City reach to a 9.7 percent reduction in the Omaha reach.

The BIOP alternative is the one prescribed in the 1994 USFWS Biological Opinion. It has a Gavins Point Dam 17.5 kcfs spring rise followed by a 25/21 summer low flow. The 25 kcfs release extends from June 21 to July 15 and is followed by a 21 kcfs release from 16 July to 15 August. The Gavins release then goes back up to 25 kcfs until September 1 when the release goes back on navigation targets for the remainder of the navigation season. The BIOP alternative also has the same conservation measures as the MRBA alternative. The BIOP alternative has an average annual benefit of $5.75 million. By reach, the reductions would average from 23.1 to 72.8 percent.

The FWS30 alternative reflects characteristics similar to the BIOP alternative with the same release durations as the BIOP but reflecting a higher spring rise to 30 kcfs in comparison to the initial spring rise of 17.5 kcfs under BIOP. The FWS30 alternative has an average annual benefit of $5.46 million. By reach, these reductions would average from 26.9 to 79.0 percent compared to the CWCP.

Table 5.12-2 summarizes navigation service level and season length expressed in years for the CWCP and each of the six submitted alternatives. Operation of the Mainstem Reservoir System for navigation includes two checkpoints for determining navigation service level and season length: the March 15 check and the July 1 check. Navigation service levels can range from full service to minimum service, a difference of 6 kcfs and 1 foot of draft (9 versus 8 feet). In the 1930 to 1941 drought, there were years of no service. Under the CWCP, navigation season length can range from 5.5 to 8.33 months. The submitted alternatives provide differing season lengths.

Review of Table 5.12-2 indicates that the submitted alternatives provide changes in service level and season length that can be viewed as either positive changes or negative changes. The MLDDA alternative would provide similar service to the CWCP. This alternative would have 91 8-month or 8.33-month seasons; however, it would have 3 non-navigation years versus only 1 for the CWCP. All of the other alternatives would have 5 non-navigation years, all in the 1930 to 1941 drought. The ARNRC, BIOP, and FWS30 alternatives

Table 5.12-2. Summary of navigation service level and season length data (years).

		CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Service Level								
March Check	Full	56	53	60	63	63	67	68
	Partial	24	26	22	25	26	20	17
	Minimum	19	18	13	7	6	8	10
	No Service	1	3	5	5	5	5	5
July Check	Full	59	54	64	60	63	64	66
	Partial	16	22	12	27	25	22	18
	Minimum	24	21	19	8	7	9	11
	No Service	1	3	5	5	5	5	5
Season Length								
	5.5 to < 6 Months	5	3	95	0	0	95	95
	6.0 to < 6.5 Months	2	0	0	0	0	0	0
	6.5 to < 7.0 Months	1	1	0	0	0	0	0
	7.0 to < 7.5 Months	0	1	0	35	32	0	0
	7.5 to < 8 Months	0	1	0	0	0	0	0
	8 Months	45	53	0	10	14	0	0
	8.33 Months	46	38	0	50	49	0	0

would have season lengths that can never be considered to be 8 months long. The low summer flows under all three alternatives would be too low to provide even minimum navigation service in most years. Because of the unpredictability of having adequate water to navigate, these alternatives would not take advantage of high runoff years that may provide adequate flows on the Lower River to navigate from April 1 through December 15, an 8.33-month season. The ARNRC alternative navigation season can end as early as October 1 because its season length in extended droughts would decrease gradually as the drought progresses. The other two alternatives, however, are based on two storage levels, one for each of the two checkpoint dates. This type of reduction is referred to as having a navigation trigger storage level for each checkpoint.

The BIOP and FWS30 alternatives would have navigation seasons that end no earlier than November 25 at the mouth. The trade-off is that there is generally no navigation service from about June 29 (June 18 at Sioux City) through September 14 at the mouth. The low flow would end on September 1, and it takes about 3 days to increase the releases from Gavins Point Dam enough to have full service water in the river plus another 11 days for that water to get to the mouth of the river. This means that the navigation season lengths are generally about 5.5 months long, whether in droughts or normal runoff periods.

Finally, the MRBA and MODC alternatives would have season lengths that range from 7.1 months long in multi-year droughts to 8.33 months in the higher runoff years. From a service level standpoint, the MRBA and MODC alternatives would also have the benefit of going to minimum service in the fewest number of years. They would only go to minimum service in extremely low runoff years when system storage does not experience a gain between the two checkpoints. The drawback is that these two alternatives would have fewer 8- or 8.33-month seasons than the CWCP, 60 and 63 years, respectively, versus the 91 years for the CWCP.

Annual benefits for the 100-year history of the river for the CWCP and the submitted alternatives are shown in Figures 5.12-2 to 5.12-4. The MLDDA alternative's annual values closely track the CWCP with decreased benefits seen primarily during the 1930 to 1941 drought when 3 non-navigation years occurred, compared to 1 non-navigation year for the CWCP. The ARNRC alternative values on this figure mimic the patterns seen in the CWCP and the MLDDA alternative values, except that they occur at lower annual values in the non-drought periods. This alternative has slightly higher values than the other two alternatives in the drought periods because of higher conservation during droughts.

Figure 5.12-3 shows the annual values for navigation under the CWCP, MRBA, and MODC alternatives. The greatest differences between the MRBA and MODC alternatives compared to the CWCP occur during droughts, whether for a short duration or the longer duration of the three major droughts because of their higher drought conservation measures. Both the MRBA and the MODC alternatives would incur 5 non-navigation years compared to 1 non-navigation year for the CWCP during the 1930 to 1941 drought.

Figure 5.12-4 shows the annual values for navigation under the MRBA, BIOP, and FWS30 alternatives. As discussed above, the MRBA alternative includes additional conservation benefits compared to the CWCP and is the base plan to which the Gavins Point Dam releases in the BIOP and FWS30 alternatives were added. All three alternatives respond similarly in the 1930 to 1941 drought. The BIOP and FWS30 alternatives have lower annual values in the non-drought periods because of the inability to navigate and during the summer low-flow period.

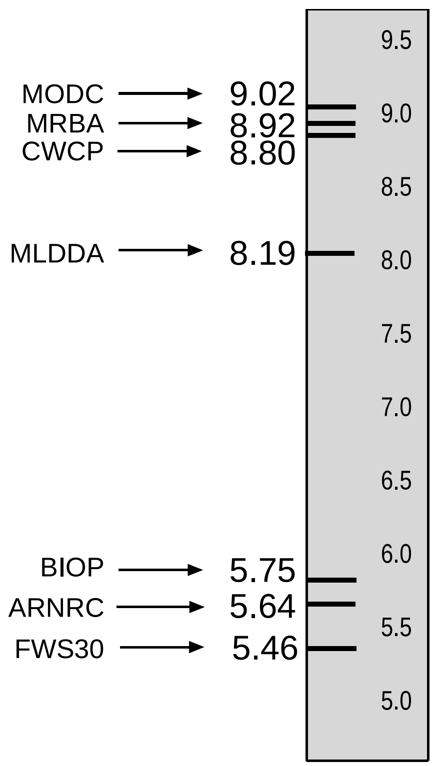

Figure 5.12-1. Average annual navigation benefits for the submitted alternatives ($millions).

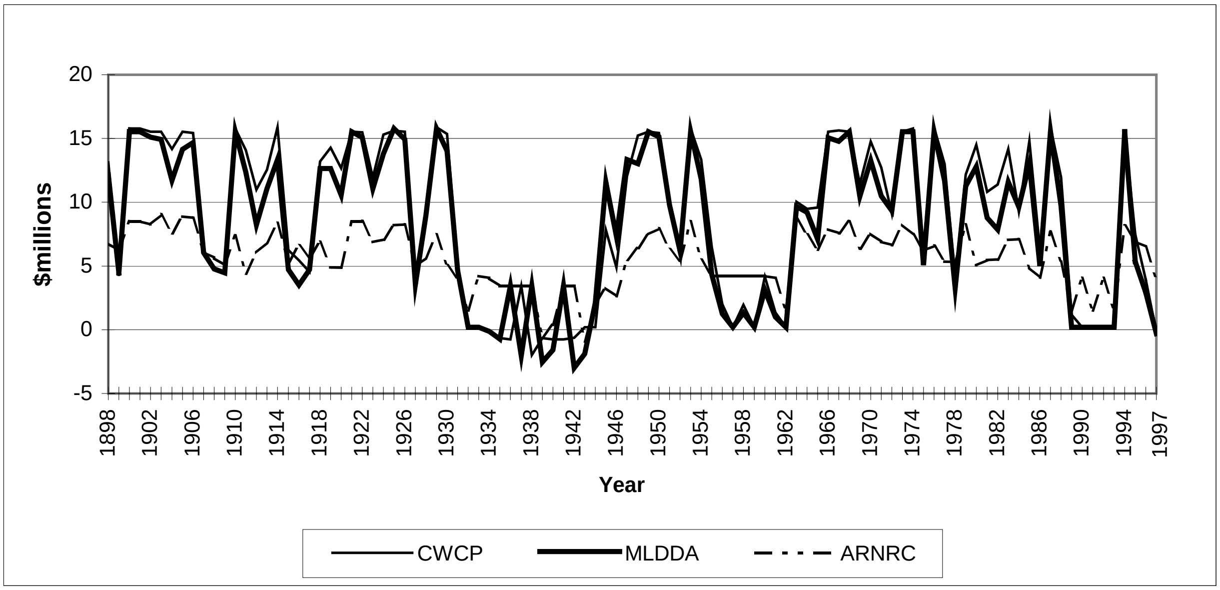

Figure 5.12-2. Annual navigation benefits for alternatives CWCP, MLDDA, and ARNRC.

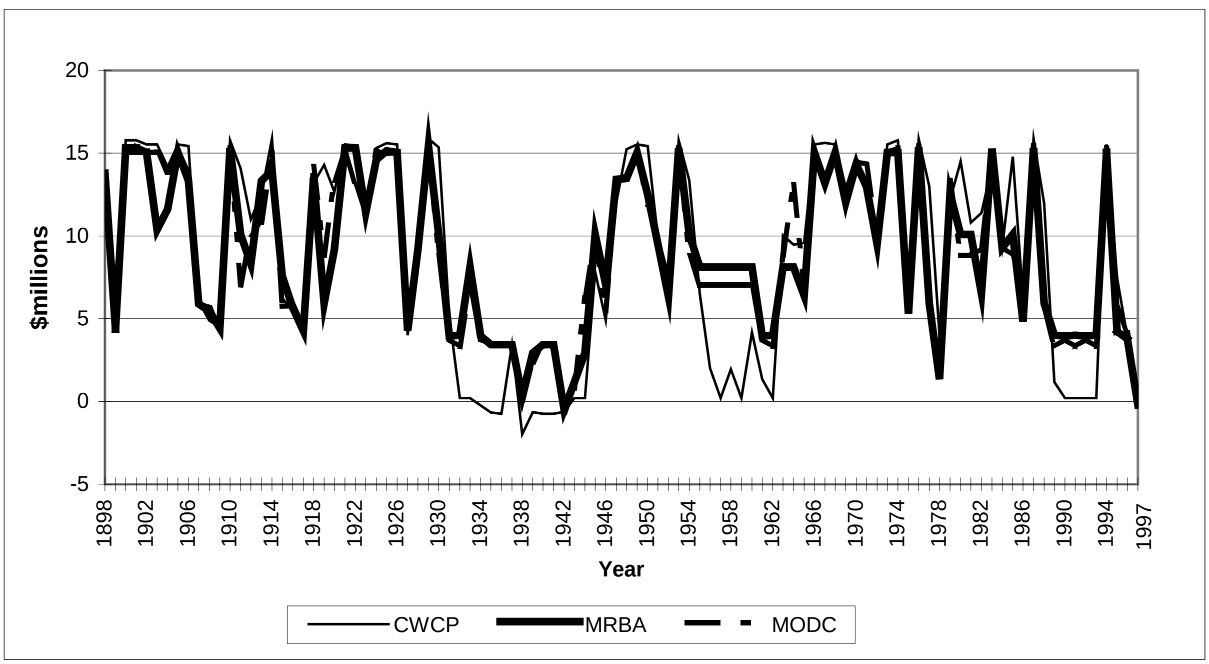

Figure 5.12-3. Annual navigation benefits for alternatives CWCP, MRBA, and MODC.

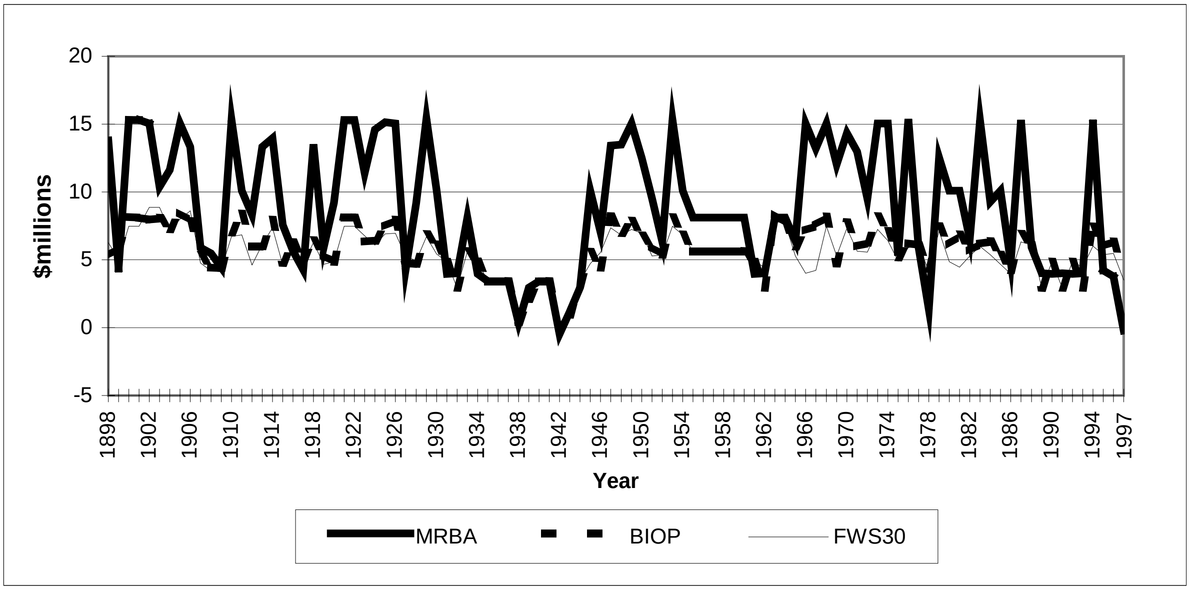

Figure 5.12-4. Annual navigation benefits for Alternatives MRBA, BIOP, and FWS30.

5.13 TOTAL NATIONAL ECONOMIC DEVELOPMENT ECONOMICS

Total average annual Missouri River National Economic Development (NED) benefits are the summation of economic benefits for flood control, recreation, water supply, navigation, and hydropower. A change in the water control plan has positive or negative effects on the individual uses in response to the various changes incorporated in the alternative plans. Detailed technical analyses and discussion of these topics are contained in individual technical reports supplemented by discussions in sections of this document describing impacts to the individual uses. The following summarizes the comparison of total NED benefits for the CWCP and the submitted alternatives.

Table 5.13-1 and Figure 5.13-1 provide total average annual NED benefits for the 100-year period. The table also provides the average annual NED value for each major economic use. Although the emphasis is on change in economic performance of each use, it is useful to note that of the total NED benefits, the largest portion of the benefits is provided by hydropower, followed by water supply, flood control, recreation, and navigation. Tribal benefits are discussed under each of the economic resources and are not accumulated here because Tribal benefits cannot be directly added for all the economic uses.

