Des Moines River Basin Master Reservoir Water Control Manual

Des Moines River, Saylorville Lake & Lake Red Rock





December 2019

US Army Corps
of Engineers
Rock Island District

MASTER WATER CONTROL MANUAL

DES MOINES RIVER BASIN

SAYLORVILLE LAKE / LAKE RED ROCK

U.S. ARMY CORPS OF ENGINEERS
MISSISSIPPI VALLEY DIVISION
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

OCTOBER 1989
REVISED DECEMBER 2019

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REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during non-duty hours, contact the duty forecaster at the phone number listed in the daily instructions email or the Chief, Water Control Section at [redacted].

DES MOINES RIVER
SAYLORVILLE LAKE/LAKE RED ROCK

Des Moines River Basin Minnesota and Iowa

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
REVISION DECEMBER 2019

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B	Saylorville Lake Water Control Manual, December 2019
C	Drought Contingency Plan for Lake Red Rock and Saylorville Lake, October 1996.

SAYLORVILLE LAKE

PERTINENT DATA

Location	Des Moines River, River mile 213.7, Polk County, Iowa.
Drainage Area	5,823 square miles
Volume of 1-inch of runoff	310,560 acre-feet
Uncontrolled drainage area	4,038 square miles dam to control point

DAM EMBANKMENT

Type	Rolled Earth-fill with Riprap Slope Protection.
Height	915.5 Feet NGVD (125 feet above streambed)
Length	6,750 feet
Top width	44 feet

OUTLET FACILITIES

Type of outlet	One Circular Concrete Conduit with one Intake Tower.
Conduit Diameter	22 feet
Type of service gates	3 electrically operated, each open 8ft wide by 19 feet.

SPILLWAY

Type	Controlled pneumatic crest gates mounted on a concrete chute spillway
Crest elevation	884 feet NGVD
Number and size of gates	5 gated sections, (2-80 ft wide outside sections and 3-90 ft wide center sections)
Top elevation of pneumatic gates	Inflated: 890 feet NGVD; Deflated 884 feet
Real estate guide taking lines (fee title)	892 feet NGVD

Pertinent Elevation-Area-Discharge Data

Description	Elev NGVD Ft	Surface Area Acres *	Incremental Storage Ac-Ft *	Elev. Band Ft	Maximum Spillway Capacity Ft^3/S	Maximum Outlet Capacity Ft^3/S
Top of Surcharge Pool	908	25,560	574,000	890-908	213,700	24,000
Top of Flood Control Pool	890	15,990	561,800	836-890	21,000	22,000
Top of Conservation Pool	836	4,970	64,650	793-836	N/A	12,500

* Based on 2014 area and volume computations. At request of IA DNR, the conservation pool may vary between elevations 836 and 840 from 15 September to 01 March.

All elevations listed in this report pertaining to Saylorville Lake are referenced to NGVD29 datum. To convert NGVD29 to NAVD88 datum, add 0.14 feet.

LAKE RED ROCK

PERTINENT DATA

Location	Des Moines River, River mile 142.9, Marion County, Iowa.
Drainage Area	12,323 square miles
Volume of 1-inch of runoff	657,230 acre-feet

DAM EMBANKMENT

Type	Rolled Earth-fill with riprap protection.
Height	797 Feet NGVD (110 feet above streambed)
Length	5,841 feet
Top width	44 feet

OUTLET FACILITIES

Type of outlet	Rectangular concrete conduits through the spillway structure.
Type of service gates	14 hydraulically operated slide gates, each 5 feet wide by 9 feet high.

GATED SPILLWAY

Type	Ogee weir with tainter gates and stilling basin.
Crest elevation	736 feet NGVD
Number and size of gates	5 tainter gates, each41 feet wide x 46 feet high
Stilling Basin	241 feet wide x 180 feet long
Real estate guide taking lines	760 feet NGVD fee title, 783 flowage easement

Pertinent Elevation-Area-Discharge Data

Description	Elev NGVD Ft	Surface Area Acres *	Incremental Storage Ac-Ft *	Elev. Band Feet	Maximum Spillway Capacity Ft^3/S	Maximum Outlet Capacity Ft^3/S
Top of Surcharge Pool	791.6	85,700	756,700	780-790	378,000	40,000
Top of Flood Control Pool	780	66,800	1,463,300	742-780	225,000	37,700
Top of Pool Conservation	742	14,870	185,500	700-742	9,200	27,000

* Based on 2011 area and volume computations.

Seasonal Variation: The normal conservation pool elevation is 742 feet NGVD. At request of IA DNR, the conservation pool may vary between elevations 741.5 and 747 feet from 15 September to 01 March.

All elevations listed in this report pertaining to Lake Red Rock are referenced to NGVD29 datum. To convert NGVD29 to NAVD88 datum, add 0.08 feet.

UPPER MISSISSIPPI RIVER BASIN
DES MOINES RIVER BASIN, IOWA AND MINNESOTA
MASTER WATER CONTROL MANUAL

I - INTRODUCTION

1-01. Authorization. The Des Moines River Master Water Control Manual has been prepared in accordance with directives contained in:

a. Engineering Manual, EM 1110-2-3600, Management of Water Control Systems, 10 October 2017.
b. Engineering Regulation, ER 1110-2-8156, Preparation of Water Control Manuals, 11 December 2018.

1-02. Purpose and Scope. This manual provides pertinent regulation information relative to the project features of the Saylorville Lake and Lake Red Rock projects located on the Des Moines River, Iowa.

1-03. Related Manuals and Reports. The titles of related manuals and reports appear in appendices A (Lake Red Rock) and B (Saylorville Lake) to this manual. An abbreviated list is given below.

a. Appendix A of Des Moines River Basin Master Water Control Manual, Lake Red Rock, December 2019
b. Appendix B of Des Moines River Basin Master Water Control Manual, Saylorville Lake, December 2019.
c. Appendix C Master Reservoir Regulation Manual Drought Contingency Plan for Lake Red Rock and Saylorville Lake, October 1992.
d. Des Moines River Basin Master Regulation Manual, October 1989

1-04. Project Owner. The United States Government is the owner of the Saylorville Lake and Lake Red Rock Projects.

1-05. Operating Agency. The U.S. Army Corps of Engineers (USACE) is responsible for the operation of the Saylorville Lake and Lake Red Rock Projects.

1-06. Regulation Agency. The USACE, Rock Island District, as owner of the projects, has direct responsibility for regulating the projects for the authorized purposes of flood risk management, low flow augmentation, water supply, and fish and wildlife management. While the projects are not regulated to support recreation, recreation is an authorized purpose at both projects. The Rock Island District Water Control Section issues operating instructions and hydrologic forecasts for the projects.

1-07. Vertical Datum. NGVD29 was the datum used in the design and construction of the Saylorville Lake and Lake Red Rock projects. In order to convert the datum to NAVD88, 0.14 feet should be added to Saylorville Dam elevations and 0.08 feet should be added to Red Rock Dam elevations. All elevations that are referred to in this report are referenced to NGVD.

II – BASIN DESCRIPTION AND CHARACTERISTICS

2-01. Location. The Des Moines River Basin originates in southwestern Minnesota. It extends southeasterly across west-central Iowa to its confluence with the Mississippi River near Keokuk, Iowa. The major sub-basins are long and narrow with streams generally flowing northwest to southeast. The Des Moines River Basin includes all or part of 39 counties in Iowa, seven counties in Minnesota and one county in Missouri. The basin is approximately 535 miles in length and has a total drainage area of 14,470 square miles.

Major tributary sub-basins to the Des Moines River include the West Fork Des Moines River, East Fork Des Moines River, Boone River, North Fork Raccoon River, South Fork Raccoon River, North River, Middle River, South River and Whitebreast Creek. Table 2-1 lists the drainage area contributions for each of these referenced sub-basins.

Average slope of the Des Moines River ranges from two to three feet per mile upstream of Red Rock Dam and 1.3 to 1.6 feet per mile downstream of the dam.

TABLE 2-1

MAJOR SUB-BASINS IN THE DES MOINES RIVER WATERSHED

Sub-basin Watershed	Drainage Area At Mouth (Square Miles)
West Fork Des Moines River	2,308
East Fork Des Moines River	1,315
Boone River	906
North Fork Raccoon River	2,298
South Fork Raccoon River	1,143
North River	400
Middle River	558
South River	590
Whitebreast Creek	430

Saylorville Lake covers parts of Polk, Dallas, and Boone counties in central Iowa. The dam is at river mile 213.7 on the Des Moines River. It is within Polk County, about 10 miles north of the City of Des Moines.

