

# **Bendway Weir Survey Evaluation Mississippi River Dogtooth Bend**

**April, 1994**

**U. S. ARMY CORPS OF ENGINEERS**



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## **Introduction**

John E. Chance & Associates, Inc. (JECA) was contracted to evaluate the Bendway Weirs at Dogtooth Bend in the Mississippi River (Mile 22-24). JECA performed this evaluation under contract number DACW43-93-D-0509 Delivery Order No. 2. A Bendway Weir is a submerged manmade rock structure placed in the river bend to redistribute flow and improve navigation conditions.

The purpose of this evaluation is to analyze existing bathymetry data over the weirs and create cross-sectional and profile comparisons of each structure. These comparisons will be utilized to determine the influence the weir had on the surrounding river bottom. A color shaded plan view of the river bottom transition (cut and fill) from one bathymetry survey to the next was also generated to help in the analysis.

## **Study Area and Data**

Dogtooth Bend, located on the upper Mississippi River at Mile 23 is a major bend in the river. In three miles, the river flow changes direction by approximately ninety degrees from southeast to northeast. This change in direction creates a strong current on the right descending bank while on the opposite bank there is a slack current allowing the build up of a sand bar. This sand bar decreases the width of the navigation channel through the bend. The weirs were constructed to redistribute some of the river flow from the right bank to the left bank in hopes of keeping the sand bar from accreting so far into the river. This would widen the navigation channel without the requirement of dredging.

The Dogtooth Bend Weir System consists of thirteen (13) submerged structures. These structures are located from Mile 22.45 to Mile 24.2, with a higher concentration of weirs near the center of this reach.

Data analyzed in this study was collected over a 2½ year period by similar bathymetry systems. A multibeam swath echo sounder collected each data set. The data sets are not edited for anomalies as this was not included in the scope of work. The dates of the bathymetry surveys included in this evaluation are as follows:

- January 1991
- August 1991
- November 1991
- January 1992
- September 1993

The centerline alignments for the weirs were taken from a drawing titled Mississippi River Hydrographic Survey, Mile 22.1 To Mile 24.2, dated June 14, 1989 and prepared by Computer Aided Design & Drafting. This drawing was supplied by the U. S. Army Corps of Engineers, St. Louis District. These alignments were labeled proposed.

#### **Weir 24.2 (R)**

This weir is the first structure of the system that the river flow encounters. The next weir is located approximately 1,400 feet down river from Weir 24.2 (R). Over the transition periods of the study the general trend was slight to moderate deposition of material over the area surrounding the weir. This is excluding the short period from August 1991 to November 1991 where the data indicates the opposite is true. The most recent data shows the weir has directly influenced the deposition of material in the area from station 1+00 to 3+50 and from 0 to 100 feet right of the alignment.

The data does not indicate any major changes to the weir structure have taken place over the study period. There is no indication of structure loss due to scouring or of a trend that would affect the structure in the future.

### **Weir 23.9 (R)**

This is the second weir of the system. There is a weir approximately 1,400 feet up river and a weir approximately 1,400 feet down river from Weir 23.9 (R). Over the transition period from January 1991 to August 1991 the data indicates an area of scour from station 1+75 to 3+00 and 20 to 200 feet left of the alignment. There is also a trend of deposition of material over this time over the area from station 8+00 to the left descending bank. During the transition period from August 1991 to November 1991 a major area of scour developed. This area was oriented along the river flow and was located from station 8+00 to 13+00. There were also some small areas of scouring that developed near station 2+50 on the same orientation. There is little change over the next transition period of November 1991 to January 1992 except a streak of deposition at station 4+00. The last transition period, January 1992 to September 1993 shows some slight scouring of material from station 1+50 to 4+00 on the up river side of the weir and a corresponding area of deposition on the down river side of the weir. The data also indicates there is an area of deposition from station 15+00 to 13+00 moving into the river.

The data does not indicate any major changes to the weir structure have taken place over the study period. There is no indication of structure loss due to scouring or of a trend that would affect the structure in the future.