The CWCP maximizes none of the benefits among the alternatives. Total average annual NED benefits for the CWCP are estimated at $1,781.9 million.

The MLDDA alternative, which sets aside more of the system storage for flood control, maximizes flood control and water supply benefits but provides 0.1 percent fewer average annual total benefits than the CWCP. Compared to the CWCP, the MLDDA alternative increases recreation, flood control, and water supply benefits but provides fewer navigation and hydropower benefits.

The ARNRC alternative, which has greater drought conservation and modified releases and unbalancing of system storage for fish and wildlife, includes a summer low release from Gavins Point Dam that will interrupt navigation. Based on input from the Tennessee Valley Authority, the Corps assumed that navigation can continue during the spring and fall, and the ARNRC alternative provides 0.4 percent fewer average annual total benefits than the CWCP. Benefits are reduced for navigation, flood control, and water supply but are greater for recreation and hydropower due to higher average pool levels.

The MRBA alternative, which increases drought conservation but not as much as the ARNRC alternative, maximizes recreation benefits among the submitted alternatives and provides 0.3 percent greater total average annual benefits than the CWCP. Benefits are greater than the CWCP for navigation, recreation, water supply, and hydropower, and are lower for flood control.

The MODC alternative, which increases drought conservation in the same manner as the MRBA alternative and delays evacuation until mid-September, produces similar economic outputs as the MRBA alternative as might be expected due to their very similar water control features. The primary difference from the MRBA alternative

Table 5.13-1. Average annual total NED benefits by resource ($millions).

	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Navigation	8.8	8.2	5.6	8.9	9.0	5.8	5.5
Recreation	84.7	85.2	87.1	88.0	87.7	86.6	87.7
Flood Control	410.3	410.5	406.7	407.8	407.3	407.2	406.7
Water Supply	610.1	611.4	600.8	610.4	610.1	608.6	608.4
Hydropower	668.0	664.4	675.0	672.6	674.5	679.1	679.2
Total NED	**1,781.9**	**1,779.6**	**1,775.2**	**1,787.8**	**1,788.6**	**1,787.2**	**1,787.4**

is a $1.9 million average annual increase in hydropower benefits. Total average annual NED benefits are 0.4 percent greater than the CWCP.

The BIOP and FWS30 alternatives have the same drought conservation measures as the MRBA alternative but also include modified releases and unbalanced system storage for fish and wildlife. Both alternatives produce 0.3 percent greater total average annual NED benefits than the CWCP. Hydropower benefits are also maximized with these submitted alternatives.

The FWS30 alternative with a higher spring rise provides slightly greater total, hydropower, and recreation benefits than the BIOP, but lower benefits for navigation, flood control, water supply.

Table 5.13-2 compares the average annual total NED benefits for the CWCP and the submitted alternatives during various time periods of the 100-year period of analysis assuming relatively normal navigation can continue during the spring and fall months for the split season alternatives. These data provide insight into the total economic benefits of the alternatives over the full 100-year period, each major drought period, and each period not under the influence of a major drought. In general, total economic NED benefits are lower during drought periods and higher during non-drought periods. Alternatives that have higher benefits during drought periods are not the same alternatives that have highest benefits during the non-drought periods. During drought periods, the FWS30 alternative provides the greatest benefits followed by the BIOP and MODC alternatives. Overall, for all drought periods and during the 1930 to 1941 drought and subsequent 9-year recovery period, the FWS30 alternative has the highest benefits. In contrast, during the two more recent and shorter extended droughts, the BIOP alternative provides slightly greater benefits than the FWS30 alternative. All the submitted alternatives provide greater combined benefits than the CWCP during the three droughts.

The CWCP provides greater combined average annual benefits during the four non-drought periods than any of the submitted alternatives. The ARNRC alternative provides the least total average annual benefit during non-drought periods of the submitted alternatives.

Table 5.13-2. Average annual total NED benefits for alternatives ($millions).

	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
1898-1929 Non-drought	1,749	1,742	1,731	1,745	1,745	1,741	1,739
1930-1950 Drought	1,663	1,672	1,692	1,698	1,703	1,693	1,705
1951-1953 Non-drought	2,831	2,825	2,806	2,829	2,838	2,829	2,821
1954-1965 Drought	1,673	1,668	1,680	1,681	1,678	1,690	1,688
1966-1987 Non-drought	1,919	1,914	1,897	1,916	1,916	1,912	1,906
1988-1993 Drought	1,434	1,428	1,445	1,437	1,439	1,453	1,452
1994-1997 Non-drought	1,978	1,979	1,904	1,963	1,955	1,973	1,980
Total Non-drought	1,878	1,873	1,855	1,874	1,874	1,872	**1,946**
Total Drought	1,631	1,634	1,651	1,652	1,655	1,655	**1,732**
Total Period	1,782	1,780	1,775	1,788	1,789	1,787	**1,863**
Difference from CWCP	–	(2)	(7)	6	7	5	9

Differences in average annual total NED benefits from CWCP ($millions)

	CWCP	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
1898-1929 Non-drought	–	(6)	(18)	(4)	(4)	(7)	(6)
1930-1950 Drought	–	9	29	34	40	30	47
1951-1953 Non-drought	–	(5)	(25)	(2)	7	(2)	(8)
1954-1965 Drought	–	(4)	7	8	6	17	17
1966-1987 Non-drought	–	(5)	(22)	(3)	(3)	(7)	(9)
1988-1993 Drought	–	(6)	11	3	4	18	18
1994-1997 Non-drought	–	1	(75)	(15)	(24)	(6)	1
Total Non-drought	–	(6)	(24)	(4)	(4)	(7)	**(6)**
Total Drought	–	3	20	22	24	24	**34**
Total Period	–	(2)	(7)	6	7	5	**9**

Figure 5.13-2 shows average annual total NED benefits for each of the alternatives over the 100-year period. Split season alternatives are presented both assuming navigation continues and assuming it is extinguished.

Very little difference in economic performance of the alternatives can be discerned from the figure for any of the years. Years with benefit spikes generally correspond to years with greater flood control benefits (Figure 5.13-3).

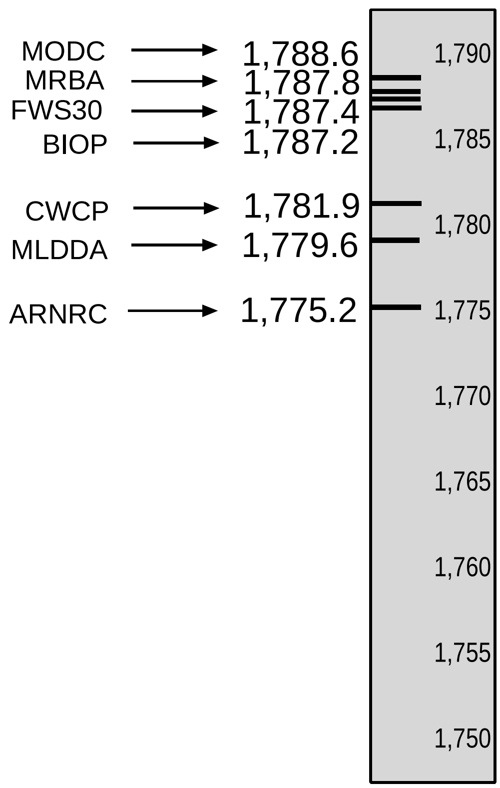

Figure 5.13-1. Average annual total NED benefits for submitted alternatives ($millions).

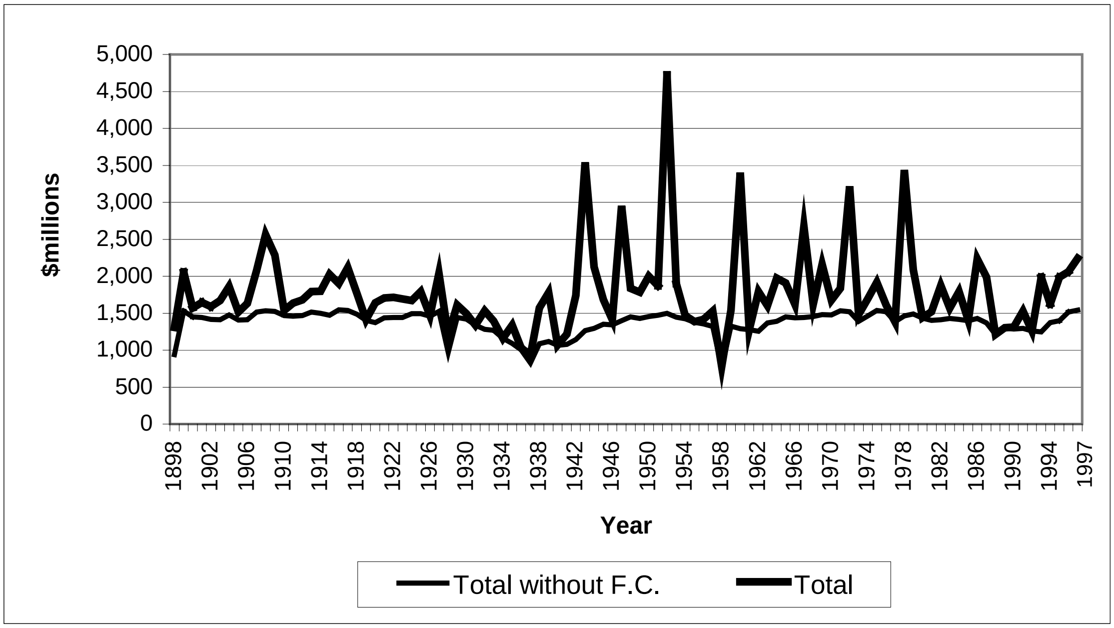

Figure 5.13-2. Average annual total NED benefits for submitted alternatives.

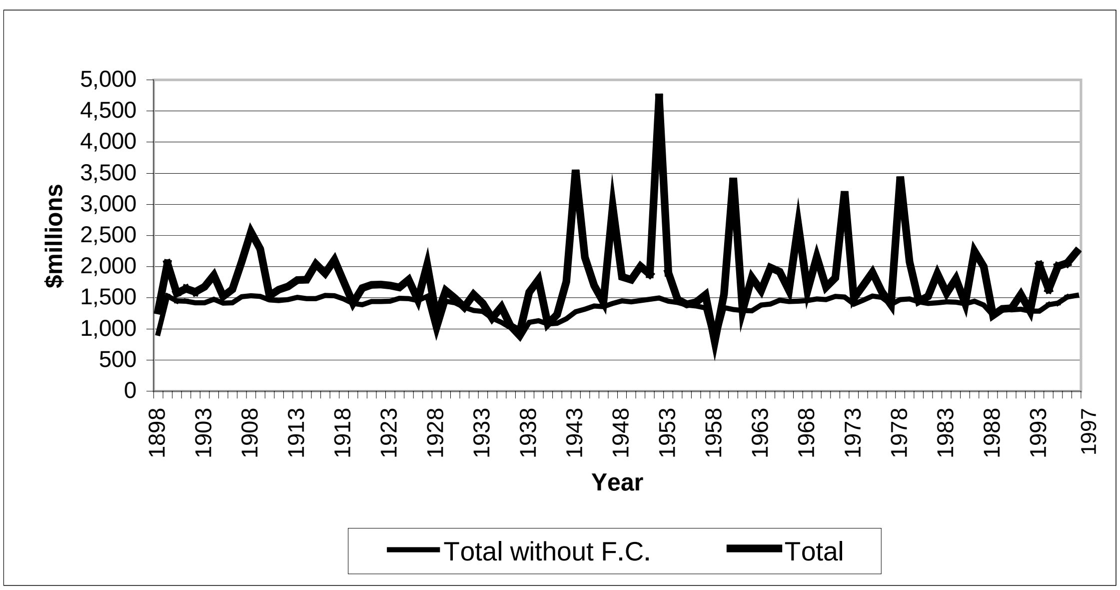

Figure 5.13-3. Average annual total NED benefits for CWCP: total and total without flood control.

5.14 HISTORIC PROPERTIES

Historic properties, as defined by the National Historic Preservation Act, include historic and prehistoric archaeological sites, historic architectural and engineering features and structures, and resources of significance to American Indians and other social or cultural groups. Historic properties located within the lakes and immediately adjacent zones are subject to the effects of impounded water, as described in the Historic Properties technical report (Corps, 1994q). Nearly all water-related effects on historic properties are a direct or indirect function of lake level, which determines if a given site is inundated or subject to shoreline erosion.

The long-term potential for erosion at each known site was evaluated based on the monthly water level in each of the three upstream lakes and Lake Sharpe. The index values derived for comparative purposes are inversely related to the number of months the known sites are potentially subject to shoreline erosion forces. The assumption for potential erosive action was that the site had to be within 3 feet above and 5 feet below the water surface of the lake to be affected by the erosive forces. The historic properties index values presented and discussed in this section are, therefore, like other values computed for other resources and economic uses: the higher the value, the less adverse the effect on *known* historic properties on the upper four lakes.

It should be kept in mind that when shoreline erosion forces are diverted to lower elevations in a lake, areas that may not have been intensively surveyed for historic properties prior to lake filling are affected. Undiscovered sites within the lake have already been damaged to some extent by inundation; however, inundated sites are somewhat protected from the adverse effects of shoreline erosion and looting. Lake levels during periods of drought decline further under the CWCP than the other alternatives and thereby protect known sites from shoreline erosion. Alternatives that limit the drawdown of the upper three lakes with additional drought conservation will limit the erosive impact on the *unknown* sites. This is, no doubt, a benefit; however, because only the effect to known historic sites is considered in the historic properties index, these alternatives have a lower historic properties index than the CWCP. Overall, it is difficult to say which alternative is the best plan to follow for the total set of historic properties within the Mainstem Reservoir System.

Water elevations in the two remaining downstream lakes vary little among the alternatives, and no significant change from current conditions is anticipated. Although there are a significant number of historic properties on Lake Sharpe, the adverse effects on historic properties do not vary among the alternatives because of the relatively stable water elevations. Data concerning historic properties along open river reaches are inadequate for general analysis, but unlikely to measurably influence the index values established for the upstream lakes.

Table 5.14-1 presents the average annual total index values for the three upstream lakes and Lake Sharpe. It also includes the average annual values for each of these lakes. The average annual total

Table 5.14-1. Average annual historic property values for the upper three mainstem lakes and Lake Sharpe (relative index).

	1898 to 1997				
Alternative	**Total**	**Fort Peck Lake**	**Lake Sakakawea**	**Lake Oahe**	**Lake Sharpe**
CWCP	**5,015**	143	2,658	2,011	204
MLDDA	**5,183**	151	2,777	2,051	204
ARNRC	**4,637**	153	2,366	1,914	204
MRBA	**4,877**	139	2,563	1,972	204
MODC	**4,858**	146	2,546	1,962	204
BIOP	**4,792**	152	2,499	1,937	204
FWS30	**4,795**	152	2,508	1,932	204

index value for the CWCP is 5,015. This total is distributed among Fort Peck Lake (2.8 percent), Lake Sakakawea (53.0 percent), Lake Oahe (40.1 percent), and Lake Sharpe (4.1 percent). Figure 5.14-1 shows that the alternatives are grouped between 4,637 and 5,183, a difference of 546 units.

Figure 5.14-1 also shows that the alternatives fall into four clusters. The MLDDA alternative has the highest value, which is 168 units greater than the CWCP value. The next cluster of alternatives are the MRBA, MODC, FWS30, and BIOP alternatives, which have values ranging from 138 to 223 units lower than the CWCP. Finally, the ARNRC alternative has the lowest historic properties index value at 155 units lower than the BIOP alternative, the alternative with the lowest index value of the cluster of alternatives above it in value.