Lake Red Rock is located in parts of Marion, Warren, Jasper, and Polk Counties, Iowa. Red Rock Dam is located 142.9 miles above the mouth of the Des Moines River, about 60 miles downstream from the City of Des Moines, and about 70 miles downstream of Saylorville Dam. Figure 2-01 is a general map of the Des Moines River Basin showing the location of the Saylorville Lake and Lake Red Rock Projects.

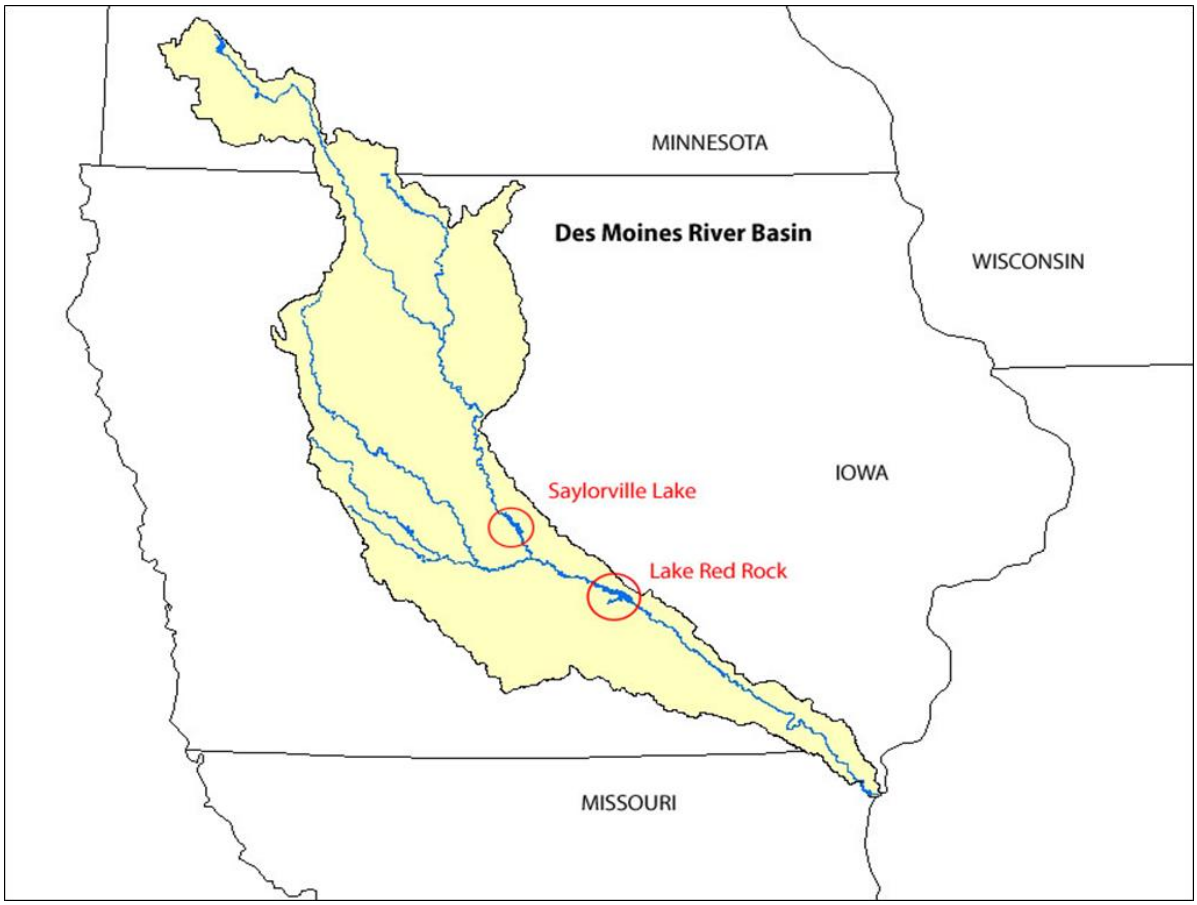


Figure 2-1

2.02. Geology and Topography. The geologic formations are of two types, marine and continental deposits. They differ widely in character, origin and age. The underlying rock consists principally of shale and limestone deposited many millions of years ago while the area was beneath shallow seas. These sediments have since changed to hard rock. After the area was uplifted above the sea at the end of the Cretaceous period, the bedrock surface underwent extensive alteration by erosion.

The present surficial features have been developed by several stages of advancement and regression of continental glaciers over the bedrock erosional surface. The last continental glaciation to completely cover the basin was known as the Kansan stage. When the ice receded, the area was covered by a relatively level drift plain and a deep soil developed on the upland surface. Water and wind erosion have since dissected this plain until only remnants of the original surface remain. Following this, a layer of wind-blown silt called loess was deposited over most of Iowa. The loess probably had its origin in the flood plain of the Missouri River, although loess derived from flood plains adjacent to interior rivers and streams is present.

At about the same time as the loess deposition, a final stage of glaciation called the Wisconsin covered the northern half of the basin. The glacier advanced to about the present location of Des Moines and is known as the Des Moines Lobe. When it retreated, it left behind a drift plain similar to that left after the Kansan.

The land surface of Des Moines Lobe, however, has undergone little modification since the retreat of the ice sheet. The two landform regions relating directly to the Wisconsin and Kansan drift areas are quite different and the transition between the two is abrupt. The area covered by the Wisconsin drift is quite youthful and is characterized as relatively flat with numerous shallow depressions. In places, relatively impermeable materials inhibit infiltration resulting in shallow lakes and marshes. South of Des Moines, the topography is much more mature. The upland areas are well dissected by numerous streams so that only remnants of the original drift plain remain as comparatively narrow ridgetops. The area is described as moderately to steeply rolling hills interspersed with areas of uniformly level upland divides and level alluvial lowlands.

2-03. Soils. The Des Moines River Basin covers an area that extends from the southwest corner of Minnesota to the southeast corner of Iowa and the northeast corner of Missouri. It includes all or parts of 47 counties. There are many types of soil. The dendritic drainage pattern is controlled in most places by thick glacial till, but in some places limestone bedrock and shale outcrop in the stream valleys. The soils of the basin can be broadly grouped on the basis of parent materials and native vegetation. The upper half of the basin is dominated by Wisconsin glacial till-derived soils developed under a native vegetation of prairie grasses. The lower half consists of soils derived from Kansan glacial till on the steeper slopes and loess on the ridge tops and gently sloping areas. Both prairie and forest vegetation has influenced soil development in these parent materials. Forest vegetation was commonly adjacent to the major streams. Detailed information about the individual soils is available in published county soil survey reports.

2-04. Climate. The annual precipitation over the Des Moines River Basin is approximately 36 inches. About 70 percent of precipitation occurs during the six-month period from April through September. The mean annual snowfall over the basin is about 35 inches. The average temperature is 51 degrees, ranging from 17 degrees during the winter to 74 degrees during the summer. Mean annual lake evaporation is about 36 inches. The 7-day, 10-year low flow at the Saylorville dam site is 140 cfs. and at the Red Rock dam site 255 cfs.

Table 2-2 lists the normal temperature and precipitation at Fort Dodge, Des Moines, and Keokuk, Iowa for the period from 1981 through 2010.

Table 2-2

Fort Dodge Normal Temperature and Precipitation 1981-2010

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Max °F	26.5	31.8	44.7	60	71	80.6	83.9	81.5	74.5	61.7	44.9	29.6	57.7
Min °F	7.9	12.4	24.2	35.6	48.2	58.3	62.6	60.5	50.5	38.3	25.2	12.3	36.5
Mean °F	17.2	22.1	34.5	47.8	59.6	69.4	73.2	71	62.5	50	35.1	21	47.1
Precip (in.)	0.92	0.8	2.07	3.35	4.1	4.9	4.68	4.69	2.89	2.1	1.79	1.26	33.55

Des Moines Normal Temperature and Precipitation 1981-2010

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Max °F	31	36.1	49	62.3	72.4	81.6	85.7	83.8	76.1	63.1	47.9	34	60.4
Min °F	14.3	18.8	29.7	41.1	52.2	62	66.8	64.8	55.2	43	30.5	18	41.5
Mean °F	22.6	27.4	39.3	51.7	62.3	71.8	76.3	74.3	65.6	53.1	39.2	26	50.9
Precip (in.)	1.00	1.28	2.3	3.86	4.74	4.94	4.47	4.13	3.05	2.64	2.19	1.42	36.02