### **Weir 23.7 (R)**

This is the third weir of the system. There is a weir approximately 1,400 feet up river and a weir approximately 1,300 feet down river from Weir 23.7 (R). From January 1991 to August 1991 there was a small area of slight deposition that developed near station 7+25 and feathered out down river. There was also a small area of scouring at station 4+50 and 250

feet left of the alignment. From August 1991 to November 1991 there was a small area of scouring that evolved near station 3+50 and 200 feet right of the alignment. Also, during this period there was an area of scour from station 10+00 to 13+00. The next period, November 1991 to January 1992, there was some deposition of material down river of the weir near station 3+50 to 5+00 and 200 feet to 350 feet right of the alignment and a localized area of deposition centered near station 11+00. The last period of January 1992 to September 1993 indicates an area of major deposition that begins at the weir located from station 3+00 to 4+50 and trails off down river.

The data does not show any major changes to the weir structure have taken place over the study period. There is no indication of structure loss due to scouring or of a trend that would affect the structure in the future.

#### Weir 23.5 (R)

This is the fourth weir of the system. There is a weir approximately 1,300 feet up river and a weir approximately 700 feet down river from weir 23.5 (R). From January 1991 to August 1991 major scouring took place at two locations, near station 3+00 on the down river side of the weir and near station 6+00 and 250 feet left on the up river side of the weir. Also, during this time there was some slight deposition of material near station 11+00 to 13+00. The transition period from August 1991 to November 1991 essentially indicates just the opposite of the previous period. Data from November 1991 to January 1992 indicates a major area of deposition located from station 9+00 to 12+00 both up river and down river of the weir. The last transition period from January 1992 to September 1993 shows two major areas of scour, one up river of the weir 150 feet at station 5+50 and the second down river of the weir 300 feet at station 3+50. These two scour areas are separated by approximately 225 feet

with the weir located between them. The elevation change over this 225 feet starts at 255 feet then to 276 feet and back down to 255 feet. There is also a major area of deposition that starts at the weir between stations 2+00 to 3+00 and trails off down river for approximately 200 feet.

The data does not indicate any major changes to the weir structure have taken place over the study period. However, there is the possibility the scouring pattern observed over the last transition period could undermine the weir structure near station 4+75 if the two scour holes were to enlarge.

#### Weir 23.4 (R)

This is the fifth weir of the system. There is a weir approximately 700 feet up river and a weir approximately 700 feet down river from Weir 23.4 (R). From January 1991 to August 1991 there was major scouring immediately adjacent to the weir from station 1+00 to 2+00 both up river and down river. There was also slight deposition of material from station 10+00 to the northerly edge of data (station 11+00). During the second transition period from August 1991 to November 1991 the scouring trend continued on the up river side of station 3+00 to 4+00. This area seems to be an enlargement of the area mentioned above between stations 1+00 to 2+00. Major scouring was occurring at station 13+00 and 300 feet left of the alignment and continuing down river from there. The transition from November 1991 to January 1992 indicates some moderate deposition of material occurring through the scour area at station 13+00 mentioned previously. This trend was from the northerly extent (station 14+00) of the data to where it diminished near station 7+00. There was also a moderate scour hole that began to develop near station 4+00 and 300 feet right of the alignment. During the last transition period of January 1992 to September 1993 the deposition along the



left descending bank continued to migrate further toward the center of the river. There is also some deposition on the down river side of the weir immediately adjacent to it from station 1+00 to 5+00, with the main deposit feathering out down river 200 feet from station 4+00. The scour hole at station 4+00 and 300 feet right of the alignment continued to enlarge and deepen. A new scour hole also developed at station 4+00 to 6+00 and 300 feet left of the alignment. This hole continues down river to the weir where it runs along the base of the weir from station 1+00 to 7+00.

The data does not indicate any major changes to the weir structure have taken place over the study period. However, there is the possibility the scouring pattern observed over the last transition period could undermine the weir structure anywhere from station 1+00 to 7+00 if the scour hole were to deepen and enlarge.

#### Weir 23.3 (R)

This is the sixth weir of the system. There is a weir approximately 700 feet up river and a weir approximately 700 feet down river from Weir 23.3 (R). From January 1991 to August 1991 there was similar deposition of material along the left descending bank as with the previous weir. This deposition was from station 14+00 to 10+00 where it diminished. There was also slight scouring both up river and down river from weir station 6+00. A major scour hole developed near the right descending bank at station 0+50 and 250 feet right. During the transition from August 1991 to November 1991 the locations identified during the previous period were affected in the opposite manner, the deposition areas were scoured and material was deposited in the scoured areas. The period from November 1991 to January 1992 indicates there was a deposition of material from the left descending bank (station 15+00) to where it diminished near station 10+00. Also developing during this period were two major

scour holes at station 7+50 and 300 feet left and 300 feet right of the alignment. During the last transition period of January 1992 to September 1993 the deposition area continued to migrate from the left bank toward the center of the river. Another area of deposition also developed near station 1+00 and 300 feet right of the alignment. The two major scour holes from the earlier period deepened and enlarged. The large scour hole located on the up river side of the weir migrated to the base of the weir and scoured away portions of the weir near station 5+50.