The primary difference between the CWCP and MLDDA alternatives is that the MLDDA alternative decreases the base flood control by 2 MAF. This change results in higher index values for historic properties in the upper three lakes than the CWCP. The ARNRC alternative, with its unbalanced intrasystem regulation, increased conservation during droughts, and a split navigation season, results in a higher historic properties index for Fort Peck Lake and lower index values for Lake Sakakawea and Lake Oahe than the CWCP. The MLDDA alternative results in an overall 3.3 percent increase in the index value for historic properties while the ARNRC alternative results in a 7.5 percent decrease in the index value. This is primarily due to the respective change in index values for Lake Sakakawea and Lake Oahe, which have the most identified sites.

An unbalanced intrasystem regulation and an increase in conservation in the upper three lakes, as with the MRBA alternative, results in an overall decrease in the historic property index compared to the CWCP. Lake Sakakawea experiences the greatest decrease (95 units, or 3.6 percent) while Fort Peck Lake experiences the least (4 units, or 2.8 percent). While the CWCP and MRBA alternatives maintain a flat release from Gavins Point Dam during the summer, the MODC alternative extends lower flows on the Lower River into September of many years. This results in an increase in the historic property index for Fort Peck Lake (2.1 percent) and a decrease in the historic property index for Lake Sakakawea and Lake Oahe (4.2 and 2.4 percent, respectively).

The BIOP and FWS30 alternatives would have a similar effect on historic properties in the upper three lakes: there would be higher index values for Fort Peck Lake and lower index values for the two remaining lakes. When compared to the CWCP, both of these alternatives result in the greatest impact on Lake Sakakawea, where there would be a 6.0 and 5.6 percent decrease in the historic properties index values, respectively. The flow modification on the Lower River to create a spring rise and summer low flow appears to be a factor as these two alternatives have a lower total value than the MRBA and MODC alternatives, which have the same level of conservation of water in the lakes during droughts.

The annual values for total historic properties for the alternatives are shown on Figures 5.14-2 through 5.14-4. Generally, all of the alternatives lie within the 3,500- and 5,000-unit range early in the analysis and then, between 1928 and 1933, there is a steady increase to about 7,500 units, resulting in an overall decrease in adverse erosion impacts on historic properties. All of the alternatives plateau at this level for about 10 years before a decreasing trend back to about 3,500 units. The alternatives fluctuate between 3,500 and 7,000 units until about 1988, when there is a general increase to about 7,000 units. The highest values generally occur during the two major droughts, the 1954 to 1961 and the 1987 to 1993 drought. The increased index values during the three periods occur because these are drought periods and the lakes are lowered below many of the known sites.

Five Tribal Reservations are located along the uppermost lakes of the Mainstem Reservoir System, where water level fluctuations may result in impacts to historic properties. Table 5.14-1 allows comparison of how the different alternatives influence historic properties index values for the affected Reservations during the 100-year period of analysis. Changes in historic properties index values are discussed for each Reservation, starting with the Fort Berthold Reservation in North Dakota and proceeding downstream. Further, the analysis does not attempt to address impacts to unknown sites and/or inundated sites.

It should be noted that impacts to Reservations may not necessarily coincide with impacts to the associated Tribes. Historically, the various Tribes used lands in many different locations, not limited by the extent of their current Reservations. Thus, historic sites within the bounds of a particular Reservation may be important to Tribes on other Reservations.

On Fort Berthold Reservation, the least impact to historic properties occurs under the MLDDA alternative, which has the highest historic property index values at Lake Sakakawea (Table 5.14-1). Compared to the CWCP, the MLDDA alternative results in a 4.5 percent increase in the index value at Lake Sakakawea. The other five alternatives all have lower index values, ranging from 3.6 percent (MRBA) to 11.0 percent (ARNRC) below the CWCP.

Standing Rock and Cheyenne River Reservations, located on Lake Oahe, face the lowest risk to historic properties under the MLDDA alternative (Table 5.14-1). The CWCP, at 2,011, has the second-highest historic property index value of all the submitted alternatives. Values under the remaining five alternatives range from 1.9 percent (MRBA) to 4.8 percent (ARNRC) below those of the CWCP

Lower Brule and Crow Creek Reservations, which are located on Lake Sharpe, show no change in the historic properties index under any of the submitted alternatives (Table 5.14-1). This is likely because none of the submitted alternatives has a significant effect on water level fluctuations in Lake Sharpe, compared to the CWCP.

Fort Berthold Reservation is located on Lake Sakakawea. The CWCP has an historic property index of 2,658 at Lake Sakakawea, the highest of the alternatives considered in detail. The MCP results in a decrease of 3.8 percent from this value, while the GP options result in even greater drops. The greatest decrease from the CWCP (and thus the greatest increase in risk to historic properties) occurs under the GP2028 option (8.5 percent), while the smallest decrease among the GP options occurs under GP1521 (7.6 percent).

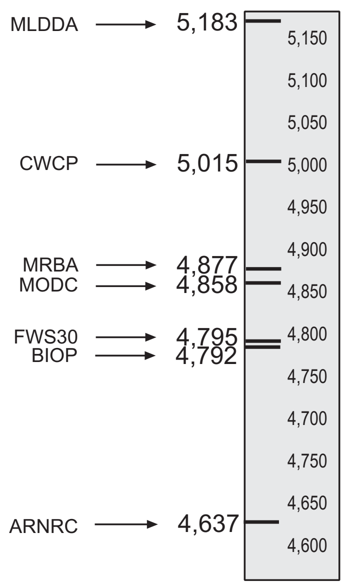

Figure 5.14-1. Average annual historic properties values for Fort Peck Lake, Lake Sakakawea, Lake Oahe, and Lake Sharpe for the submitted alternatives.

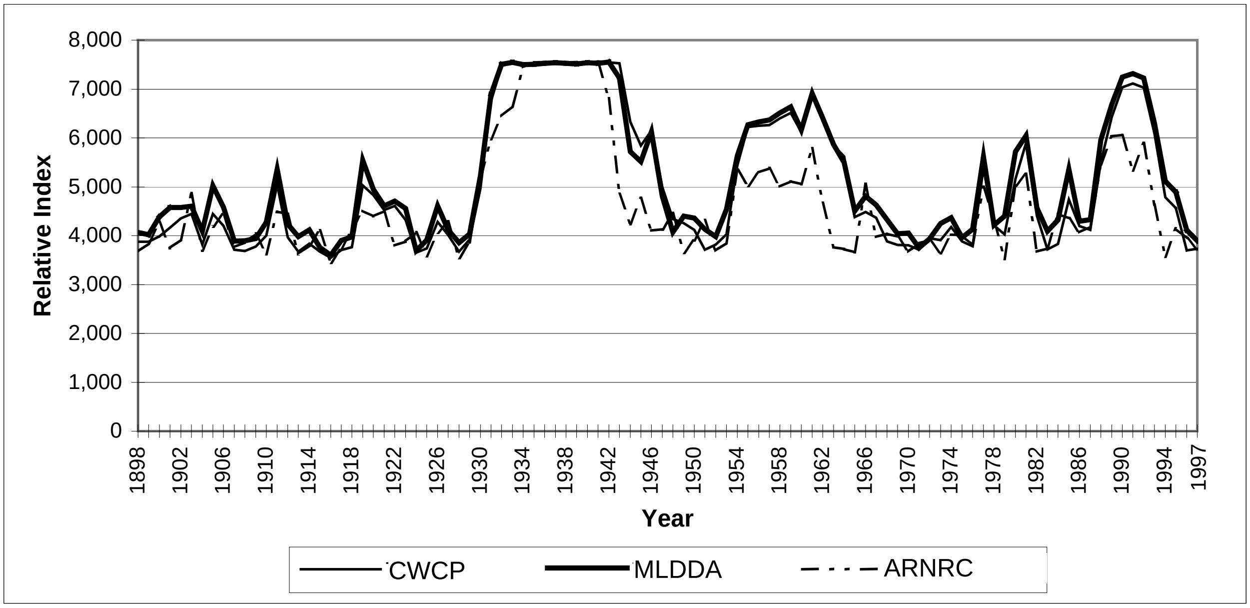

Figure 5.14-2. Annual values for historic properties for alternatives CWCP, MLDDA, and ARNRC.

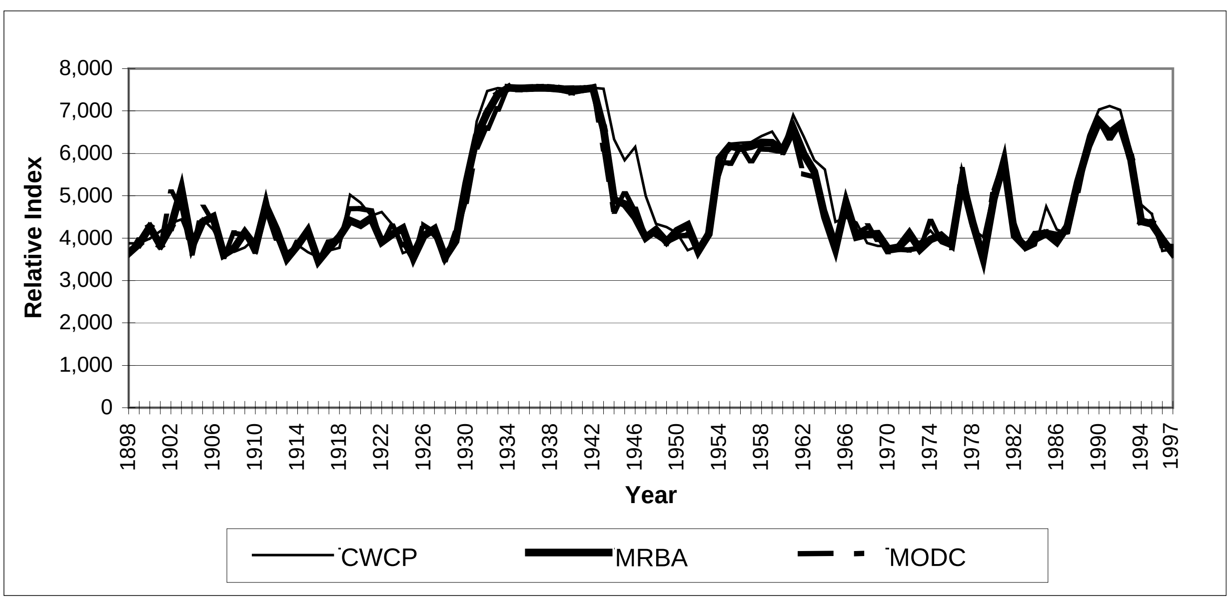

Figure 5.14-3. Annual values for historic properties for alternatives CWCP, MRBA, and MODC.

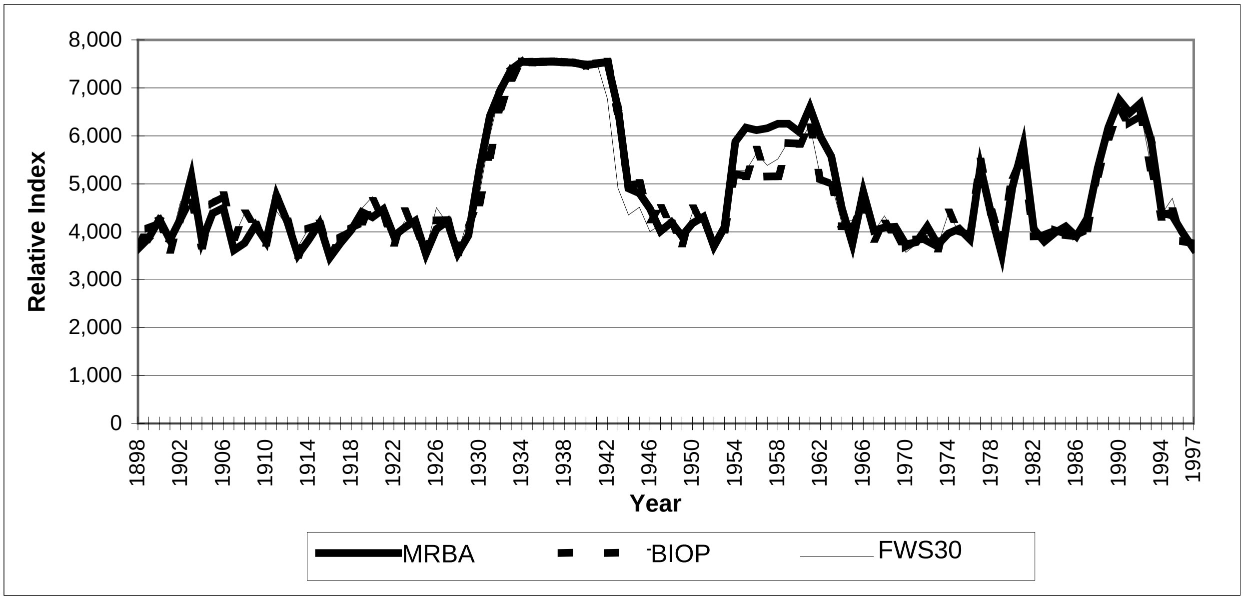

Figure 5.14-4. Annual values for historic properties for alternatives MRBA, BIOP, and FWS30.

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5.15 MISSISSIPPI RIVER IMPACTS

The changes in the operating criteria making up each of the alternatives presented in this chapter provide different release patterns from Gavins Point Dam. Some of these differences are more pronounced than others. In some cases, they are dramatic enough to show up on the annual hydrograph for Hermann, Missouri, which is the last location modeled on the Missouri River. These flows join those from the Upper Mississippi River to make up the flow that passes St. Louis, Missouri. Because of these differences and the concerns regarding impacts on the Mississippi River, an analysis was conducted of potential impacts to the Mississippi River, including impacts to the endangered pallid sturgeon. Prior studies and analyses of annual hydrographs indicated that continued evaluations of Mississippi River water intakes, saltwater intrusion, and flood damage were not warranted. Impacts on these resource categories were determined to be indistinguishable. For the submitted alternatives addressed in this chapter, Mississippi River resource evaluations were conducted for hydraulics and hydrology, navigation, and channel improvement features. Details on methods employed in these studies and previous evaluations are included in the Mississippi River Studies technical report (Corps, 1998l).

5.15.1 Hydraulic Impacts to the Mississippi River

The availability of daily flow data on the Missouri River allowed the use of a more sophisticated UNET unsteady flow routing method to determine the Mississippi River stages and flows as compared to a more crude method used for the DEIS, in which only monthly Missouri River flows were available. The existing UNET code was modified to allow a controlled diversion of the Mississippi River flow into the Atchafalaya River through the Old River Complex, and the existing UNET models of the Mississippi and Atchafalaya Rivers were adapted to the needs of the Study. Simulations were completed using the flows at Hermann, Missouri, for the alternatives as the only changeable variable. The periods of the simulation were 1930 through 1995 for the Middle Mississippi River and 1935 through 1995 for the Lower Mississippi/Atchafalaya River system. Results from these simulations were used to conduct the impact analyses for the other categories listed above.

This portion of the EIS discusses the results of the hydraulic analyses performed to determine the impact of the Missouri River Mainstem Reservoir System operating alternatives on the stages and flows on the Mississippi River. Discussions are limited to the CWCP and the MLDDA, ARNRC, MRBA, MODC, BIOP, and FWS30 alternatives. The discussion is also limited to the gaging stations at St. Louis, Missouri, and Cairo, Illinois, which were used to evaluate the economic impact to Mississippi River navigation. A brief discussion of the Missouri River flow at Hermann is also included.