Keokuk Normal Temperature and Precipitation 1981-2010

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Max °F	34	38.9	50.4	63.3	73.2	82.6	86.6	85.1	77.7	65.8	51.2	37.2	62.3
Min °F	17	20.4	30.4	42	52.4	62.3	66.8	64.9	55.7	44.2	33	20.9	42.6
Mean °F	25.5	29.6	40.4	52.6	62.8	72.5	76.7	75	66.7	55	42.1	29	52.4
Precip (in.)	1.38	1.63	2.58	3.76	5.17	4.83	4.27	3.63	3.61	3.33	2.89	2.12	39.2

2-05. Storms and Floods. Records of flood flows at several points on the Des Moines River have been kept for varying periods intermittently since 1903. Stages were recorded at Des Moines, Iowa, as early as 1893. A search of newspaper files and historical records indicates that prior to 1903, floods of major proportions occurred in June 1851, June 1858, April 1862, June 1865, July 1869, July 1875, April 1876, July 1881, April 1888, May 1892, April 1897, and July 1902. Of these floods, the June 1851 flood apparently was the greatest and most destructive. Several of the larger floods are described in the following paragraphs along with more recent floods.

a. Flood of May-June 1903. The first flood for which actual records are available occurred in May and June 1903, and only partial records are available for this flood. The flood stage exceeded that for 1851 by several feet at Keosauqua, Iowa. The storm series producing this flood followed the same general pattern as that for 1851. Several weeks of extremely wet weather were climaxed by heavy rainfall from 24 through 31 May. Precipitation was fairly uniform over the entire watershed although the greatest intensities were reported in the central part of the basin. Flooding in 1903, as in 1851, was not confined to the Des Moines River Basin, but occurred on a number of other watersheds. Severe flooding occurred on the Mississippi River. The peak discharge of the 1903 flood at Des Moines, Iowa (2nd Avenue gage), was 42,000 cfs on 31 May 1903. Prior to the floods of 1944 and 1947, the peak discharge of the 1903 flood at Keosauqua had been estimated as 94,000 cfs by the U.S. Geological Survey. On the basis of discharge measurements made during the floods of 1944 and 1947, the peak discharge of the 1903 flood at Keosauqua has been revised to 146,000 cfs occurring on 1 June 1903. The crest flow at Tracy, Iowa, has been estimated at 130,000 cfs on 31 May 1903.

b. Flood of June 1935. The rainfall of June 1935 was one of the heaviest on record for June, and it was preceded by frequent heavy rains in May. There were four consecutive crests of bank-full or higher stages which occurred below Des Moines and moved down past Ottumwa. The third of these crests was the highest and reached a stage of 15.4 feet at Ottumwa on 28 June 1935. On the lower Des Moines, damaging flood conditions were reported for three periods during the month. The maximum discharge at Ottumwa was 53,200 cfs on the 28th, and the maximum discharge at Keosauqua was 54,400 cfs occurring on the 29th with a stage of 25.9 feet. Note, the datum for this gage was changed from elevation 557.36 NGVD to elevation 547.36 NGVD, adding 10 feet to previously reported gage heights. For this and the following flood descriptions, the 547.36 datum is used. No severe flooding occurred on the Des Moines River above Des Moines, Iowa.

c. Flood of September 1938. A severe late summer flood occurred on the upper Des Moines and Boone Rivers in September 1938. The flood was caused by two periods of rainfall, each several days long, which occurred during the first half of the month over the upper portion of the Des Moines River Basin. The crest flow of the Des Moines River at Boone, Iowa, was 24,500 cfs on 18 September 1938. The Des Moines River at Des Moines, Iowa (2nd Avenue gage), had a peak discharge of 24,800 cfs on 20 September 1938.

d. Flood of May-June 1944. Flooding in May and June 1944 resulted from prolonged periods of wet weather. In view of the damage caused and the general extent of the areas flooded, the 1944 floods are considered as major floods. Each of the 1944 flood crests appeared to be the accumulative result of several periods of rainfall rather than runoff from a single, heavy rainfall. The average precipitation for Iowa during May was approximately 2 inches above normal while precipitation for June was about one inch above normal. The storm patterns were regional and not confined to the Des Moines River Basin. Severe flooding on other tributaries, combined with that on the Des Moines River, synchronized to result

in Mississippi River stages of record levels at some localities. The Des Moines River at Des Moines, Iowa (2nd Avenue gage), had a peak discharge of 34,000 cfs on 23 May 1944. The Des Moines River below the Raccoon River, at Des Moines, Iowa (Scott Street gage), crested with a discharge of 53,200 cfs on 24 May 1944. At Ottumwa the crest stage of 17.7 feet occurred on 24 May, with a peak discharge of 73,200 cfs. At Keosauqua the maximum discharge was 72,300 cfs on 25 May corresponding to a crest stage of 28.3 feet.

e. Flood of June 1946. The lower basin flood of June 1946 was caused by a three day burst of excessive rainfall over the southeastern portion of Iowa. Amounts ranging from approximately 6 inches to almost 8 inches in a 24-hour period were reported by several observers in the area. The crest flow at Keosauqua, Iowa, was 78,300 cfs on 18 June, corresponding to a crest stage of 29.5 feet. Lesser rainfall amounts occurred over the central and upper basin. Ottumwa experienced a maximum discharge of 43,300 cfs on 20 June corresponding to a stage of 13.6 feet. No severe flooding occurred on the Des Moines River above Des Moines, Iowa.

f. Floods of June 1947. The floods of June 1947 exceeded all previous records at a number of points within the Des Moines River Basin. The flooding was caused by several bursts of moderately heavy and comparatively widespread rainfall. Heaviest rainfall concentrations were over areas south and west of Des Moines, Iowa, and immediately west of Fort Dodge, Iowa. Prior to these storms, May had been characterized by intermittent rainfall from the 12th through the 31st. This resulted in the average monthly precipitation over the lower and central portions of the Des Moines River Basin being 0.50 to 2.00 inches above normal for the month of May. Flooding in June 1947 was widespread, as in the earlier major floods of 1851 and 1903. Regional storms extending over several weeks caused many tributaries to reach record or near record stages. Mississippi River stages in some areas reached record levels. The Des Moines River at Des Moines, Iowa (2nd Avenue gage), crested on 26 June 1947 with a discharge of 39,500 cfs. The Raccoon River at Van Meter, Iowa had a maximum discharge of 41,200 cfs on 13 June 1947. This was the greatest discharge of record at Van Meter. However, a second peak occurred at Van Meter with a peak discharge of 39,700 cfs on 25 June 1947. The Des Moines River below the Raccoon River at Des Moines, Iowa (Scott Street Gage), had a maximum discharge of 77,000 cfs on 26 June 1947. At Ottumwa the peak discharge was 135,000 cfs on 7 June with a crest stage of 20.2 feet, the highest on record. At Keosauqua the maximum discharge corresponding to the 7 June flood at Ottumwa was 123,000 cfs on 8 June; however, a second flood that occurred about a week later resulted in a slightly higher crest flow at Keosauqua amounting to 124,000 cfs on 16 June, corresponding to a maximum stage of 25.1 feet.

g. Flood of June 1954. The flood of June 1954 exceeded many prior records at and upstream of Des Moines, Iowa (2nd Avenue gage). A series of thunderstorms developed over the upper Des Moines River Basin during the period 1-21 June. A severe thunderstorm began on 17-18 June in the Spencer-Estherville area, culminating with 5.63 inches of precipitation in 24 hours in Fort Dodge reported on the morning of 21 June. From 18 to 22 June, Britt, Iowa, in the headwaters of the Boone River, reported 11.91 inches of rain. The major rise on the Des Moines River, arriving at Fort Dodge simultaneously with severe local thunderstorm activity, produced record-breaking stages and flows from Fort Dodge to Des Moines. Crest flows from the Raccoon River at Van Meter peaked on 25 June at 20,800 cfs. The Des Moines River at Des Moines, Iowa (2nd Avenue gage), crested on 24 June at 60,200 cfs, the greatest of record. The combined Raccoon-Des Moines flow crested at Des Moines River below the Raccoon River (Scott Street Gage) at 67,300 cfs on 24 June. Flow contributions from the tributaries downstream of Des Moines were negligible. The peak flow at Ottumwa was 61,400 cfs on the 28th corresponding to a

peak stage of 16.9 feet. At Keosauqua, the maximum discharge was 60,800 cfs corresponding to a peak stage of 26.1 feet.