The data indicates a partial breach to the weir structure took place over the study period near station 5+50. There is also the possibility the scouring pattern observed over the last transition period could undermine the weir structure even farther anywhere from station 4+00 to 7+00 if the scour hole were to deepen and enlarge.

#### Weir 23.2 (R)

This is the seventh weir of the system. There is a weir approximately 600 feet up river and a weir approximately 800 feet down river from Weir 23.2 (R). From January 1991 to August 1991 the general trend of deposition near the left bank on the previous weirs was also prevalent on Weir 23.2 (R). This deposition area diminished near station 10+00. Also during this time an area of deposition developed from station 4+00 to 5+00 and right of the alignment for approximately 200 feet. A third area of deposition developed from station 2+50 to 4+00 and left of the alignment for approximately 150 feet. Three major scour holes developed during this time. The first is located at station 8+00 near the base of the weir and grew deeper up river. The second is located from station 2+50 to 5+00 and 300 feet left of the alignment. The third is from station 1+00 to 3+00 immediately adjacent to the base of the weir and down river approximately 200 feet. From August 1991 to November 1991 the

area from station 10+00 to the left bank was moderately scoured. Material began depositing in the first and second scour holes identified during the last transition period. The third scour hole enlarged toward down river and is located near station 1+50 and 250 feet right of the alignment. The transition from November 1991 to January 1992 indicates a major area of deposition beginning from station 14+00 to 12+00 and 300 feet left of the alignment and feathering out down river. Also the scour hole located from station 7+50 to 11+00 and 300 feet left of the alignment enlarged and deepened over this transition period. During the last transition period from January 1992 to September 1993 the deposition of material near the left bank continued and enlarged toward the center of the river and down river from the previous period. Another area of deposition was at station 4+00 and 300 feet left of the alignment. A final area of deposition was located immediately next to the weir on the down river side of stations 2+00 to 4+00 and diminished approximately 150 right of the alignment. The area of scour from the previous period located near 300 feet left of station 7+50 continued to deepen and had enlarged to the base of the weir from station 5+50 to 8+50. Scouring also developed near the up river side of the weir from station 2+00 to 4+00. A small scour hole developed near 250 feet right of the alignment at station 1+50.

The data does not indicate any major changes to the weir structure have taken place over the study period. However, there is the possibility the scouring pattern observed over the last transition period could undermine the weir structure anywhere from station 2+00 to 8+00 if the scouring were to deepen and enlarge.

#### **Weir 23.1 (R)**

This is the eighth weir of the system. There is a weir approximately 800 feet up river and a weir approximately 700 feet down river from Weir 23.1 (R). From January 1991 to

August 1991 major scouring took place at three locations. The first was a major area adjacent to the down river side of the weir from station 8+00 to 9+00 and growing wider down river. The second is located from station 3+00 to 4+00 and 100 feet to 300 feet right of the alignment. The third is near 300 feet left of the alignment at station 4+50. Some slight deposition occurred from 200 feet right of the alignment at station 9+50 to 300 left of the alignment at station 11+00 and towards the left bank. From August 1991 to November 1991 the area of deposition near the left bank mentioned earlier was now beginning to scour. Material was beginning to deposit in the second and third scour locations from the earlier period. The third transition period from November 1991 to January 1992 indicates material was being deposited in the first scour hole described above. Two areas of scour also began to develop. The first was at station 6+50 and 200 feet right of the alignment. The second is located next to the down river side of the weir at station 4+00. During the final transition period of the study from January 1992 to September 1993 major deposition of material occurred from station 9+00 to the left bank. Deposition is also located on the down river side of the weir from station 1+50 to 3+00 for approximately 150 feet and from station 4+50 to 6+50 for approximately 300 feet. Two major scour areas developed during this time. One was located on the up river side of the weir from station 1+50 to 4+00. The second was from station 7+50 to 9+00 and 100 feet right of the alignment. The weir structure from station 7+75 to 9+00 was scoured away by this feature during this period.