Hermann, Missouri

The only variable that differentiated the numerical model runs on the Mississippi River for each alternative was the flow at Hermann. The differences in flow patterns at Hermann that occur among the alternatives should, therefore, be reflected at downstream gaging stations along the Mississippi River. Figure 5.15-1 shows the average monthly flow on the Missouri River at Hermann for the CWCP and the submitted alternatives. The alternatives that do not have a Gavins Point Dam spring rise (MLDDA, MRBA, and MODC) mimic the CWCP between January and September. Differences begin to emerge in the fall months, with the MLDDA alternative having slightly higher flows and the MODC and MRBA alternatives having higher flows in October and lower flows in November. The spring rise alternatives (ARNRC, BIOP, and FWS30) begin to diverge from the CWCP in late spring. Higher flows at Hermann occur with these alternatives in April, May, and June, followed by sharply lower flows in July and August during the period of low summer releases from Gavins Point Dam. The fall months are once again higher than the CWCP as the remainder of the flood storage is evacuated. Mean monthly stages at Mississippi River gaging stations for the submitted alternatives should reveal similar patterns of increase or decrease in mean monthly stages when compared to the CWCP.

St. Louis, Missouri

Figure 5.15-2 shows the computed mean stage for each month at St. Louis for the CWCP and the alternatives. The pattern of flow change seen at Hermann is replicated here, as expected, with minor changes in the fall months with the MLDDA, MRBA, and MODC alternatives and more significant changes, particularly in July and August, with the ARNRC, BIOP, and FWS30 alternatives.

Figures 5.15-1 and 5.15-2 provide a glimpse of how the alternatives compare to the CWCP and with each other, but the impact of the alternatives to flooding, which begins at 30 feet on the St. Louis gage, and to navigation, which begins when the St. Louis gage falls below 2.0 feet, must be analyzed on an event-by-event basis using the daily stage hydrographs.

Figure 5.15-3 displays the annual maximum stage, in feet above the 30-foot flood stage, attained at St. Louis under each alternative. By focusing on the feet above flood stage, critical periods for increased flood risk are identified. The greatest increase in the annual maximum stage during flooding conditions was 0.9 foot, which occurred in 1965 under the FWS30 and BIOP alternatives. The ARNRC alternative was 0.6 foot higher in 1965, followed by the MLDDA alternative at 0.4 foot higher and the MRBA and MODC alternatives, each at 0.3 foot higher. The greatest decrease in the annual maximum stage during flooding conditions was 0.6 foot, which occurred in 1969 under the ARNRC alternative.

Figure 5.15-4 shows the minimum stage attained at St. Louis each year for each alternative. The stage at which navigation on the Middle Mississippi River begins to be affected is 2.0 feet. Under the CWCP, stages below 2.0 feet occur in all but 11 years out of the 66 years modeled (1930 to 1995). The 11 years in which the stage does not fall below 2.0 feet all occur between 1973 and 1995. In the last 13 years (between 1983 and 1995), there were only four years in which the stage fell below 2.0 feet. As shown in Figure 5.15-4, the greatest decrease in the annual minimum stage was 3.9 feet, which occurred in 1975 under the ARNRC alternative, while the greatest increase in the annual minimum stage was 1.1 foot in 1994, also under the ARNRC alternative. In general, during the most severe low-flow periods, when stages fall below -2.0 feet at the St. Louis gage, none of the alternatives result in a stage that is more than 0.5 foot lower than the CWCP.

Figure 5.15-5 shows the annual stage duration curves at St. Louis for the CWCP and the alternatives. The duration curves show the percent of time a given stage is equaled or exceeded. For example, under the CWCP, the stage of 2.0 feet (the stage at which navigation impact begins) is exceeded about 77 percent of the time, meaning the river remains below 2.0 feet about 23 percent (100 - 77) of the time. An increase in the exceedance duration figure, therefore, means that the river spends more time above that stage and less time below that stage, and conversely, a decrease in the exceedance duration figure means that the river spends less time above that stage and more time below that stage. Figure 5.15-5 shows virtually no difference in the annual stage duration at St. Louis for the CWCP and the alternatives. The greatest change in the annual exceedance duration at any given stage was a decrease of 1.18 percent at the stage of 0.0 foot under FWS30, compared to CWCP. The 1.18 percent is equivalent to 4.3 days per year.

Figures 5.15-6 through 5.15-17 show stage exceedance duration curves at St. Louis for each month of the year. Although the annual stage duration curves (Figure 5.15-5) showed no significant variation between the CWCP and the alternatives, monthly stage duration curves reveal significant differences during certain months. During the month of June when the Gavins Point Dam spring rise would have worked its way downstream to St. Louis, there are 1 to 3 percent increases in the exceedance durations for the ARNRC, BIOP, and FWS30 alternatives; however, the increases are limited to stages in the 9 to 23 feet range, which has little impact on either flood control or navigation. Significant decreases in exceedance duration at low stages occur during July and August under the ARNRC, BIOP, and FWS30 alternatives. These changes include a 10 percent decrease under the ARNRC alternative at the 2.0-foot stage and a 9 percent decrease with the BIOP and FWS30 alternatives at the 2.0-foot stage. Significant increases in exceedance duration, on the order of 5 percent, occur at low stages under the ARNRC, BIOP, and FWS30 alternatives during October as a result of floodwater being evacuated in the fall. Significant decreases in exceedance duration at low stages occur in November under the MRBA, MODC, and FWS30 alternatives, including a 10 percent decrease at the -1.0-foot stage for the MODC alternative.

Cairo, Illinois

Unlike the Middle Mississippi, which typically crests in April or May and reaches the lowest levels in December and January, the Lower Mississippi at Cairo, Illinois, typically crests in March or April and reaches its lowest levels in September or October. By December or January, the Cairo gage is usually on a rise. A change in the Missouri River flow, therefore, affects the Lower Mississippi somewhat differently than it does the Middle Mississippi, particularly during the low-flow periods.

Figure 5.15-18 shows the computed mean stage for each month at Cairo for the CWCP and the alternatives. The pattern of flow change at Hermann is replicated here as it was at St. Louis, although the impact on stage at Cairo is a fraction of that at St. Louis due to attenuation, the introduction of the Ohio River flow, and the fact that the river is much larger at Cairo than at St. Louis.

Figure 5.15-19 shows the annual maximum stage, in feet above the 40-foot flood stage, attained at Cairo under each alternative. The greatest increase in the annual maximum stage from what it was for the CWCP among the six alternatives was 0.7 foot under the FWS30 alternative in 1968. The ARNRC and BIOP alternatives resulted in a 0.4-foot increase in maximum stage in 1968. The greatest decrease in the annual maximum stage while in flood was 0.6 foot, which occurred in 1938 under the MLDDA alternative.

Figure 5.15-20 shows the minimum stage attained at Cairo each year under each alternative. The stage at which the navigation on the Lower Mississippi begins to be affected is 11.8 feet, which, under the CWCP, occurs in about 60 percent of the 61-year (1935 to 1995) study period. The greatest decrease in the annual minimum stage was 2.1 feet, which occurred in 1970 under the BIOP and FWS30 alternatives; however, the reduction occurred when the stage was well above the 11.8-foot triggering stage for navigation impacts. The greatest decrease in the annual minimum stage while the river was below the 11.8-foot triggering stage was 1.6 feet, which occurred in 1976 under the ARNRC alternative. The BIOP and FWS30 alternatives resulted in a 1.3-foot reduction in stage in 1976. Other years when an alternative had a significant negative impact on minimum stages at Cairo include 1936, which had a 1.5-foot decrease for the MLDDA, ARNRC, MRBA, and MODC alternatives, and 1988, which had a 1.5-foot decrease with the ARNRC alternative. The greatest increase in the annual minimum stage was 3.4 feet in 1939 under the ARNRC alternative, which had a tremendous impact on the Lower Mississippi navigation.

Figure 5.15-21 shows the annual stage duration curve at Cairo for the CWCP and the alternatives. The duration figures are given in percent of time a given stage is equaled or exceeded. The figure demonstrates that there is no appreciable difference between the annual stage duration curves for the CWCP and the alternatives at the Cairo gage on the Mississippi River. Monthly stage duration curves, though not presented, would likely show differences between the alternatives similar to those seen at St. Louis, but on a smaller scale.

5.15.2 Navigation

A primary concern regarding changes in the Water Control Plan for the Missouri River Mainstem Reservoir System is the potential effect on Mississippi River navigation. Reduced Missouri River flows increase the probability of low-water navigation conditions in the Mississippi River system south of Lock and Dam 27 upstream from St. Louis and where the Missouri River enters the Mississippi River. With low water, the maximum tow size and draft are restricted below efficient levels at various locations on the Middle and Lower Mississippi River. Conversely, increased flows from the Missouri River decrease the probability of low-water navigation restrictions and decrease the total transportation costs of using these river reaches.

A navigation economic analysis was conducted to estimate the implications for navigation on the Mississippi River system of the different water control plans for the Mainstem Reservoir System. This analysis was broken down into shallow draft and deep draft analyses by reach on the Middle

Mississippi (from St. Louis to Cairo, Illinois) and on the Lower Mississippi (from Cairo to the Mouth of Passes, Louisiana).

Increased navigation costs begin on the Middle Mississippi when the stage at St. Louis drops to 2.0 feet, which translates to a discharge of 90 kcfs or less. Various changes in tow size and draft must occur to continue to navigate between 2.0 feet and -4.5 feet (44 kcfs), when navigation must be suspended. Similarly, there are no restrictions on the Lower Mississippi when the gage reading at Cairo is above 11.8 feet (189 kcfs). Tow size and draft restrictions are required between 11.8 feet and 3.5 feet (80.5 kcfs) at the gage, and navigation is suspended below 3.5 feet at Cairo.

Table 5.15-1 presents the average annual Mississippi River lost navigation efficiency costs. The total average navigation cost resulting from lost efficiency due to low flows on the Mississippi River for the CWCP is $45.27 million. The MODC alternative increased the annual lost efficiency by $1.34 million and the BIOP alternative had the most favorable impact by decreasing the annual lost efficiency by $7.32 million. A contributing factor to the favorable impact of the BIOP alternative is the conservation of water during the split summer Missouri River navigation season. The split navigation season allows for higher releases in October and November, which is coincident with the low-flow period on the Mississippi. All of the alternatives except the MODC alternative provided improvements in Mississippi River navigation efficiency.

5.15.3 Mississippi River Channel Improvement Features - Mouth of the Missouri River to Gulf of Mexico

The low water reference plane (LWRP) on the Mississippi River is used to establish the crown elevation for dikes and other river engineering works. It is also used by navigation interests to obtain a general idea of the depth of water available at critical locations on the river. The LWRP profile along the Mississippi River is developed from LWRP stages computed at individual gaging stations based on the 97 percent exceedance flow for a specified period of record (typically from 1954 to the time of computation) being applied to a series of rating curves from a more recent period (typically the past 10 years). The LWRP was most recently recomputed in 1992 using the 1954 to 1991 period of record flows and 1982 to 1991 rating curves. Current LWRP stages for the Mississippi River downstream of St. Louis are shown in Table 5.15-2.

To assess the impacts of the alternatives on the Mississippi River LWRP, the original LWRP computation procedure was modified to produce reasonable estimates of the impacts on the Mississippi River LWRP resulting from the change in the Missouri River flow. The current analysis consisted of four steps, as described below.

1. Compute the 97 percent exceedance flow at each of the 10 Mississippi River discharge-gaging stations, listed in Table 5.15-2, for the CWCP and the alternatives using the 1954 through 1991 period of record. Table 5.15-3 contains the 97 percent exceedance flows at each gaging station for each alternative computed from model-routed flows.

Table 5.15-1. Average annual Mississippi River lost navigation efficiency average annual costs ($millions).

Missouri River Alternative	Cairo	St. Louis	Both Reaches	Difference from CWCP Scenario
CWCP	18.77	26.50	45.27	0
MLDDA	14.60	24.24	38.84	(6.43)
ARNRC	15.68	23.71	39.39	(5.88)
MRBA	17.99	26.04	44.03	(1.24)
MODC	17.89	28.72	46.61	1.34
BIOP	14.96	22.99	37.95	(7.32)
FWS30	15.98	24.92	40.90	(4.37)

Table 5.15-2. Current Mississippi River LWRP stages (feet).

Gaging Station	Current LWRP
St. Louis	-3.5
Chester	-0.6
Thebes	4.8
Cairo	9.9
Memphis	-6.7
Helena	-2.2
Arkansas City	-1.1
Vicksburg	2.4
Natchez	7.3
Red River Landing	12.3

Table 5.15-3. 97 percent exceedance flow (kcfs).

Alternative	St. Louis	Chester	Thebes	Cairo	Memphis	Helena	Arkansas City	Vicksburg	Natchez	Red River Landing
CWCP	56.4	59.2	60.1	138.9	147.7	151.2	170.0	176.7	173.9	130.0
MLDDA	56.1	58.7	59.6	137.6	147.0	150.4	169.1	175.6	173.1	129.6
ARNRC	56.5	59.3	60.0	136.2	145.5	149.3	167.9	173.7	172.3	128.6
MRBA	54.4	56.8	57.7	136.7	146.0	149.2	167.3	172.8	170.3	127.8
MODC	53.8	56.0	56.8	134.9	145.9	148.7	166.9	171.8	169.8	127.8
BIOP	55.5	58.2	59.2	135.0	144.6	147.7	167.1	172.9	172.4	128.3
FWS30	55.1	57.7	58.5	135.0	144.6	148.0	166.9	172.5	171.5	127.8

2. Use the 1988 (low-water year) observed discharge measurements to develop low-water rating curves at each of the 10 gaging stations by drawing a best-fit curve through measured points. Then raise or lower the curve to match the point defined by the existing LWRP stage and the 97 percent exceedance discharge from the CWCP. The use of the single rating curve (1988) deviates from the actual method used in computing the LWRP. The actual method involves developing a set of 10 rating curves (one for each year from 1982 through 1991), converting the 97 percent exceedance flow to stages, and then taking the average of the 10 stages to determine the LWRP. A single rating curve was used in this study for the sake of expediency.

3. Draw a line tangent to each of the rating curves at a point defined by the existing LWRP stage and the 97 percent exceedance discharge from the CWCP alternative. This tangent line defines the slope of the curve at the LWRP stage. The slopes, shown below, were rounded off and grouped by Corps District reaches for simplicity and consistency of results:

   St. Louis District
(St. Louis, Chester, Thebes) — 5.5 kcfs/foot

   Memphis District
(Cairo, Memphis, Helena) — 13 kcfs/foot

   Vicksburg District
(Arkansas City, Vicksburg, Natchez) — 14 kcfs/foot

   New Orleans District
(Red River Landing) — 18 kcfs/foot

4. Compute the impact on the LWRP by applying the slope to the difference in the 97 percent exceedance flows (between CWCP and other alternatives). Table 5.15-4 shows the computed differences in the LWRP, with the positive values indicating the raising of the LWRP and the negative values indicating the lowering of the LWRP. Table 5.15-5 shows the adjusted LWRP stages.

Table 5.15-4 shows that all alternatives have a negative impact by lowering the LWRP, typically by 0.2 to 0.5 foot along the Middle Mississippi and 0.2 to 0.3 foot along the Lower Mississippi. The worst case scenario occurs under the MODC alternative, which lowers the LWRP by as much as 0.6 feet along the Middle Mississippi and by as much as 0.3 feet along the Lower Mississippi. The lowering of the LWRP will require the training dikes on the Mississippi River to be extended farther into the river at a substantial cost.

Table 5.15-6 presents the cost associated with Mississippi River channel improvement feature modifications resulting from the respective alternatives. A previous study by the St. Louis District determined that, for each 0.1 foot of reduction in existing the LWRP, the cost of new construction of training structures for the Middle and Lower Mississippi River reaches would be $5 million. This cost is associated with maintaining a 9-foot navigation channel in the Mississippi River. This does not include environmental impacts that may accrue from changing channel improvement features.

Table 5.15-4. Change in Mississippi River LWRP relative to the CWCP (feet).