g. Flood of March-April 1960. The late winter and spring of 1960 was unusually severe. The average temperature for March was the coldest on record. Entering the month of March, snow covered the entire basin, with additional snowfall occurring during the month. At the end of March, Des Moines had its heaviest snowpack since 1912. Keosauqua had a record total snowfall of 52 inches for the winter. In late March and early April, a sudden temperature rise into the 50's lasting several days coupled with rainfall of about 0.50 inches produced a rapid snowmelt of the snowpack which had a water content of about 1.5 inches. The flow for the Raccoon River at Van Meter peaked on 2 April 1960 at 32,300 cfs. The Des Moines River at Des Moines, Iowa (2nd Avenue gage), peaked on 1 April 1960 at 36,200 cfs while the combined Raccoon-Des Moines flow crested at Des Moines (SE 14th Street gage), peaked at 68,900 cfs on 2 April 1960. At Ottumwa, the river crested at a 17.5-foot stage on 1 April, corresponding to a discharge of 70,500 cfs. At Keosauqua the peak discharge occurred on 2 April at 73,800 cfs corresponding to a crest stage of 28.3 feet.

h. Flood of April 1965. The flood of April 1965, like that of 1960, was caused by snowmelt runoff augmented by rainfall. December 1964 was very cold, contributing to significant frost depths. The winter was the coldest in 30 years overall. Heavy accumulations of snow developed over the central and upper portions of the Des Moines River Basin. At the end of March, the water content of the snow cover over the watershed above Des Moines, Iowa, averaged from 2 to 4 inches. Rapid snowmelt began during the first week of April with temperatures in the 50's and 60's, and rainfall totaling about 1.0 to 1.5 inches. The Raccoon River at Van Meter, Iowa, crested on 6 April at 22,300 cfs. The Des Moines River at Saylorville, Iowa, crested on 10 April 1965 at 47,400 cfs while the combined Raccoon-Des Moines flow at Des Moines, Iowa (SE 14th Street gage), reached 65,500 cfs on 11 April 1965. The river crested at Ottumwa on 11 April at a stage of 18.3 feet, corresponding to a peak discharge of 78,600 cfs. At Keosauqua the river crested on 12 April at a stage of 29.4 feet, corresponding to a peak discharge of 79,800 cfs. The flood was noteworthy for its long, broad crest. At Keosauqua the flow stayed between 72,000 cfs and 79,000 cfs over a five day period, 11-15 April inclusive. Flooding on the Mississippi River was the highest on record, as snowmelt and rainfall runoff from the Upper Mississippi River Basin tributaries combined to produce record stages from St. Paul, Minnesota, to Hannibal, Missouri.

i. Flood of March-April 1969. The winter of 1968-1969 was one of the most severe winters on record for the Upper Des Moines River Basin in terms of icing conditions, below normal temperatures, and unusually heavy snow accumulation. Approximately 75 percent of the accumulated winter's precipitation was still present in the snowpack at the end of March. The melting of the snowpack for most of the Des Moines River Basin began the second week of March; however, the upper portion of the Des Moines River Basin did not begin its snowmelt until the first week of April. The Raccoon River at Van Meter, Iowa, crested on 25 March at 22,800 cfs. The West Fork Des Moines River at Estherville, Iowa, crested on 12 April at 16,000 cfs. This was a record discharge. The Des Moines River at Saylorville, Iowa, had two crests. The first crest was 21,800 cfs on 27 March, and the second crest was 23,800 cfs on 18 April 1969. The combined Raccoon-Des Moines flow crested at Des Moines (SE 14th Street gage) at 41,200 cfs on 27 March 1969. At Ottumwa, the river crested at 11.6 foot stage on 17 April, corresponding to a discharge of 32,200 cfs. At Keosauqua the peak discharge occurred on 19 April with a flow of 39,800 cfs corresponding to a crest stage of 21.8 feet. Later in the summer, Lake Red Rock reached an elevation of 764.82 on 2 August 1969. This was the first year in which reservoir operation modified downstream flows.

j. Flood of April 1979. The flood of April 1979, like that of 1965, was caused by snowmelt runoff augmented by rainfall. In February 1979, the flood potential was high due to above normal snow cover. Warmer weather conditions reduced the water content of the snowpack by late February and thus reduced the flood potential considerably. However, flooding still occurred as the Des Moines River. At Stratford, Iowa, a stage of 21.59 feet on 31 March 1979 was recorded, and was over the 14-foot flood stage for 25 days in late March and early April. The peak average daily inflow to Saylorville Lake was 28,800 cfs, occurring on 1 April 1979. Saylorville Reservoir's flood control capabilities were utilized during March, July and again in August and September. The maximum lake level was 883.81 feet NGVD on 5 April 1979. This was the highest pool elevation since Saylorville Dam began ponding water on 2 July 1975. The maximum elevation utilized 82 percent of the available flood control storage. The operation of Saylorville Reservoir reduced the peak stages at 2nd Avenue in Des Moines by 2.8 feet and Southeast 14th Street in Des Moines by 3.8 feet. The peak average daily inflow into Lake Red Rock was 50,700 cfs occurring on 23 March 1979. During this flood the reservoir rose to a peak elevation of 767.28 feet on 10 May 1979. The Saylorville Lake was operated in tandem with Lake Red Rock for this flood. At Ottumwa the peak stage of 11.3 feet occurred on 20 April corresponding to a flow of 33,400 cfs. At Keosauqua the peak discharge also occurred on 20 April with a flow of 38,500 cfs and a corresponding crest stage of 21.5 feet.

k. Flood of July 1982. Winter snowfall was above normal at most stations in the Rock Island District. Des Moines, Iowa recorded 62.9 inches of snowfall, which is 189 percent of normal. Above freezing temperatures at the end of February left the Rock Island District with a minimal snowpack. Above normal precipitation in March and April, coupled with snowmelt, produced moderate flooding in the spring. Following the spring runoff period, the precipitation exceeded normal every month, except August and September, in the Mississippi River Basin. Saylorville Lake and Lake Red Rock were above conservation pool from February through August 1982. The most significant flood event occurred in July 1982 when intense rains caused extreme flooding downstream of Lake Red Rock. Monroe County, Iowa, took the brunt of two storms, receiving about 7-inch rains on both 3 July and 16 July and nearly 2 feet of rain during that two-week period. Cedar Creek near Bussey, Iowa, which enters the Des Moines River below Red Rock Dam, responded with floods with peak discharges of 100,000 and 80,000 cfs on the 3rd and 16th of July. The maximum lake level for Saylorville Lake was elevation 855.55 feet NGVD on 28 July 1982. The operation of Saylorville Dam reduced the peak stage at the Des Moines 2nd Avenue gage by 2.0 feet and the Des Moines SE 14th Street gage by 1.9 feet. The maximum lake level for Lake Red Rock was elevation 757.11 feet NGVD on 19 July 1982. The tandem operation of Saylorville and Red Rock reservoirs reduced the peak stage at Tracy, Iowa by 10.9 feet; at Ottumwa, Iowa by 7.6 feet, and at Keosauqua, Iowa by 6.6 feet. Near record stages on the Des Moines River below Lake Red Rock would have been reached had the two reservoirs not been constructed and in operation. The tandem operation of Saylorville and Red Rock Reservoirs during the two July flash flood events prevented $48,400,000 worth of damage downstream of Red Rock Dam.

l. Flood of Summer 1983. The significance of this season was commencement of flood storage in Lake Red Rock in mid February 1983 and continuous utilization of the flood storage until the end of August 1983. The maximum level of Lake Red Rock was 774.0 feet, N.G.V.D., on 29 May 1983. This was 76 percent of the available flood control storage. The pool was above elevation 760 feet from April 1983 through July 1983. The operation at Saylorville reduced the peak stage in Des Moines at both the 2nd Avenue gage and the SE. 14th Street gage by 2.8 feet, utilizing 80% of the available flood control

storage. The tandem operation of Saylorville and Red Rock reservoirs reduced the peak stage at Tracy, Iowa, by 8.8 feet; at Ottumwa, Iowa by 4.8 feet; and at Keosauqua, Iowa by 4.4 feet.

m. Flood of June 1984. The April-June rainfall in Iowa was 16.9 inches and ranked as the second highest amount for these months in 112 years. The maximum rainfall for this period, 19.3 inches, occurred in 1947. The 1984 flood was the largest volumetric flood that had occurred since 1917 and prior to 1993. The volume surpassed even the record-setting 1947 flood by 50 percent. The 1984 flood volume was about 6 million acre-feet as compared to 4 million acre-feet during the 1947 flood. Saylorville and Red Rock Reservoirs used their flood control capabilities from April through August 1984. The most significant flood event occurred in June 1984 when approximately 5 feet of water went over the concrete and earthen spillway at Saylorville Lake. The maximum lake level for Saylorville Lake was elevation 889.25 NGVD on 22 June 1984. This was the highest elevation attained since the dam was placed in operation in 1977 and utilized 98 percent of the available flood control storage. It was also the first time the emergency spillway was used. The operation of Saylorville reservoir reduced the peak stage at the Des Moines 2nd Avenue gage by 2.6 feet. The maximum lake level for Lake Red Rock was elevation 779.61 feet NGVD on 25 June 1984. This was the highest elevation ever attained at this project since Lake Red Rock was placed into operation in 1969, and utilized 98 percent of the available flood control storage. The tandem operation of Saylorville and Red Rock Reservoirs reduced the peak stage at Tracy, Iowa, by 3.9 feet, at Ottumwa, Iowa, by 4.1 feet, and by 6.9 feet at Keosauqua, Iowa. The tandem operation of Saylorville and Red Rock Reservoirs prevented $17,500,000 worth of damage downstream of Saylorville ($5,500,000) and Red Rock ($12,000,000) during 1984.