The data indicates the section of the weir structure from station 7+75 to 9+00 was lost due to scouring during the study period. Continuing loss of the end of the weir structure is probable due to continued scouring. There is also the possibility the scouring pattern observed

over the last transition period could undermine the weir structure anywhere from station 2+00 to 4+00 if the scouring were to continue in that area.

### **Weir 23.0 (R)**

This is the ninth weir of the system. There is a weir approximately 700 feet up river and a weir approximately 700 feet down river from Weir 23.0 (R). From January 1991 to August 1991 there was a major scour area from station 8+50 to the left descending bank. There was also a moderate scour area next to the weir and up river from station 5+00 to 8+50 and adjacent to the weir and down river from station 6+50 to 8+50. Also, during this period a major area of deposition was located adjacent to the weir and down river from station 3+00 to 4+50. The second transition period indicates a major deposition of material over the major scour areas of the first transition period. During the transition period from November 1991 to January 1992 a major scour hole developed that was located adjacent to the up river side of the weir from station 7+00 to 12+00 and wrapped around the end of the weir to the down river side then continued down river. During the last transition period from January 1992 to September 1993 there was a significant amount of material deposited in the scour hole from the last period from station 9+00 to 12+00 and left of the alignment. There was also deposition of material adjacent to the weir from station 1+50 to 2+75 and down river approximately 150 feet. The scour area from the last period that wrapped around the weir on the down river side enlarged and deepened to the extent that it partially scoured away the weir from station 7+50 to 9+50.

The data indicates the section of weir structure from station 7+75 to 9+00 was lost due to scouring during this study. Continuing loss of the end of the weir structure is probable due to continued scouring.

## Weir 22.9 (R)

This is the tenth weir of the system. There is a weir approximately 700 feet up river and a weir approximately 600 feet down river from Weir 22.9 (R). From January 1991 to August 1991 there was major scouring adjacent to the weir and up river from station 9+00 to 12+00 and wrapping around to the down river side of the weir at station 8+50. Also, there were two areas of major deposition. The first was located adjacent to the weir on the down river side from station 2+50 to 4+00 and feathering out approximately 300 feet from the weir. The second is located from station 5+50 to 7+50 and 150 right of the alignment and on down river. The transition period from August 1991 to November 1991 indicates major deposition of material from adjacent to the weir on the up river side from station 6+00 to 12+00 and up river then wrapping around the end of the weir to station 8+50 and down river approximately 250 feet. During the transition period from November 1991 to January 1992 a major area of scour developed from adjacent to the weir at station 5+50 to 10+50 and extending up river. This area wrapped around the end of the weir to the down river side and extended to station 6+00 and right of the alignment for approximately 300 feet. Some minor deposition of material also occurred during this period from station 11+00 to 12+50 along the left bank of the river. During the last transition period from January 1992 to September 1993 the scour hole from the previous period located on the up river side of the weir migrated toward the left bank and was located from station 9+50 to 12+00 and 100 feet left of the alignment then up river. The scour hole previously located on the down river side of the weir migrated up river and partially scoured away the weir from station 8+50 to 9+50. Another area of scour developed 200 feet right of the alignment from station 2+00 to 3+00 and extended down river. An area of deposition also developed from station 11+50 to 13+00 and continued along

the left bank with the exception of an area of approximately 200 feet in length up river of station 13+00.

The data indicates that the section of the weir structure from station 8+50 to 9+50 was lost due to scouring during the study period. The continuing loss of the end of the weir structure is probable due to continued scouring.

#### **Weir 22.8 (R)**

This is the eleventh weir of the system. There is a weir approximately 600 feet up river and a weir approximately 600 feet down river from Weir 22.9 (R). From January 1991 to August 1991 there was major scouring from station 10+50 to the extent of the data (13+00). This extended up river and down river from the weir. There was also three major areas of deposition. The first two are located from station 5+00 to 10+00 and are adjacent to the weir. They extend from the weir in both directions, one up river and the other down river. The third area is located adjacent to the weir and extends down river from station 1+50 to 3+00. The second transition period indicates a moderate area of scour located from station 9+00 to 11+00 and extending down river. From November 1991 to January 1992 moderate deposition of material occurred from station 9+00 to 12+00 both down river and to a lesser extent up river. A moderate area of scour also developed near 300 feet left of the alignment at station 10+00. During the transition period from January 1992 to September 1993 there was slight scouring over the general area from the right descending bank to station 10+00 both up river and down river of the weir. There also was slight deposition of material from the left bank to station 10+50 both up river and down river.