Alternative	St. Louis	Chester	Thebes	Cairo	Memphis	Helena	Arkansas City	Vicksburg	Natchez	Red River Landing
CWCP	0	0	0	0	0	0	0	0	0	0
MLDDA	-0.05	-0.08	-0.09	-0.10	-0.06	-0.06	-0.06	-0.07	-0.06	-0.02
ARNRC	0.03	0.03	-0.01	-0.21	-0.17	-0.15	-0.15	-0.21	-0.11	-0.08
MRBA	-0.35	-0.43	-0.44	-0.17	-0.13	-0.16	-0.19	-0.28	-0.25	-0.13
MODC	-0.46	-0.57	-0.60	-0.31	-0.14	-0.19	-0.22	-0.35	-0.29	-0.12
BIOP	-0.17	-0.17	-0.16	-0.30	-0.25	-0.27	-0.20	-0.27	-0.11	-0.09
FWS30	-0.24	-0.27	-0.29	-0.30	-0.24	-0.25	-0.22	-0.29	-0.17	-0.12

Table 5.15-5. Revised Mississippi River LWRP (feet).

Alternative	St. Louis	Chester	Thebes	Cairo	Memphis	Helena	Arkansas City	Vicksburg	Natchez	Red River Landing
CWCP	-3.5	-0.6	4.8	9.9	-6.7	-2.2	-1.1	2.4	7.3	12.3
MLDDA	-3.55	-0.68	4.71	9.80	-6.76	-2.26	-1.16	2.33	7.24	12.28
ARNRC	-3.47	-0.57	4.79	9.69	-6.87	-2.35	-1.25	2.19	7.19	12.22
MRBA	-3.85	-1.03	4.36	9.73	-6.83	-2.36	-1.29	2.12	7.05	12.18
MODC	-3.96	-1.17	4.20	9.59	-6.84	-2.39	-1.32	2.05	7.01	12.18
BIOP	-3.67	-0.77	4.64	9.60	-6.95	-2.47	-1.30	2.13	7.19	12.21
FWS30	-3.74	-0.87	4.51	9.60	-6.94	-2.45	-1.32	2.11	7.13	12.18

Table 5.15-6. Mississippi River channel improvement features cost by alternative.

Alternative	St. Louis LWRP (feet)	Change in LWRP (feet)	Increased Cost ($millions)
CWCP	-3.50	0.0	0
MLDDA	-3.55	-0.05	2.5
ARNRC	-3.47	0.0	0
MRBA	-3.85	-0.35	17.5
MODC	-3.96	-0.46	23.0
BIOP	-3.67	-0.17	8.5
FWS30	-3.74	-0.24	12.0

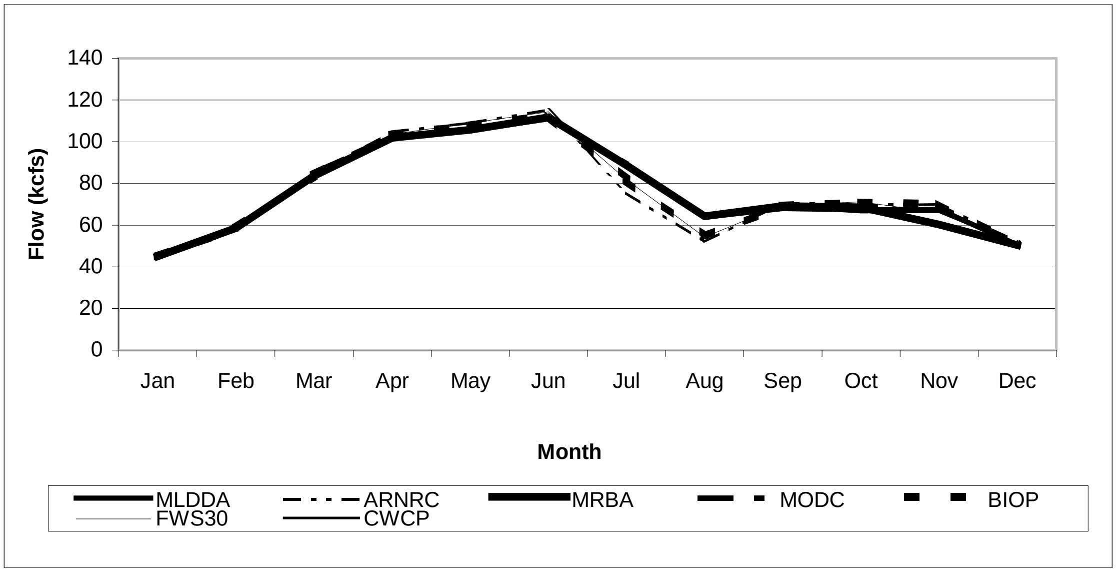

Figure 5.15-1. Average monthly flow at Hermann, Missouri.

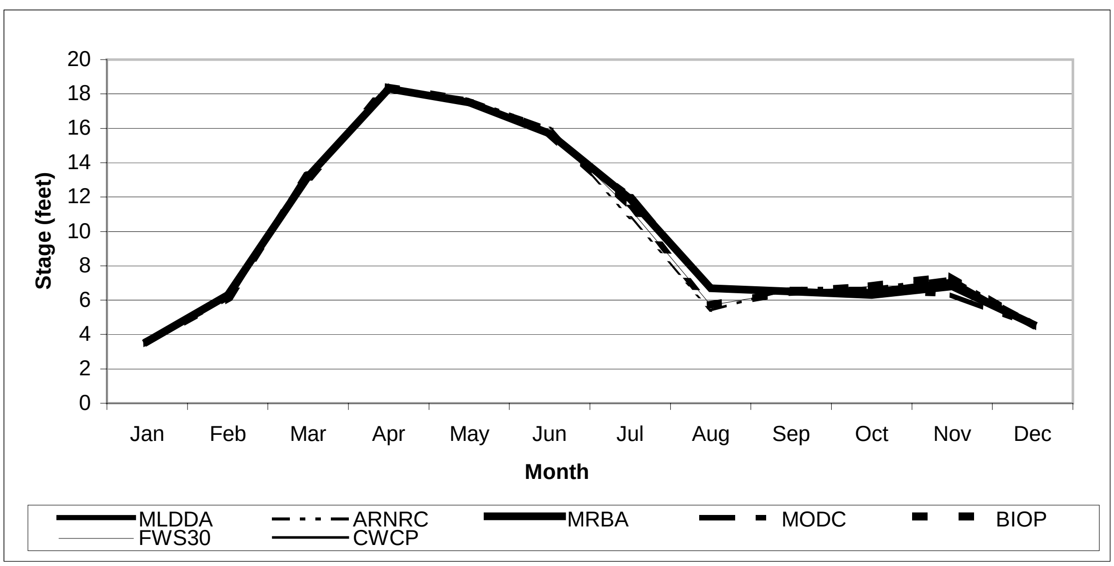

Figure 5.15-2. Mean monthly stage at St. Louis.

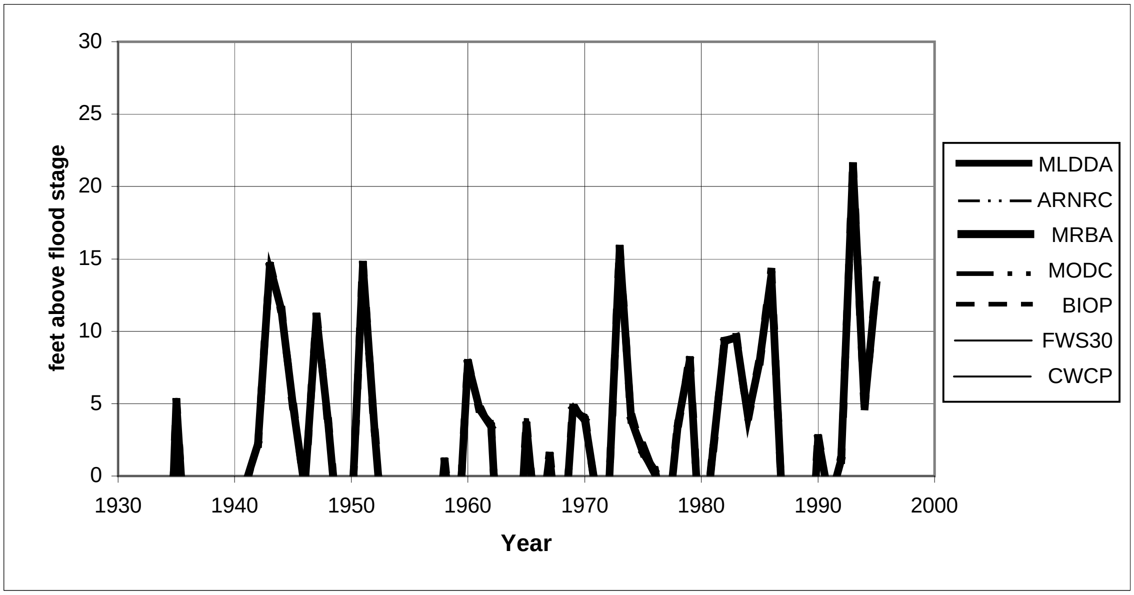

Figure 5.15-3. Maximum annual feet above flood stage at St. Louis.

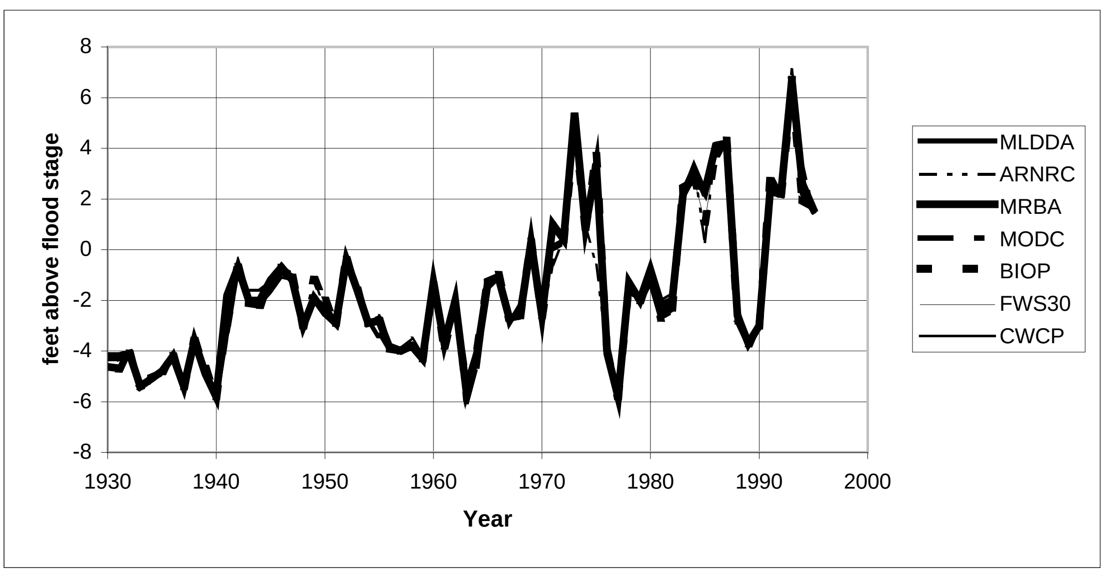

Figure 5.15-4. Minimum annual feet above flood stage at St. Louis.

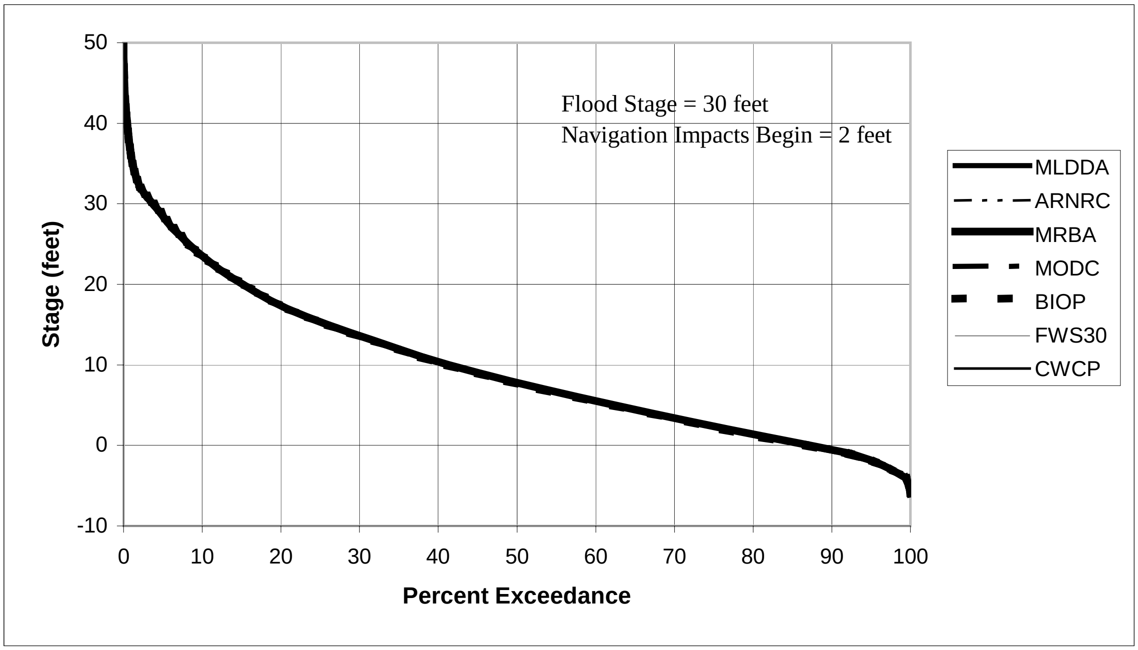

Figure 5.15-5. Average annual St. Louis stage duration.

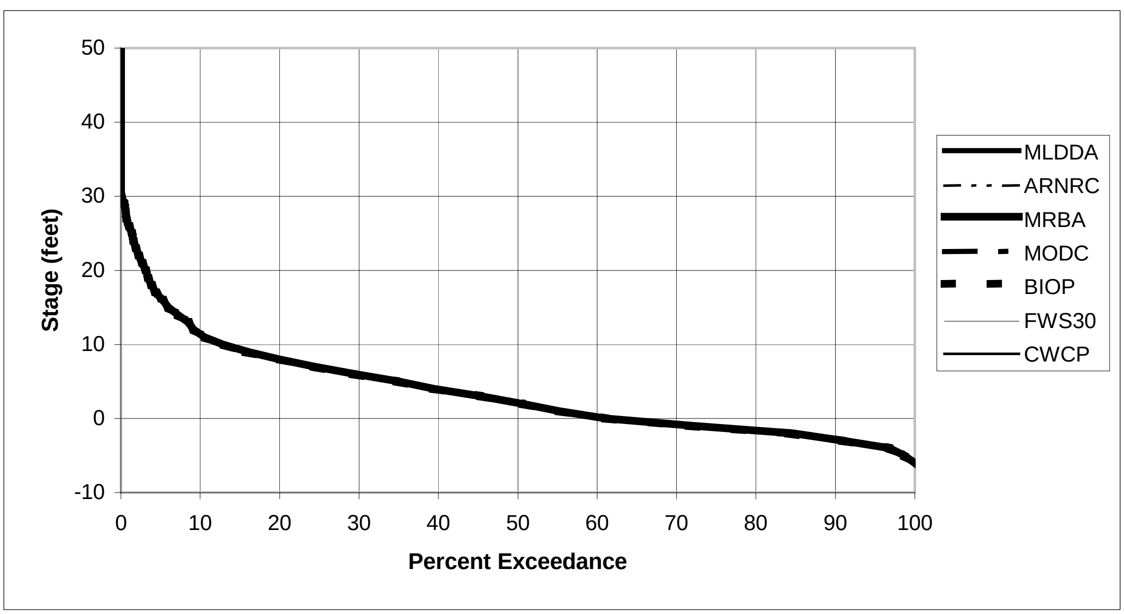

Figure 5.15-6. St. Louis stage duration, January.