n. Flood of May-June 1991. The first half of 1991 was the second wettest in 117 years of record. Storms tracked over the same area for several weeks resulting in very saturated soil conditions and high runoff. The Des Moines River at Stratford, Iowa, gaging station was above its 14-foot flood stage for a duration of 76 days during 1991. This long duration of flooding caused Saylorville Lake to rise to an elevation of 889.07 feet NGVD which represents 96 percent of the flood control storage. This was the second highest level since the dam went into operation in 1977. The spillway at Saylorville Lake was used from June 6 through 15. Lake Red Rock utilized 97 percent of its flood control storage with the pool reaching a level of 779.30 feet NGVD on 18 June 1991, which ranks as the second highest since the dam went into operation. Flood stage reductions were 3.1 feet in Des Moines, between 3 and 8 feet below Red Rock and about one foot on the Mississippi River. A total of $13 million in flood damages was prevented by the three Corps of Engineers flood control reservoirs in the State of Iowa.

o. Flood of 1993. The widespread flooding of 1993 broke historical records in many areas and surpassed the design flood for many of the corps' structures along the Mississippi and Des Moines Rivers. The flooding that occurred was the result of successive storm events that occurred over the course of several months. Wet antecedent conditions and relatively heavy snow across the Upper Des Moines River Basin led to saturated soils and high baseflow, greatly increasing the potential for spring flooding. Precipitation in Iowa and Minnesota during November 1992 was the highest since 1895.

Above normal soil moisture heading into winter and cold, cloudy conditions during January and February limiting early snowmelt, created an increased potential for spring flooding. In late March rainfall combined with rapid snowmelt produced widespread flooding across much of Iowa. The Des Moines River basin was no exception. Inflows into Saylorville Lake steadily increased throughout the remainder of March into early April. The largest average daily inflow, 45,700 cfs, occurred on April 3. However, reservoir releases were held below 13,000 cfs due to high discharges on the Raccoon River which

triggered regulation for the downstream control point in Des Moines . By April 5, the pool reached elevation 875.0 feet. Above this pool level the reservoir outflow was increased to 16,000 cfs. However, inflow to the reservoir continued to exceed outflow. On April 21, the pool was at elevation 880.4 feet and inflow was approaching 30,000 cfs. Because the pool was predicted to exceed elevation 884 feet, the outflow was increased to 21,000 cfs. On 23 April, water overtopped the spillway. The pool crested on April 27 at elevation 886.16 feet. Reservoir releases were kept at 21,000 cfs until May 16 when the reservoir fell below elevation 875.0 feet. During the rest of the month the reservoir returned to normal as releases were gradually reduced to 12,000 cfs.

Then from June through August thunderstorm after thunderstorm tracked east across the state. This pattern resulted from an unusual stationary high-pressure dome over the southeastern United States that pumped moist air north from the gulf. In addition, a low-pressure system in the northern Rocky Mountains was continuously spinning off cool air fronts. In Iowa, 1993 was the wettest of 121 years of record and the 14th coldest.

On 30 June about one to two inches of rain fell in the basin above Saylorville Dam. With the pool above elevation 887 feet, releases were increased. The pool reached elevation 890 feet on 5 July. The conduit and spillway discharge totaled 31,400 cfs and the pool began to slowly fall.
Between July 8th and 9th a storm over the Raccoon River basin resulted in up to 6.5 inches of rain and caused flash flooding. The peak discharge of 70,100 cfs at Van Meter occurred on the 10 July. On 9 July, three to four inches of rain fell on a broad area above Saylorville Lake pushing the pool above elevation 890 feet. Releases were increased from 34,500 cfs to 37,900 cfs. Further increases in discharge were not made in order to minimize flood damage in the City of Des Moines. By 11 July the total discharge was 39,200 cfs (due to increased spillway discharge). That morning the Raccoon River reached record levels and overtopped the levee at the Des Moines Waterworks upstream of the Federal Project. In order to aid flood fighting efforts in Des Moines at S.E. 6th Street and at the abandoned IPALCO power plant federal levee T-wall, at 11 a.m. discharges from Saylorville were reduced by 4,400 cfs to 34,800 cfs. Over the next few days, the conduit discharge was held constant at 11,500 cfs. The spillway discharge continued to increase as the pool rose as inflows exceeded outflows.

On July 13, the pool crested at elevation of 892.03 feet (107.6 percent of flood control capacity) with the outflow at 43,400 cfs. At first as the pool started falling, releases were slowly decreased. When the discharge in the Raccoon River declined, the reservoir release was increased to help lower the pool. The change was made by increasing the discharge through the outlet. The largest outflow occurred on 18 July (44,500 cfs). The increase did not worsen flooding in Des Moines.

By July 22, the falling pool had reduced the spillway discharge. To continue lowering the pool, the sluice gates were opened fully. The reservoir fell below the spillway crest on 29 July (outflow 21,700 cfs). The conduit remained fully open through July and into August when the outflow was reduced to prevent bank sloughing in the reservoir.

At Lake Red Rock, the frequent and heavy rainfall in April and May, coupled with cutbacks in reservoir outflow due to downstream flooding along the Mississippi and Des Moines Rivers, resulted in a peak reservoir elevation of 777.35 feet NGVD on May 16. Releases from Saylorville Lake kept inflow to Lake Red Rock above average during June. However, little rainfall occurred early in the month allowing the lake to fall to 773.27 feet NGVD by June 13, while maintaining an outflow of 22,000 cfs.

On June 19, 2.54 inches of rain were recorded at the dam, and the lake level once again began to rise. As the pool rose, outflows were increased, per the regulation schedule, reaching 45,000 cfs on July 4. On July 5, 3.57 inches of rain fell at the reservoir, and inflow increased from a daily average of 51,800 cfs to 100,400 cfs. Rain continued to fall almost daily keeping inflow high. As the pool rose, outflow from the dam continued to be increased. A peak inflow of 134,900 cfs occurred July 11. The reservoir crested on July 13 at an elevation of 782.68 feet NGVD (112% of the flood control capacity) and a corresponding peak discharge of 104,500 cfs. During the event, reservoir releases were kept below those prescribed in the regulation manual in order to aid downstream flood fighting efforts while simultaneously maintaining the flood control pool below elevation 783.0 feet NGVD to avoid flooding of non-easement land. Downstream flow at the control points of Ottumwa and Keosauqua peaked at 112,000 cfs and 111,000 cfs, respectively. A deviation to the regulation plan was requested, and subsequently approved, to allow for the use of greater than prescribed outflows in drawing down the pool, and to request the authority to lower the pool to elevation 732.0 feet NGVD (10 feet below the conservation pool) to facilitate the repair of five tainter gate cables which broke during the flood event. A pool elevation of 732.46 was reached on October 11.The total monthly precipitation for June and July were 8.30 inches (187% of normal) and 10.48 inches (260% of normal), respectively. During the period of March 1 through September 30 a total of 22.38 inches of runoff entered the lake. This represents nearly ten times the storage capacity available at the full flood control pool, and more than five times the normal runoff of 4.3 inches for this period. The 10 to 30-day peak inflows for 1993 had an estimated frequency of once in 1000 years. The flood of 1993 also produced record or near record stages on the South River, Whitebreast Creek, English Creek, and Cedar Creek.