The data does not indicate any major changes to the weir structure have taken place over the study period. There is no indication of structure loss due to scouring or of a trend that would affect the structure in the future.

#### Weir 22.7 (R)

This is the twelfth weir of the system. There is a weir approximately 600 feet up river and a weir approximately 1,400 feet down river from Weir 22.8 (R). From January 1991 to August 1991 there was moderate scouring of the area from station 12+50 to 13+50 both up river and down river of the weir. There was also a major area of deposition located adjacent to the weir and up river from station 8+00 to 11+50. Slight deposition of material was also located next to the weir and down river from station 9+50 to 11+50, and 200 feet left of the alignment at station 5+00 and 200 feet right of the alignment at station 2+00. During the period from August 1991 to November 1991 there was slight scouring of the area up river and down river from station 10+00 to 14+00. There was also moderate deposition of material adjacent to the weir and up river from station 2+00 to 3+50. During the transition period from November 1991 to January 1992 there was moderate deposition of material up river and down river from station 8+50 to 14+00. The last transition period from January 1992 to September 1993 indicates a general slight scouring of material up river from the weir from station 1+00 to 9+00. This slight scouring is also located down river from the weir from station 1+00 to 4+00. A moderate scour hole developed during this time near station 7+00 and 150 feet right of the alignment. The data also indicates a slight to moderate deposition of material from station 11+00 to 14+00 both up river and down river from the weir.



The data does not indicate any major changes to the weir structure have taken place over the study period. There is no indication of structure loss due to scouring or of a trend that would affect the structure in the future.

#### Weir 22.45 (R)

This is the thirteenth and last Weir of the system. There is a weir approximately 1,400 feet up river from weir 22.45 (R). From January 1991 to August 1991 there was slight scouring of the area from station 13+50 to 14+50 both up river and down river from the weir. There was also slight scouring of material located down river from station 6+00 to 8+00. During the transition period from August 1991 to November 1991 the scouring trend continued and expanded to include the area from station 11+50 to 14+00 both up river and down river from the weir. An area of slight deposition also developed from station 7+50 to 9+50 that extended up river and down river. From November 1991 to January 1992 the deposition area mentioned from the last transition period began to scour slightly. There was also an area of slight scour that developed adjacent to the weir on the up river side from station 2+00 to 5+50. An area of deposition developed from station 12+00 to 14+00 that extended up river and down river. During the transition period from January 1992 to September 1993 the major trend over the area of the weir was the deposition of material except for a scour hole located near station 11+50. Material was deposited from the left bank to station 7+50 both up river and down river.

The data does not indicate any major changes to the weir structure have taken place over the study period. There is no indication of structure loss due to scouring or of a trend that would affect the structure in the future.

## Summary

The first, second and third weir structures of the Dogtooth Bend Weir System have not experienced any damage over the evaluation period of this study. There have been minor events of scouring and deposition of material surrounding these weirs but the structures have not been adversely affected, nor is there evidence to support a threat of damage if the current conditions prevail.

Major scouring and deposition events have taken place surrounding the next seven weirs. The fourth and fifth weirs of the system have not yet sustained noticeable damage but could possibly do so if the most recent scouring events identified continue. The sixth weir of the system has been damaged by a scouring event that has partially breached the structure. Further damage to this weir is probable if the scouring event persists. The seventh weir of the system has not suffered any damage as of yet. If the latest scouring event perseveres, it is likely there will be damage of either a partial breach or loss of the end of the weir due to scour. The eighth, ninth and tenth weirs have sustained damage due to scouring. The eighth and ninth weirs have lost approximately 125 feet off the end of the structures while the tenth weir has lost approximately 100 feet off the end of it. The continuing loss of the end of these three weirs is expected due to the major scouring event that has persisted over the time frame of this study. The eleventh, twelfth and thirteenth weirs of the system and the surrounding area have evolved similarly to the first three weirs. There have been minor events of scouring and deposition of material but no damage to the structures has occurred. There is no evidence that suggests any threat of damage to these structures if the current pattern persists.