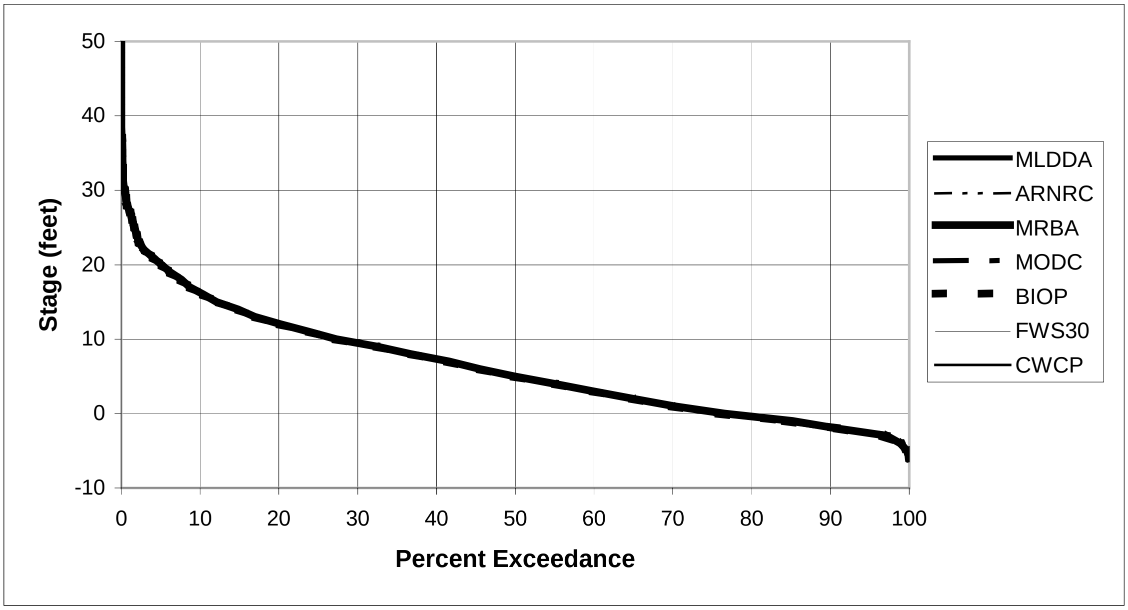

Figure 5.15-7. St. Louis stage duration, February.

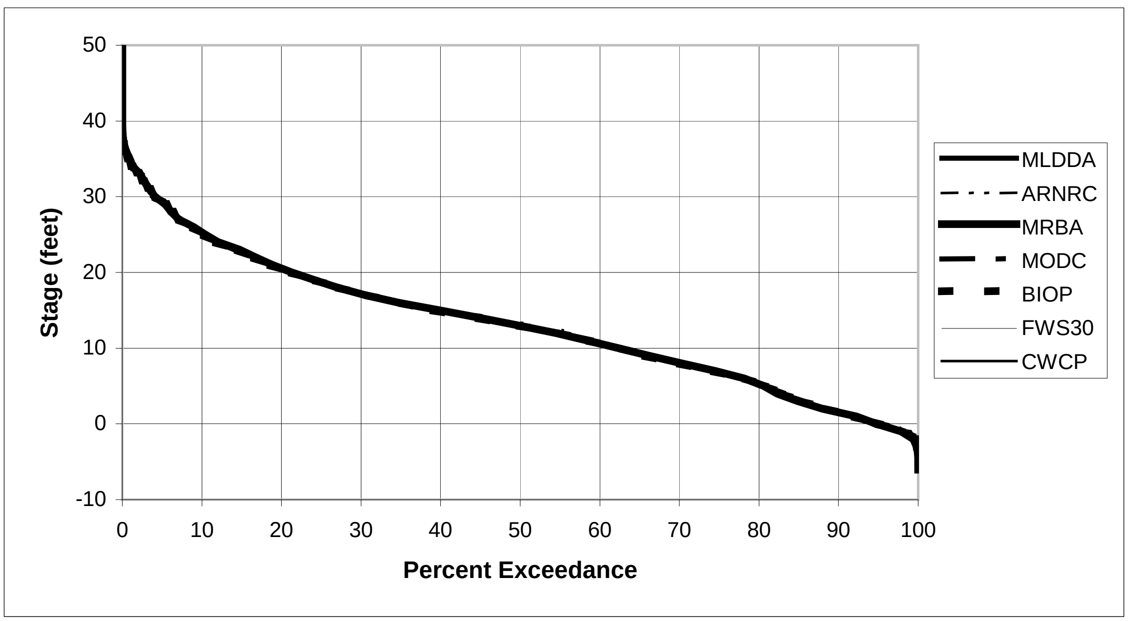

Figure 5.15-8. St. Louis stage duration, March.

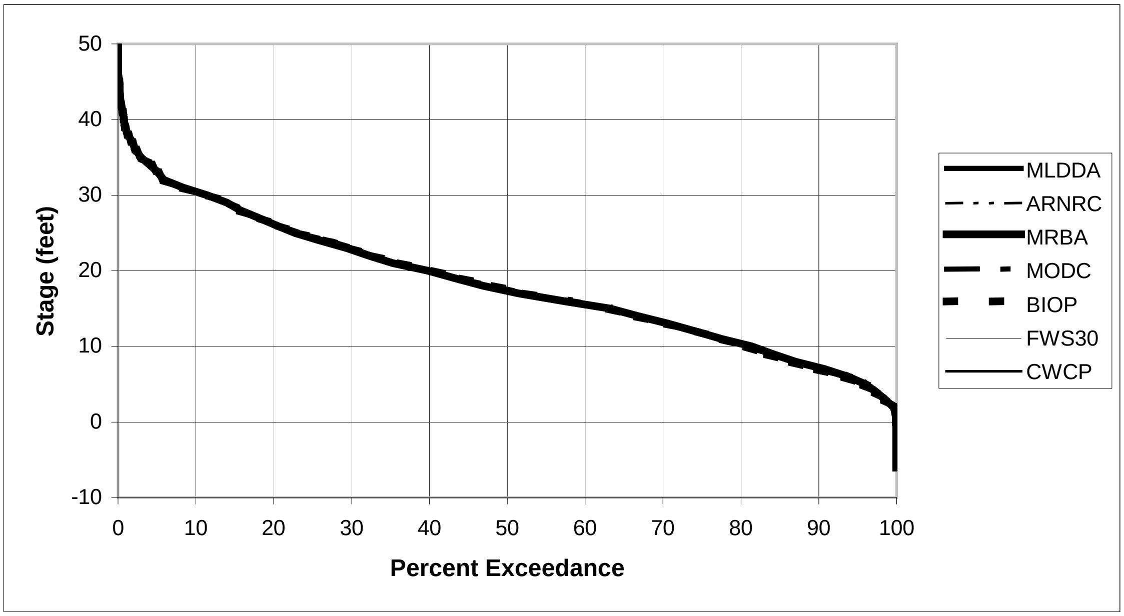

Figure 5.15-9. St. Louis stage duration, April.

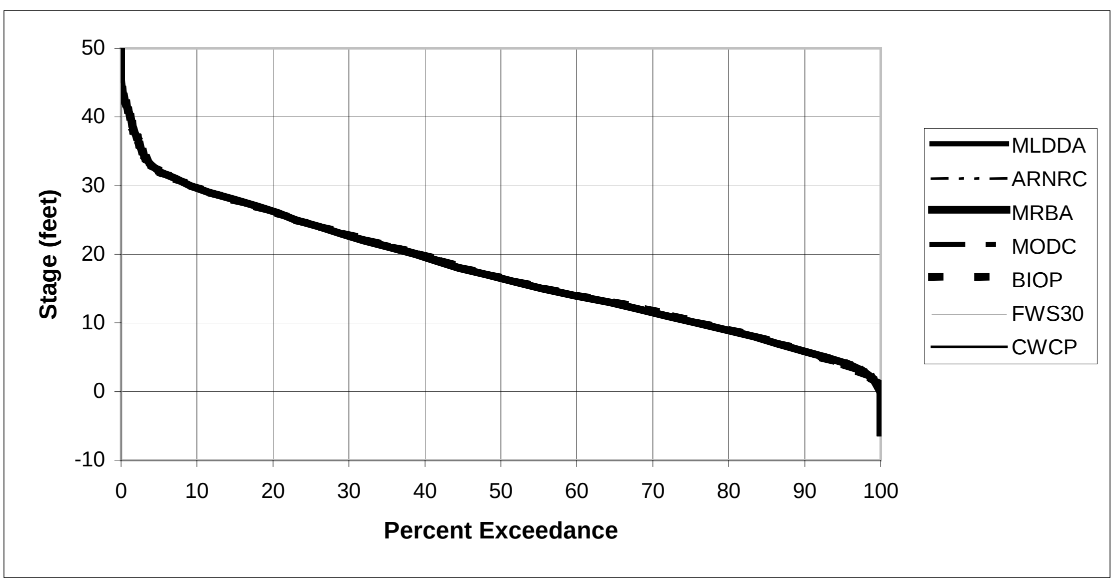

Figure 5.15-10. St. Louis stage duration, May.

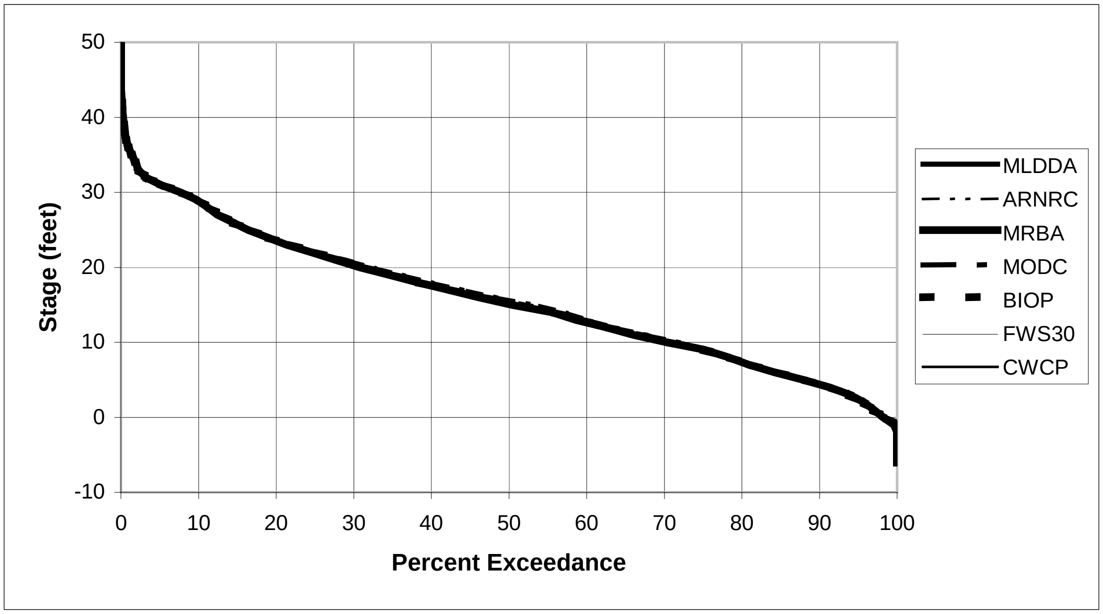

Figure 5.15-11. St. Louis stage duration, June.

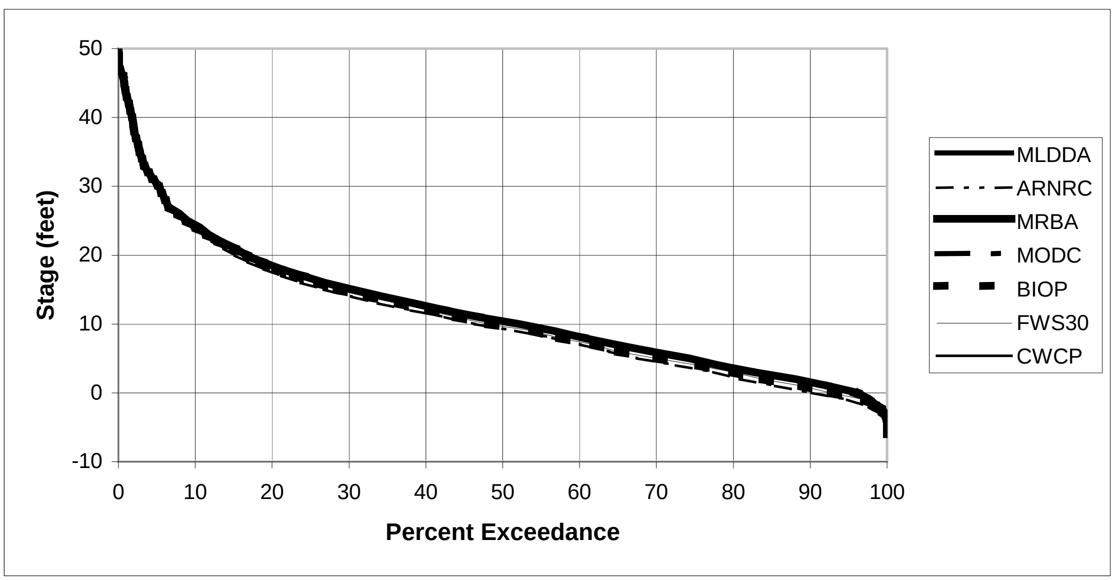

Figure 5.15-12. St. Louis stage duration, July.

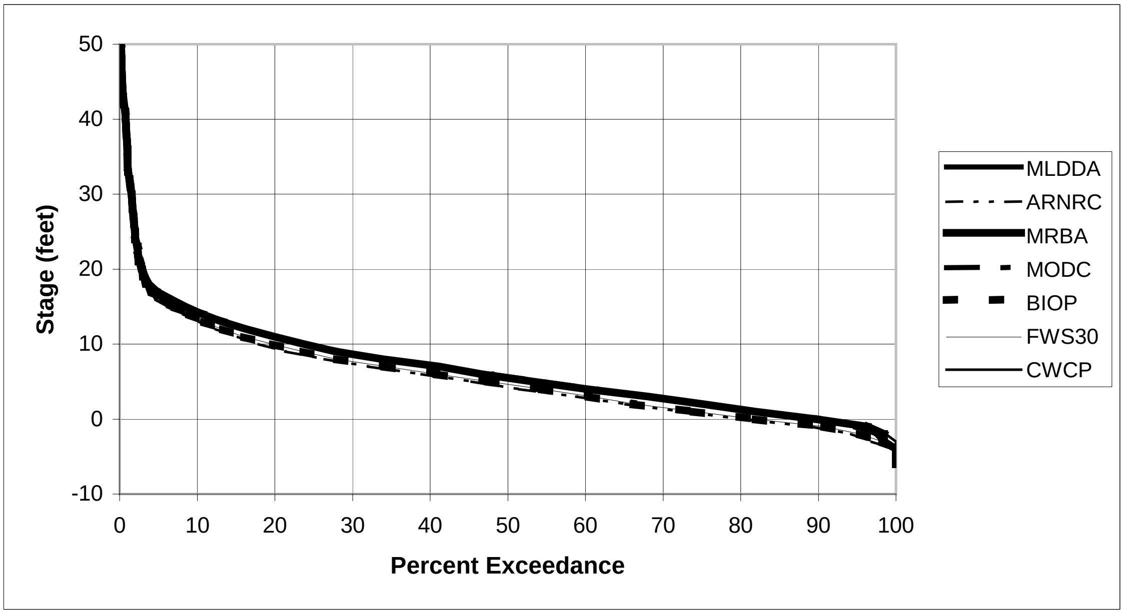

Figure 5.15-13. St. Louis stage duration, August.