Through the operation of Lake Red Rock, Saylorville Lake, and Coralville Lake Reservoirs, an estimated total of $672 million in damages was prevented. Damage reduction along the Des Moines River was estimated at $172 million. A detailed description of the 1993 flood can be found in *The Great Flood of 1993 Post-Flood Report, Upper Mississippi River Basin, Appendix B, September 1994.*

p. Flood of 2008. Wet antecedent conditions prior to the spring of 2008 was highlighted by December 2007 being the second wettest December in Iowa on record going back to 1895. While precipitation was frequent during January, and February of 2008, there were no major winter storms events like those that occurred during December. During March precipitation was well below normal over most of Iowa reducing the severity of the snow melt flooding that occurred. During April, extreme precipitation returned once again, resulting in the second wettest April on record leading to major flooding in the Des Moines River Basin. The resulting runoff caused water levels of the three flood control reservoirs located on the Iowa and Des Moines Rivers to rise significantly into early May. Although river and reservoir levels had begun to recede during the second part of May, river levels remained higher than normal. Beginning in late May and into early June the jet stream shifted resulting in a trough in the west and a ridge in the east. The low level jet-stream allowed for a continuous moisture feed as storms tracked repeatedly over the same areas much like what happened in 1993. The statewide average precipitation for Iowa over the 15-day period 29 May 2008 through 12 June 2008 was 8.99 inches. In comparison, the maximum 15-day total in 1993 was 7.81 inches.

Saylorville Reservoir began to rise above the conservation pool of 836.0 feet NGVD during late April and crested at 891.0 feet NGVD (103% flood control storage) on 12 June 2008 which was also greater than the 0.2% probability elevation. The emergency spillway pneumatic crest gates were put into operation for the first time since their installation in 1994. The gates performed as designed and afforded additional time for downstream preparation. Water was released over the emergency spillway from 10 June 2008

through 24 June 2008. The peak inflow was 60,600 cfs while the peak outflow was 44,500 cfs. Red Rock Reservoir, located downstream of Des Moines, Iowa, crested at 779.1 feet NGVD (96% flood control storage) on 14 June 2008 at the 2% probability elevation. The peak inflow was 130,800 cfs while the peak outflow was 100,000 cfs. The dam operated with no significant problems, with two of its five tainter gates fully open and a third with a partial opening. The tainter gates were operated from 10 June 2008 through 03 July 2008.

Through the operation of Lake Red Rock, Saylorville Lake, and Coralville Lake Reservoirs, an estimated total of $75.6 million in damages was prevented. Damage reduction along the Des Moines River was estimated at $8.8 million.

q. Flood of 2010. Repeated rounds of accumulating snow during late 2009 and into early March 2010, resulted 4 to 8 inches of snow water equivalent in the Des Moines River basin above Saylorville Reservoir. The ensuing snowmelt caused Saylorville to rise to 880.7 feet NGVD (75.7% flood control storage utilized) on 25 Mar 2010, 44.7 feet above the conservation pool and 3.3 feet below the top of the spillway. As the water moved downstream, Lake Red Rock, peaked at 770.6 feet NGVD (62.6% flood control storage) on 3 Apr 2010, 28.6 feet above conservation pool and 4.4 feet below the Large Magnitude Flood Schedule which relaxes downstream constraints and prescribes releases. Although both reservoirs receded during the month of April the pool elevations remained well above their normal conservation pool levels into the month of June.

During June, a statewide average of 10.14 inches rainfall was recorded, resulting in significant rises at Saylorville and Red Rock Reservoirs. As reservoir levels increased, on 29 Jun 2010, pneumatic spillway crest gates were raised at Saylorville Reservoir as water levels neared the spillway crest of 884.0 feet. The gates were subsequently lowered on 01 July 2010 based on forecasts that the pool would rise above the full pool level of 890 feet. On 01 July 2010, Saylorville Reservoir crested at 889.2 feet NGVD (97.8% flood control storage utilized), 5.2 feet above the top of the concrete spillway. Water flowed over the spillway from 01 July 2010 through 08 July 2010. The peak inflow was 60,800 cfs on 28 June 2010 while the peak outflow was 39,500 cfs.

Red Rock Reservoir crested at 778.8 feet NGVD (94.7% flood control storage) on 05 Jul 2010. The peak inflow during the event was 89,000 cfs on 12 Jun 2010 while the peak outflow was 53,500 cfs. The tainter gates on the spillway were operated from 28 June 2010 through 31 Aug 2010 in order to continue to pass high outflows to lower the reservoir to conserve remaining flood storage. The maximum inflow for 2010 was 130,000 cfs in response to heavy rainfall over central Iowa, August 8 through August 10, where 4 to 10 inches of rainfall was recorded while the peak outflow was 53,500 cfs.

Damage reduction along the Des Moines River attributed to the operation of Saylorville and Red Rock Reservoirs was estimated at $10.4 million.

r. Flood of 2018. Heavy rainfall late in the spring of 2018 resulted in Saylorville Reservoir, cresting at 886.19 feet NGVD (89.5% flood control storage utilized) on 09 July 2018, 50.2 feet above the conservation pool. The spillway pneumatic crest gates prevented water from flowing over the emergency spillway, thus avoiding degradation of the spillway channel.

Lake Red Rock crested at 766.22 feet NGVD (48.2% flood control storage) on 20 July 2018, 24.2 feet above conservation pool. Stage reductions resulting from the operation of Saylorville Dam resulted in

stage reductions in Des Moines at 2nd Avenue of 4.8 feet and 1.9 feet at SE 6th respectively which prevented $2.7 million of damage. The combined operation of the Saylorville and Red Rock Dams resulted in stage reductions of 11.4 feet at Tracy, Iowa, 10.4 feet at Ottumwa, Iowa, and 9.4 feet at Keosauqua, Iowa with $20.3 milllion of damages attributed to Lake Red Rock.

Deviations from the approved water control plans for both reservoirs were in effect during the growing season in 2016, 2017 and 2018. At Saylorville, the deviation consisted of removal of the balancing rule, increasing the control stage at SE 6th Street from 24 feet to 26.5 feet, increasing the maximum growing season release from 12,000 cfs to 16,000cfs, and the addition of a stage constraint of 21.0 feet at the 2nd Avenue gage in Des Moines. At Lake Red Rock, the growing season maximum release for lake elevations below 760 feet was increased from 18,000 cfs to 22,000 cfs. These deviations are encompassed in several of the revised rules within the water control plans for each reservoir that are presented in this manual.

III – HISTORY OF PROJECTS

3-01. Authorization. The Lake Red Rock project on the Des Moines River was selected and approved by the following laws as a unit in the general comprehensive plan for flood control in the Upper Mississippi River Basin. The project was authorized in the Flood Control Act of 1938, Public Law 761, 75th Congress, Third Session (approved 28 June, 1938) , flood control Committee Document 1, 75th Congress, First Session. Recreation and fish and wildlife facilities were subsequently authorized in the Flood Control Act of 1944, Public Law 534, 78th Congress (approved 22 December, 1944), and Section III of the Water Resources Development Act of 1976 (Public Law 94-587).

In 1958, prior to the construction of Lake Red Rock, Congress authorized the construction of Saylorville Lake in the Flood Control Act of 1958 and the recommendations of the Chief of Engineers in Senate Document No. 9, 85th Congress, First Session, Section 203 and Public Law 85-500, 85th Congress, Second Session. Project purposes included conservation and flood control for downstream reaches. This project combines with the City of Des Moines Local Protection Works project for Des Moines and Raccoon River flood risk management for the city.

3-02. Planning and Design. The process of planning and subsequent design phases for the Lake Red Rock project began in the mid-1950s. The initial Design Memorandum, Hydrology and Hydraulic analysis, was completed in November, 1956. The planning for the Red Rock Dam project was conducted by the Rock Island District, Corps of Engineers, Office of the Chief of Engineers, and the North Central Division.

Planning and design of the Saylorville project was completed in the early 1960s. In early December, 1972, the Iowa Citizens to Save Ledges State Park, Inc., the Iowa Citizens for Environmental Quality, Inc., and the Iowa chapter of the Sierra Club filed a lawsuit against the Saylorville Lake Project in the U.S. District Court for the Southern District of Iowa, Central Division. They sought to restrain the Federal Government from opening bids, awarding contracts and other activities relating to the Saylorville Lake project. This action grew from the desire of the plaintiffs to minimize the adverse effects to portions of Ledges State Park. Ledges State Park is situated in the upper portion of the Saylorville Lake project, about 15 river miles upstream from the permanent pool limits. It is one of the largest and most picturesque parks in Iowa, with an annual attendance of over 400,000 persons. The park contains 860 acres and consists of two tracts of land separated by the Des Moines River. The park includes exposed bedrock features which are unique in this portion of the state. These sandstone ledges, which give the park its name, begin at approximately elevation 870 feet.