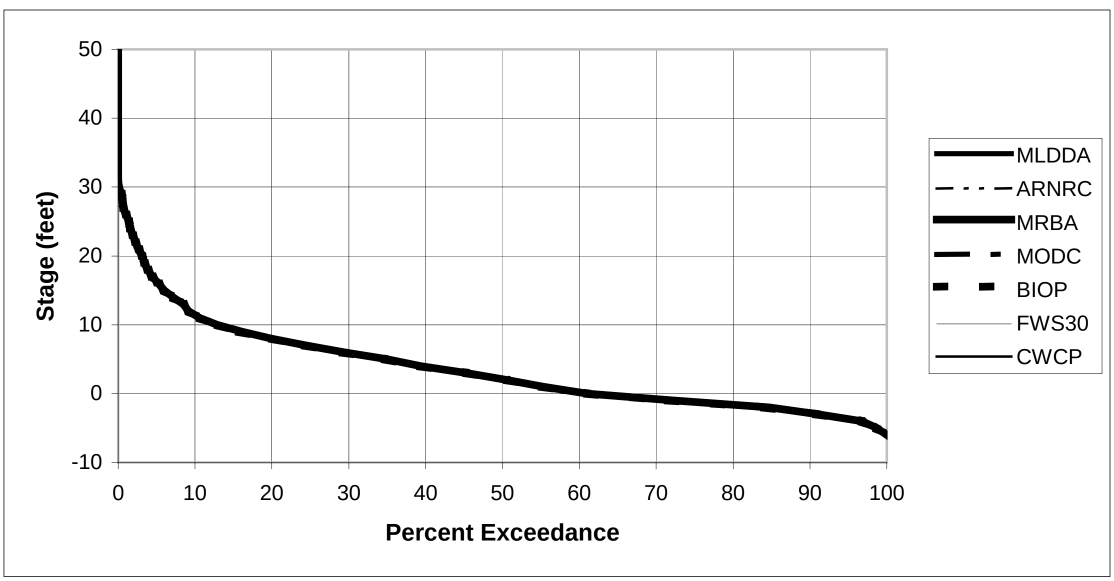

Figure 5.15-14. St. Louis stage duration, September.

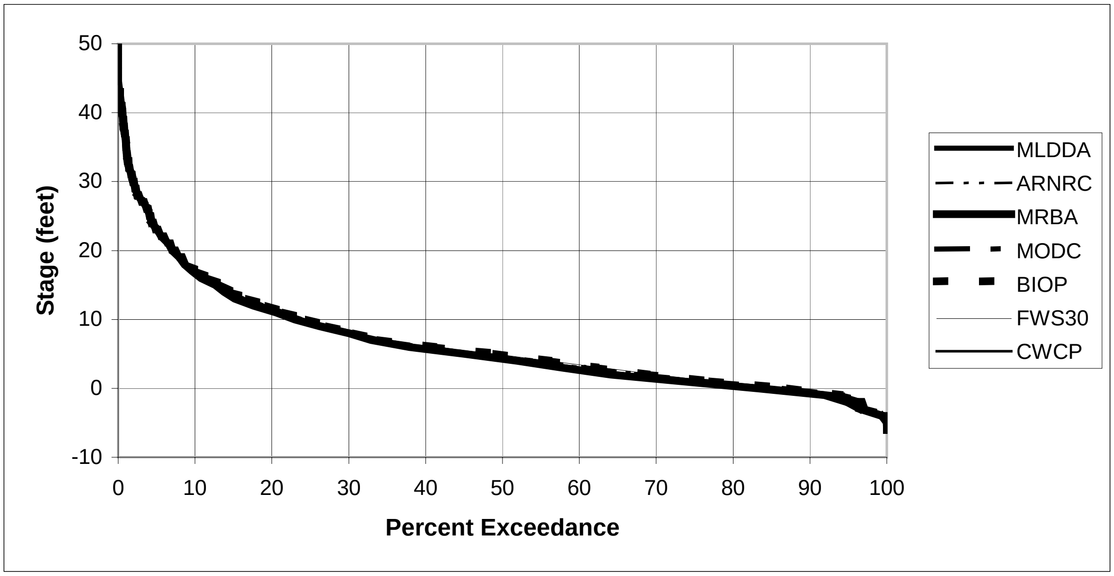

Figure 5.15-15. St. Louis stage duration, October.

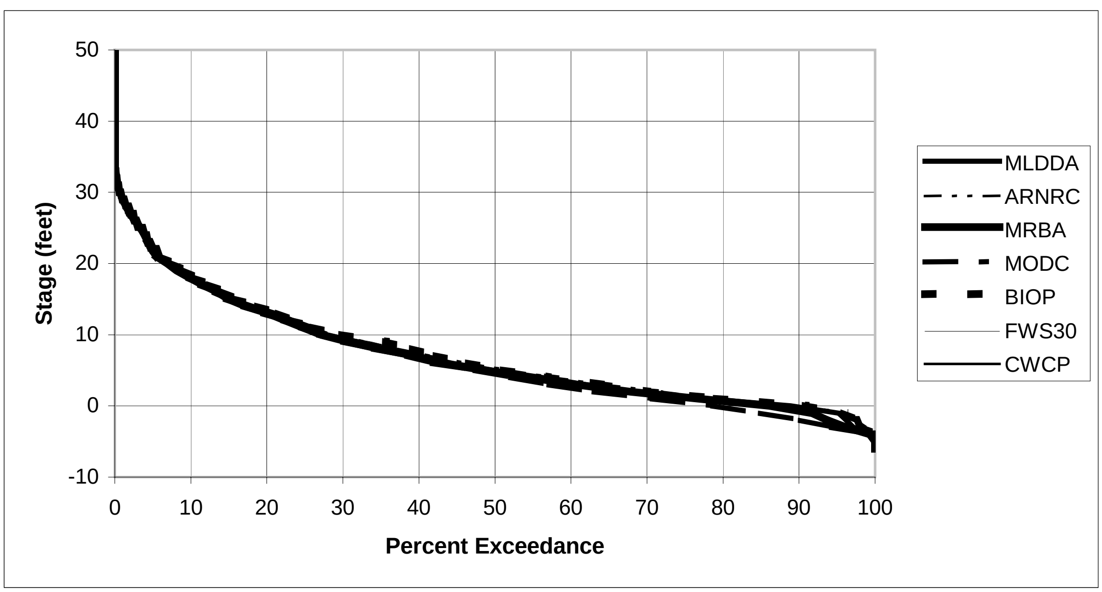

Figure 5.15-16. St. Louis stage duration, November.

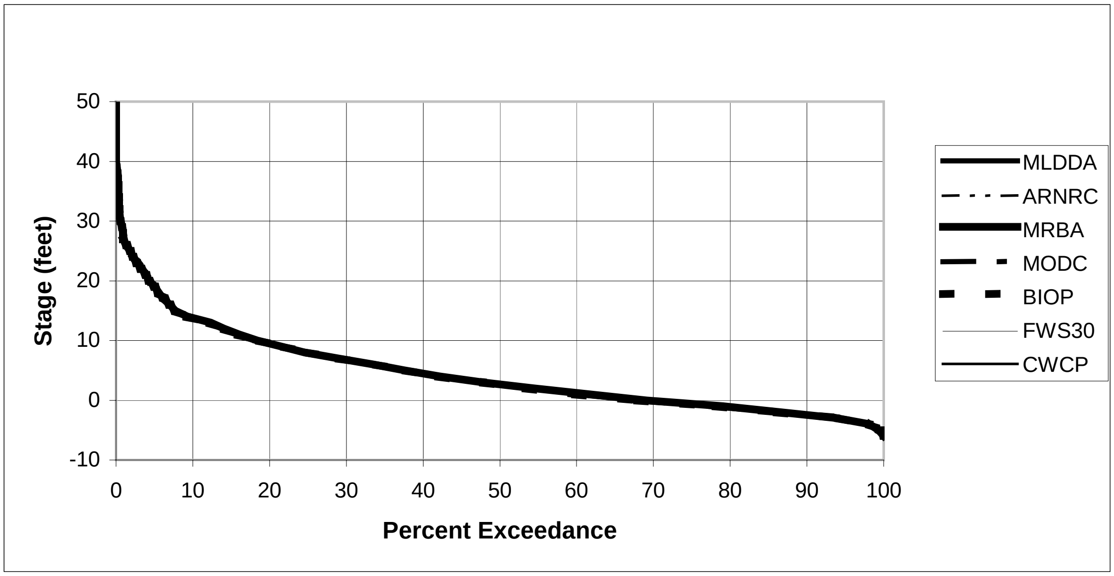

Figure 5.15-17. St. Louis stage duration, December.

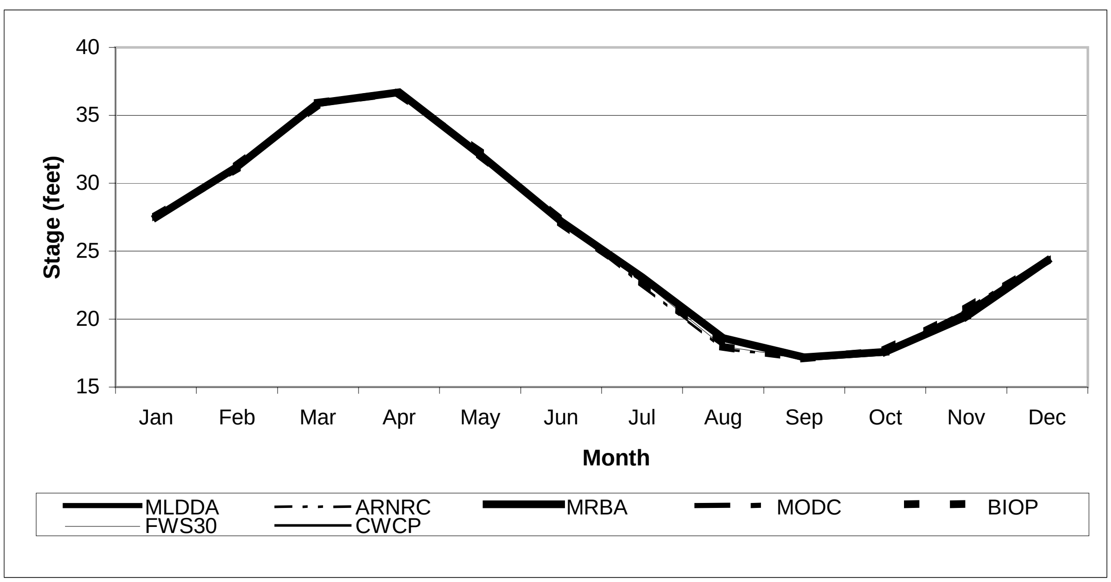

Figure 5.15-18. Mean monthly stage at Cairo.

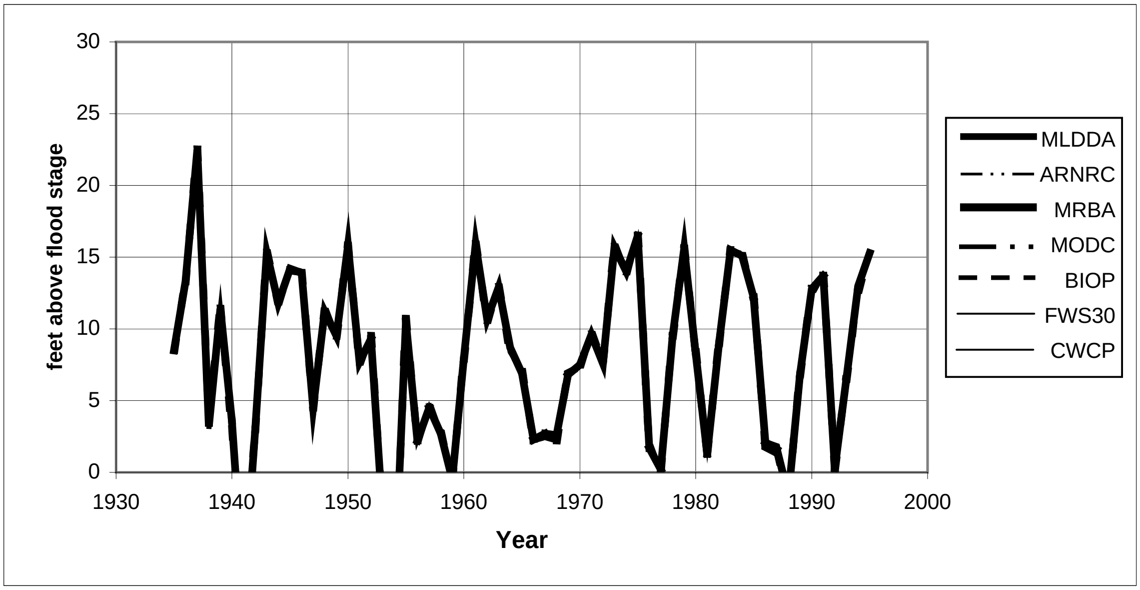

Figure 5.15-19. Maximum annual feet above flood stage at Cairo.

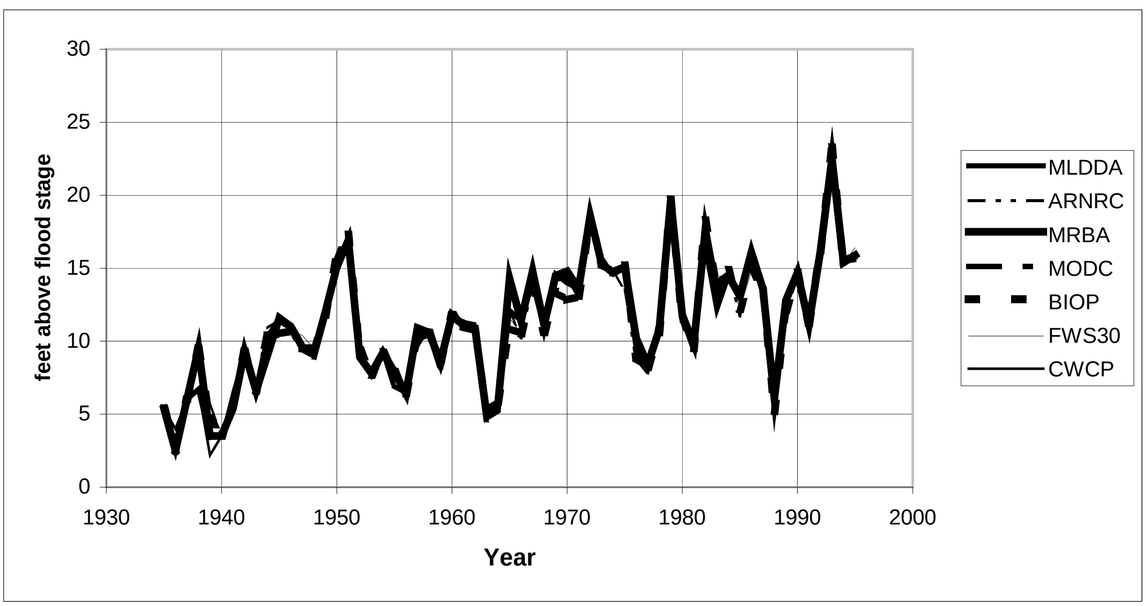

Figure 5.15-20. Minimum annual feet above flood stage at Cairo.