Reservoir flooding in this area may affect recreational facilities, change the existing habitat conditions and occasionally deny access to ·the lower portion of Ledges State Park. On 20 December, 1972, the plaintiffs and the Government filed an agreement with the court. The principal provisions of the agreement concerned the preparation of an Environmental Impact Statement for the Saylorville Lake project and the choice of measures to minimize environmental harm to Ledges State Park. The Corps of Engineers agreed that dam closure, scheduled for July, 1974, would not be made until 60 days after plaintiffs had been notified in writing of the final decision of the Corps on the alternative chosen for Ledges State Park. To determine the best solution to minimize any adverse environmental effects to Ledges State Park, a critical review of the entire Saylorville Lake project was made. The Final Environmental Impact Statement was filed with the Council on Environmental Quality on 16 May, 1974. Meanwhile, reformulation studies were initiated for project modifications, and the proposed project

modification report was published in May, 1974. Paragraph 3-05 discusses the modifications to the regulation for Saylorville Lake as a result of these project modifications.

Exhibit B, provides a list of design memoranda and related documents for both the Saylorville Lake and Lake Red Rock projects.

3-03. Construction. Construction of the Red Rock Dam was completed in three stages. The construction of Stage I was awarded to Western Contracting Corporation of Sioux City, Iowa, and construction was completed between May, 1960, and October, 1961. This work consisted of the construction of a rolled earthfill embankment section. The Stage II contract was awarded to Maxon Construction Company of Dayton, Ohio, and construction was completed between April, 1962, and August, 1966. This stage consisted of the construction of the gravity concrete control section. Investigation of the area underlying the dam revealed that work on the foundation was required. The foundation treatment work was started in May, 1964, and completed in November, 1965. Preceding the completion of Stage II, work on the rolled earthfill embankment of Stage III was initiated. Construction of Stage III was awarded to William A. Smith Contracting Co., Inc., of Kansas City, Kansas, and construction was completed between March, 1966, and May, 1969. Relocation work was accomplished concurrently with the construction of the dam.

Construction of the Saylorville Dam was also completed in three stages. The Stage I contract was awarded to G. H. Lindekugel and Son, Inc., and construction was accomplished between June, 1965, and the fall of 1967. This consisted of approximately 3,000,000 cubic yards of compacted earthfill and was intended to preload and consolidate alluvial clays underlying the foundation. The Stage I embankment was constructed across the middle of the valley floor with an opening along the east bank to allow passage of the Des Moines River flows and an opening along the west bank for the outlet works. The Stage II contract was awarded to Penker Construction Company, and construction was accomplished between April, 1967, and December, 1971. This consisted of construction of the intake structure, the spillway and the outlet works. The slurry trench contract by the COS Corporation, accomplished between June, 1972, and December, 1973, consisted of an eight-foot wide trench, with a maximum depth of 65 feet, excavated along the upstream edge of the dam. Two floods in the fall of 1972 delayed the contract completion by one year. The Stage III embankment contract by Greene Construction Company between December, 1972, and October, 1975, consisted of 4,000,000 cubic yards of compacted earthfill, completing the dam to its final section and top elevation of 915.5 feet. The Des Moines River flows were diverted through the outlet works conduit in July, 1975. The final 2,000,000 cubic yards of compacted earthfill were placed in the east opening between July and October, 1975. Unusually wet conditions in 1973 and 1974 hampered the placement of the earthfill in this contract. However, conditions during the fall of 1975 were quite favorable, allowing completion of the embankment in October, 1975. During the fall of 1974 and early spring, 1975, some subsurface movement of the underlying alluvial materials was measured. The rate of this movement was of design concern, and a remedial stability berm along the downstream toe was added. This berm, which consisted of 365,000 cubic yards of earthfill, was constructed by a joint venture of Keuter and Freiburger between April, 1975, and June, 1975. The entire structure contains about 7.6 million cubic yards of earthfill and was built under five separate contracts.

3-04. Related Projects. Relocations of municipal water supplies, utilities, railroads, highways, sewage treatment facilities and cemeteries were completed to provide for the projects and the flood control benefits resulting from the projects. Remedial work projects were completed at Avon Station, Carlisle and Southeast Des Moines and Pleasant Hill. These projects were for the construction of pump stations and interior drainage facilities to serve these communities during extended periods of high lake levels on the Red Rock Reservoir.

The Big Creek Remedial Works was built as a part of the Saylorville Lake project to provide permanent flood protection to Polk City, Iowa. This project was completed under three contracts. The first contract, between May, 1970, and October, 1972, consisted of a diversion dam across the Big Creek Valley above Polk City. A diversion channel with overflow spillway and the terminal dam was constructed across the high ground between the Big Creek Valley and the Des Moines River Valley. The lake, impounded by the diversion dam, was developed as a state recreation area through a cooperative agreement with the State of Iowa. The second contract, between December, 1970, and May, 1972, was awarded for lake clearing of theBig Creek Lake. The final contract, between May, 1972, and September, 1975, was for construction of the barrier dam across the Big Creek Valley downstream from Polk City. A pump station was built under this contract to evacuate interior drainage flows during blocked gravity conditions. Additional information can be found in the Big Creek Regulation Manual.

3-05. Modification to Regulation. Initial modifications to the regulation plan for Saylorville Lake were with regard to mitigating reservoir effects on the Ledges State Park. Ledges State Park is initially affected when the lake level reaches elevation 865 feet. The mitigation measures included implementing a vegetative management program at the park, a maximum flood release rate of 12,000 c.f.s. during the growing season from Saylorville Dam (providing the lake level is below elevation 876 feet) and the creation of a floodway corridor along the Des Moines River from the dam site to Sixth Avenue in the city of Des Moines. The maximum flood release rate could be increased during the non-growing season (16 December to 20 April) to 16,000 cfs. provided the lake level is below elevation 880 feet.

Additional modifications to the Saylorville Lake regulation were with regard to water supply and drought contingency operations. A study published in 1981 showed that Saylorville Lake could be used for water supply without significantly affecting flood control or water quality purposes. In August, 1982, a contract between the state of Iowa and the Federal Government was initiated which allowed the State to withdraw an average annual flow of 75 cfs for water supply usage. The new plan provided for an 823.5 foot water supply pool and an 836 foot conservation pool with an optional 838-foot pool in the fall. The conservation pool of 836 feet was three feet higher than the original water control plan for Saylorville Lake. The drought contingency regulation was developed to attempt to maintain flows for water quality and water supply during low-flow periods. A computer model was used to simulate reservoir operation between 1921 and 1980. Although the regulation plan proved to be effective for historic droughts, it does not guarantee that it will be the most effective plan of operation for future droughts. Additional information on the drought regulation plan can be found in Section VII of this manual. Later minor revisions to the water control plan for Saylorville were approved in 1999 consisting of increasing the flexibility of the fall pool raise by 2 feet and increasing the maximum allowable reservoir release from 12,000 cfs to 16,000 cfs when Lake Red Rock is below elevation 758 feet.

Modifications to Lake Red Rock have been primarily to permanent pool elevations to maintain conservation storage in order to meet low flow requirements on the Des Moines River. Increased sediment volumes and the requirement of a 50,000 acre-feet permanent conservation storage volume have

required increased pool elevation adjustments. The Chief of Engineers approved establishment of a conservation pool at elevation 725 feet. This provided for approximately 90,000 acre-feet for conservation and sediment storage and enabled the Saylorville Lake and Lake Red Rock to achieve the desired low flows at Des Moines and Ottumwa. In 1977, the Corps of Engineers temporarily raised the pool level to elevation 728 feet to re-establish the 90,000 acre-feet of conservation storage. This increase was needed to replace conservation storage volume lost to sedimentation during the first eight years of operation. The necessary environmental and water quality studies were completed and the permanent change was approved on August 17, 1979.

Further sediment data, sediment surveys and development of a sediment forecast model improved the sedimentation rates presented in previous reports and documents. The estimate of average annual sedimentation rate was about 3,500 acre-feet. Over the 100-year project design life, sedimentation represents 20 percent of the flood control storage capacity. However, the project will last longer than 100 years. In order to recover lost conservation pool storage, approval was given to maintain the conservation pool at elevation 734 feet in 1988 with future considerations to raise the pool to elevation 742 feet. The increase to the current level of 742 feet was enacted in February of 1992.

Other modifications to the regulation of Lake Red Rock included drought contingency and flash flood operations. The drought contingency regulation was developed to attempt to maintain flows for water quality during low-flow periods. The drought of 1976-1977 prompted this regulation modification. During the drought, the flows on the Des Moines River system fell to levels which required a request from North Central Division (NCD) to release the minimum low-flow release to lower than the 300 cfs minimum guaranteed release rate. The rate was reduced to 200 cfs on 17 June, 1977, and was held at this outflow rate until 26 August, 1977, when above normal rainfall increased the inflow into the reservoir so that normal outflows could be resumed.