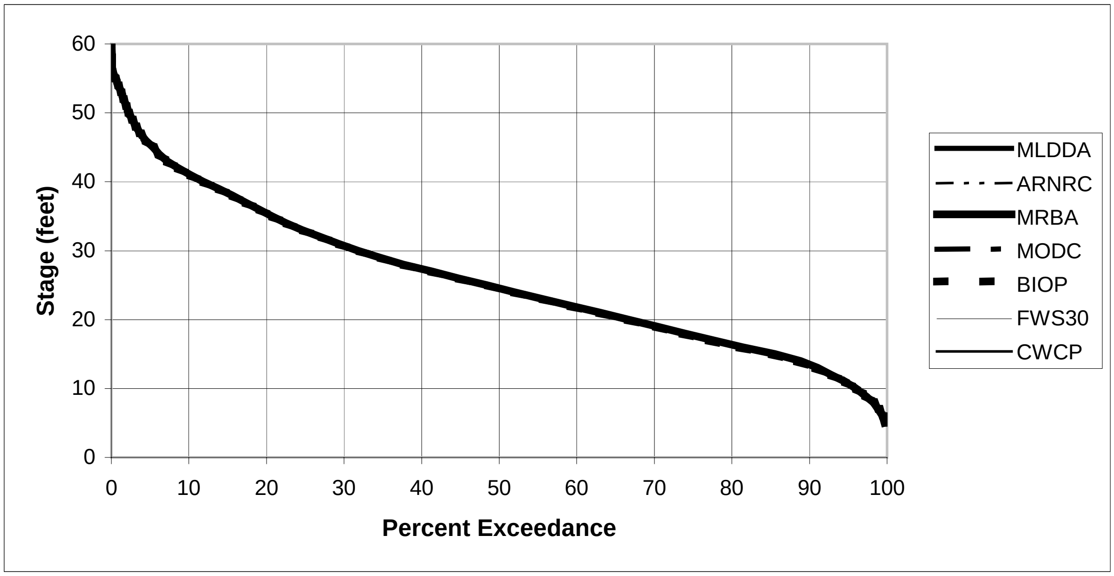

Figure 5.15-21. Cairo stage duration.

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5.16 SUMMARY OF IMPACTS OF SUBMITTED ALTERNATIVES TO AMERICAN INDIAN TRIBES

The individual sections of this chapter discuss the impacts to the various environmental resources and economic uses analyzed for the Study on the 13 Tribal Reservations along the Mainstem Reservoir System and Lower River (see Figure 1.5-1 for locations). In the introduction to Chapter 5, readers were encouraged to consider the relative effects among the alternatives, not the absolute values presented for the various resources or uses. This section of Chapter 5 synopsizes the impacts in 12 tables, one for each Reservation except for the Iowa and Sac and Fox Reservations, for which impacts are addressed on a single table because individual tables for these two Reservations would be identical.

Tables 5.16-1 to 5.16-12 present the summary of impacts for the 13 Tribes. The numbering of the tables corresponds with the order of Reservation locations, going from upstream to downstream. The order of the listing of the environmental resource and economic uses corresponds with the order they are presented in this chapter to make it easier to refer back to the individual sections for more information on an individual resource or use. Taking the value of each alternative, subtracting the CWCP value for that specific use or resource for that Reservation from it, and dividing the difference by the CWCP value results in individual numbers for each use/resource in the tables. If a specific alternative increases the value from that of the CWCP, the percent change presented in the table is positive. If the value decreases relative to the CWCP, the percent change is negative. The reader is asked to focus attention on the "significant" changes. Significant positive changes are those greater than a +1 percent, and are shaded a light gray. Significant negative changes are greater than -1 percent and are shaded black with white lettering. A change of +1 represents changes up to 1.49 percent more than, or 101.49 percent of, the CWCP value due to rounding. Similarly, a -1 represents a change up to 1.49 percent less than, or 98.51 percent of, the CWCP value.

Caution must be used when focusing on the shaded percent changes because a resource may have a special meaning to those on one or more of the Reservations, and an "insignificant" change (+1, 0, or -1 in the tables) may be an important change to those on that Reservation. If one of the resources or uses falls into that category for those associated with that Reservation, those individuals are encouraged to note whether the change is slightly positive (+1), no change (0), or slightly negative (-1). A double dash (--) indicates that data were not available for that resource or use for that Reservation or that resource or use is not applicable to the reach in which that Reservation is located. Readers are encouraged to review the table/s of interest and to make their own "value" judgements.

Table 5.16-1. Fort Peck Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	-6	1	6	0	-14	-12
Riparian Habitat	0	0	0	0	0	0
Tern and Plover Habitat	12	-56	38	-5	-45	-54
Lake Young Fish Production	--	--	--	--	--	--
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	1	9	1	3	10	9
River Warmwater Fish Habitat	-1	-19	-11	-8	-17	-13
Native River Fish Physical Habitat	0	5	1	1	2	2
Flood Control	-1	0	0	0	-2	-2
Water Supply	0	10	0	5	14	14
Hydropower	--	--	--	--	--	--
Recreation	0	8	1	2	10	9
Navigation	--	--	--	--	--	--
Historic Properties	--	--	--	--	--	--

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-2. Fort Berthold Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	--	--	--	--	--	--
Riparian Habitat	--	--	--	--	--	--
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	4	7	-1	5	11	11
Lake Coldwater Fish Habitat	-2	12	-2	6	3	4
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	--	--	--	--	--	--
Flood Control	33	-100	-33	-67	-67	-67
Water Supply	-1	12	6	7	1	7
Hydropower	--	--	--	--	--	--
Recreation	-2	14	14	11	10	15
Navigation	--	--	--	--	--	--
Historic Properties	4	-11	-4	-4	-6	-6

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-3. Standing Rock Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Wetland Habitat	80	21	-7	-35	-45	-22
Riparian Habitat	3	-38	3	1	-21	1
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	5	-2	2	7	-1	1
Lake Coldwater Fish Habitat	-3	14	5	6	12	12
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	--	--	--	--	--	--
Flood Control	40	-80	0	-20	-60	-60
Water Supply	-6	18	9	10	12	10
Hydropower	--	--	--	--	--	--
Recreation	2	10	7	7	5	10
Navigation	--	--	--	--	--	--
Historic Properties	2	-5	-2	-2	-4	-4

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-4. Cheyenne River Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	ARNRC	MRBA	MODC	BIOP	FWS30
Wetland Habitat	42	-3	-26	-9	-28	-26
Riparian Habitat	122	-39	0	-11	-39	-28
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	5	-2	2	7	-1	1
Lake Coldwater Fish Habitat	-3	14	5	6	12	12
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	--	--	--	--	--	--
Flood Control	40	-100	-20	-40	-80	-80
Water Supply	13	13	13	0	0	13
Hydropower	--	--	--	--	--	--
Recreation	0	0	0	0	0	1
Navigation	--	--	--	--	--	--
Historic Properties	2	-5	-2	-2	-4	-4

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-5. Lower Brule Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	--	--	--	--	--	--
Riparian Habitat	--	--	--	--	--	--
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	2	-23	-4	-2	-6	-9
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	--	--	--	--	--	--
Flood Control	0	0	0	0	0	0
Water Supply	0	0	0	0	0	0
Hydropower	--	--	--	--	--	--
Recreation	0	0	0	0	0	0
Navigation	--	--	--	--	--	--
Historic Properties	0	0	0	0	0	0

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-6. Crow Creek Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	--	--	--	--	--	--
Riparian Habitat	--	--	--	--	--	--
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	2	-23	-4	-2	-6	-9
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	--	--	--	--	--	--
Flood Control	100	0	0	0	0	0
Water Supply	0	1	1	1	1	1
Hydropower	--	--	--	--	--	--
Recreation	0	0	0	0	0	0
Navigation	--	--	--	--	--	--
Historic Properties	0	0	0	0	0	0

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-7. Yankton Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	3	4	1	-1	5	6
Riparian Habitat	2	0	-2	0	-4	-8
Tern and Plover Habitat	17	127	19	3	99	111
Lake Young Fish Production	-5	34	-1	5	29	30
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	-5	-15	-9	-6	-22	-23
Native River Fish Physical Habitat	0	-1	-1	0	-1	-1
Flood Control	0	0	0	0	0	0
Water Supply	0	0	0	0	0	1
Hydropower	--	--	--	--	--	--
Recreation	0	-5	-1	-1	-2	-3
Navigation	--	--	--	--	--	--
Historic Properties	--	--	--	--	--	--

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-8. Ponca Tribal Lands impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	2	-6	-1	-1	-6	-7
Riparian Habitat	0	8	-5	-3	5	6
Tern and Plover Habitat	17	127	19	3	99	111
Lake Young Fish Production	--	--	--	--	--	--
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	-5	-15	-9	-6	-22	-23
Native River Fish Physical Habitat	0	-1	-1	0	-1	-1
Flood Control	0	0	0	0	0	0
Water Supply	--	--	--	--	--	--
Hydropower	--	--	--	--	--	--
Recreation	0	-5	-1	-1	-2	-3
Navigation	--	--	--	--	--	--
Historic Properties	--	--	--	--	--	--

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-9. Santee Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	2	-6	-1	-1	-6	-7
Riparian Habitat	0	8	-5	-3	5	6
Tern and Plover Habitat	17	127	19	3	99	111
Lake Young Fish Production	-2	28	13	33	26	28
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	--	--	--	--	--	--
Flood Control	0	0	0	0	0	1
Water Supply	0	0	0	0	0	0
Hydropower	--	--	--	--	--	--
Recreation	0	0	0	0	0	0
Navigation	--	--	--	--	--	--
Historic Properties	--	--	--	--	--	--

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-10. Winnebago Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	-2	-6	3	5	-1	3
Riparian Habitat	-1	-6	-1	-2	-4	-12
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	--	--	--	--	--	--
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	0	0	0	0	-1	0
Flood Control	0	-1	0	0	0	0
Water Supply	0	0	0	0	0	0
Hydropower	--	--	--	--	--	--
Recreation	-1	-8	-1	-1	-5	-6
Navigation	--	--	--	--	--	--
Historic Properties	--	--	--	--	--	--

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-11. Omaha Reservation impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	-2	-6	3	5	-1	3
Riparian Habitat	-1	-6	-1	-2	-4	-12
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	--	--	--	--	--	--
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	0	0	0	0	-1	0
Flood Control	0	-1	-1	0	0	-1
Water Supply	0	0	0	0	0	0
Hydropower	--	--	--	--	--	--
Recreation	-1	-8	-1	-1	-5	-6
Navigation	--	--	--	--	--	--
Historic Properties	--	--	--	--	--	--

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

Table 5.16-12. Iowa and Sac and Fox Reservations impacts summary for submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Wetland Habitat	-1	16	2	4	4	9
Riparian Habitat	0	-6	-1	-1	-2	-7
Tern and Plover Habitat	--	--	--	--	--	--
Lake Young Fish Production	--	--	--	--	--	--
Lake Coldwater Fish Habitat	--	--	--	--	--	--
River Coldwater Fish Habitat	--	--	--	--	--	--
River Warmwater Fish Habitat	--	--	--	--	--	--
Native River Fish Physical Habitat	0	5	1	1	3	4
Flood Control	0	0	0	0	0	1
Water Supply	--	--	--	--	--	--
Hydropower	--	--	--	--	--	--
Recreation	0	-2	0	0	-2	-2
Navigation	--	--	--	--	--	--
Historic Properties	--	--	--	--	--	--

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.
-- denotes not available or not applicable.

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5.17 SUMMARY OF IMPACTS OF ALTERNATIVES SUBMITTED TO THE CORPS FOR CONSIDERATION

The individual sections of this chapter discuss the impacts to the various environmental resources and economic uses analyzed for the Study. In the introduction to Chapter 5, readers were encouraged to consider the relative effects among the alternatives, not the absolute values presented for the various resources or uses. This section of Chapter 5 synopsizes the impacts in a single table.

Table 5.17-1 presents the summary of impacts for the alternatives submitted to the Corps for consideration: the MLDDA, ARNRC, MRBA, MODC, BIOP, and FWS30 alternatives. The order of the listing of the environmental resources and economic uses corresponds with the order they are presented in this chapter to make it easier to refer back to the individual sections for more information on an individual resource or use. Individual numbers for each use/resource in the tables are computed by taking the average annual value of each alternative, subtracting the CWCP value for that specific use or resource from it, and dividing the difference by the CWCP value and then multiplying by 100 to get the percent change from the CWCP value. If a specific alternative increases the value from that of the CWCP, the percent change presented in the table is positive. If the value decreases relative to the CWCP, the percent change is negative. The reader is asked to focus attention on the “significant” changes (those greater than a plus or minus 1 percent and shaded a light gray (positive “significant” change) or shaded black with white lettering (negative “significant” change). (Note: A change of +1 represents changes up to 1.49 percent more than, or 101.49 percent of, the CWCP value due to rounding. Similarly, a -1 represents a change up to 1.49 percent less than, or 98.51 percent of, the value for the CWCP.) Caution must be used when focusing on the shaded percent changes because a resource may have a special meaning to an individual, and an “insignificant” change (+1, 0, or -1 in the tables) may be an important change to that person. Those individuals that situation applies to are encouraged to note whether the change is slightly positive (+1), no change (0), or slightly negative (-1). Readers are encouraged to review the table and to make their own “value” judgements.

Missouri River navigation for three of the alternatives has two percentage changes that represent the two extremes for impacts relative to the CWCP. These three alternatives have flows during the summer low-flow period that will generally be too low to provide navigation service. The smaller negative value represents the end of the spectrum where navigation would continue on both sides of the summer low-flow period. The second, greater negative value represents the other end of the spectrum when only sand and gravel mining and the movement of waterway materials to repair channel structures are the only viable forms of navigation using the river.

Two values are included for the spawning cue, one for the reach closest to Gavins Point Dam and one for Boonville, which is midway between Kansas City and the mouth of the Missouri River. For this resource category, the values for each reach cannot be summed to arrive at a single average annual value for that resource or use. A single value, the 25 percent exceedance value (value exceeded in just 25 percent of the years analyzed), was selected to be representative of the relative differences among the alternatives for connectivity. This value was selected because spring rises generally occur about one-third of the time or less. The 25 percent value would, therefore, provide better insight regarding differences among alternatives for the extent of the connectivity that would occur in years with spring rises. The 25 percent exceedance values for the individual reaches were summed to come up with a single value for each alternative on which the computations for the table could be computed.

Table 5.17-1. Impacts summary for the submitted alternatives.

	Percent Change from CWCP					
	MLDDA	**ARNRC**	**MRBA**	**MODC**	**BIOP**	**FWS30**
Missouri River						
Wetland Habitat	0	3	-1	1	-1	1
Riparian Habitat	2	-6	0	-3	-4	-6
Tern and Plover Habitat	5	37	36	36	74	70
Lake Young Fish Production	0	2	2	6	5	5
Lake Coldwater Fish Habitat	-3	9	3	5	7	7
River Coldwater Fish Habitat	-1	8	2	2	7	7
River Warmwater Fish Habitat	-3	-16	-9	-5	-15	-14
Native River Fish Physical Habitat	0	2	0	0	1	1
Historic Properties Index	3	-8	-3	-3	-4	-4
Floodplain Connectivity (25% Recurrence)	0	7	0	0	3	8
Shallow Water Fish Habitat	2	50	1	0	32	33
Spawning Cue - Gavins Point	11	83	28	28	94	167
Spawning Cue - Boonville	0	0	0	0	3	21
Flood Control	0	-1	-1	-1	-1	-1
Interior Drainage	-1	-4	-3	-2	-9	-12
Groundwater	-1	-15	0	5	-10	-15
Water Supply	0	-2	0	0	0	0
Hydropower	-1	1	1	1	2	2
Recreation	1	3	4	4	2	4
Navigation	-47	-36	1	2	-35	-38
Total NED Economics		0	0	0	0	0
Mississippi River						
Navigation Efficiency	14	13	3	-3	16	10

Light gray shading denotes a beneficial impact when compared to the CWCP.
Black shading denotes an adverse impact when compared to the CWCP.