The flash flood regulation was prompted by rainfalls during July 1982. During this period, rainfalls in the vicinity of Red Rock Dam were between 1.0 percent and 0.5 exceedence events. These large inflows to the lake were concurrent with high flows on the uncontrolled tributaries below Red Rock Dam. An emergency request was made to the North Central Division (NCD) to reduce the outflow rate to 500 cfs thereby lowering the water levels downstream. This procedure was then adopted into the regulation schedule.

In response to a significant increase in the magnitude and frequency of flooding in the Des Moines River Basin and major floods that occurred in 1993, 2008, and 2010, in 2017 a study was undertaken determine the feasibility of updating the water control plans for Saylorville and Red Rock reservoirs. Over the last 30 years, the Des Moines River Basin has experienced significant land use changes and increased precipitation. These changes influence runoff into the main stem Des Moines River and its tributaries, resulting in increased flood risk within the Des Moines River Basin. Following the 2008 Des Moines River flood, the District reevaluated the regulated flow frequencies on the Des Moines River. The Regulated Flow Frequency Study, completed in early 2010, concluded the frequency of flooding on the Des Moines River increased and indicated flood events like 1993 and 2008 are more likely to occur in the future. In addition, approved water control deviations have confirmed the need to consider updating the water control plans. In February 2019, the feasibility study and integrated environmental assessment for updating the Des Moines Master Regulation Manual were approved by the Commander of the Mississippi Valley Division (MVD). The revised versions of the water control plans are discussed in Chapter VII of this manual and are displayed in Exhibit B.

IV - DESCRIPTION OF PROJECTS

4-01. Purpose. Saylorville Lake and Lake Red Rock were authorized as part of a plan to provide comprehensive flood reduction benefits along the Des Moines and Mississippi Rivers as well as other project purposes including low flow augmentation, water supply (Saylorville), fish and wildlife habitat and recreation. The lakes are operated individually to meet these objectives.

4-02. Physical Components. Saylorville Dam is located in Polk County on the Des Moines River in central Iowa, approximately 214 miles upstream from the confluence with the Mississippi River. The conservation pool impounded by the dam is within Polk County. The flood pool extends into Dallas and Boone Counties. The City of Des Moines is 10 miles to the south of Saylorville Lake. The lake is surrounded by the growing communities of Ankeny, Johnston, and Polk City.

Saylorville Dam along with the Des Local Flood Protection Project provides flood damage reduction for the downstream Des Moines River corridor, which includes the City of Des Moines and several adjacent communities, as well as significant rural areas. The corridor downstream of Saylorville Dam starts at the dam (river mile 213.7) and ends at the Sixth Avenue Bridge in the City of Des Moines (river mile 204.28).

Red Rock Dam is located in Marion County on the Des Moines River in south-central Iowa, approximately 142.9 miles upstream from the Mississippi River confluence. The dam is located approximately 60 miles downstream from the City of Des Moines and approximately 70 miles downstream of Saylorville Dam. The conservation pool impounded by the dam is within Marion County. The flood pool extends into Jasper, Warren, and Polk Counties. Major communities near Lake Red Rock include: Des Moines, Pella, and Knoxville.

Red Rock Dam provides flood damage reduction downstream along the Des Moines River corridor, which includes the communities of Eddyville, Ottumwa, Eldon, Keosauqua, Farmington, and Bonaparte, Iowa, as well as several other communities and significant agricultural land. Regulated flows of the Des Moines River from the reservoir also provide varying degrees of protection along the Mississippi River downstream of the mouth of the Des Moines River.

In 2015 Missouri River Energy Services (MRES) began construction of hydroelectric facilities at Lake Red Rock. The project is scheduled to be completed in 2021. While generation of hydroelectric power at Lake Red Rock is not an authorized project purpose, the District will work in partnership with MRES to provide a reliable water supply for energy production. The MRES project strives to produce power to support 18,000 homes annually.

4-03. Related Control Facilities. In addition to Saylorville Dam and Red Rock Dam, there are numerous low head dams located within the Des Moines River basin that contain insignificant amounts of storage. Also local flood protection works have been constructed for the City of Des Moines (federal project), and the communities of Eddyville and Ottumwa.

The Des Moines Local Flood Protection Works project is a federal flood control project consisting of levees and interior drainage facilities. The project was designed for a flow of 100,000 cfs below the

confluence with the Raccoon River. Design flow for the Raccoon River was 60,000 cfs. The concurrent Des Moines River flow is 40,000 cfs. The Des Moines River flow of 40,000 cfs provides a 20,000 cfs outflow from Saylorville Dam and an additional inflow of 20,000 cfs to the Des Moines River between Saylorville Dam and the confluence of the Raccoon River.

4-04. Real Estate Acquisition. The Saylorville Lake project required approximately 24,520 acres of land. With the exception of existing parks, the majority of the land requirements was acquired in fee title. In certain areas, ponding easements were acquired to an elevation of 892.0 feet. The full flood control pool elevation is 890.0 feet.

The initial real estate acquisition for Lake Red Rock began in January, 1960, and was completed in June of 1973. Fee acquisition was conducted for structure sites, public use areas and for lands lower than the estimated five-year frequency pool level of elevation 760.0 feet, based on historic data between 1917 and 1959. Above elevation 760.0 feet, flowage easements granted the right for occasional flooding. These easements extended to elevation 783.0 feet. The project total of 78,424 acres consists of 47,610 acres from fee acquisition, 28,214 acres from flowage easements and 2,600 acres in riverbed use rights.

Portions of the fee-owned land are outgranted to other government entities for various purposes. The outgrants all reserve the right of the government to flood the premises whenever necessary. Approximately 27,700 acres were outgranted to the state of Iowa and administered by the Iowa Department of Natural Resources (IDNR) for recreation and wildlife management purposes. Marion County was outgranted land for recreation purposes at Roberts Creek and Cordova County parks.

Public Law 99-190 was passed by Congress in December 1985 directing the acquisition of fee simple title to flowage easement lands from willing sellers. A total of approximately 27,500 acres of land representing approximately 750 landowners had been identified as qualifying under this project. As of October 1998, a total of 3,212 acres of easement land from 39 landowners had been purchased at a total cost of $2,065,363 for lands and administrative expenses. Forty-nine landowners entered into negotiations and rejected offers made by the Government. Continuation of the acquisition program is currently unscheduled due to a lack of funding.

4.05 Public Facilities. Saylorville Lake has 32 existing recreation areas. Twenty areas are owned and administered by the Rock Island District, U.S. Army Corps of Engineers. The remaining sites are leased and administered by either the State of Iowa, local government entities, local organizations or private vendors. The major recreation sites are as follows:

Corps of Engineers - Rock Island District - Saylorville Lake
Acorn Valley Recreation Area
Big Creek Lower Spillway
Big Creek Upper Spillway
Bob Shetler Recreation Area
Cherry Glen Recreation Area
Control Tower Fishing Access
Cottonwood Recreation Area
Highway 210 Access
Lakeview Highwater Boat Ramp
Lakeview Recreation Area
Neal Smith Trail
Oak Grove Recreation Area
Prairie Flower Recreation Area
Red Feather Prairie Access
Sandpiper Recreation Area
Saylorville Hunting Access
Saylorville Lake Scenic Viewing Area
Saylorville Lake Visitor Center
Visitor Center Recreation Area
Walnut Ridge Recreation Area

Iowa Department of Natural Resources
Big Creek State Park and Recreation Area
Sycamore Access
Saylorville Wildlife Management Area
Sportsman Access
Sub 1 Access
County Road E57 Access

Polk County Conservation Board
Jester County Park Equestrian Center
Lincoln Access
Sycamore Trail Access

City of Des Moines
Prospect Park

Polk City
Polk City Recreation Sports Complex

Boone County Conservation Board
Swede Point Park
Highway 30 Access

Private Concessionaire
Saylorville Marina developed after the completion of Saylorville Lake, the Saylorville-Des Moines River Trail provides for biking and jogging. The trail is approximately 20 miles long and follows the Des Moines River. The trail is maintained by the U.S. Army Corps of Engineers from Saylorville Dam to the Sycamore access boat ramp, by the IDNR from the boat ramp to the Des Moines city limits, and by the City of Des Moines within the city limits. Additional facilities below Saylorville Lake in the Des Moines River Corridor include parking areas, sanitation facilities, water supply, boat ramps, day-use facilities and camping facilities.

Lake Red Rock has 15 public recreation areas. The Rock Island District, U.S. Army Corps of Engineers manages 11 of these areas. The state of Iowa maintains 1 area, and Marion County Conservation Board (MCCB) maintains 2 areas. One commercial concession site is maintained by private interests through lease arrangements by the Corps of Engineers. The Corps of Engineers and Marion CCB jointly manage the Volksweg Trail, a multi-purpose recreation trail that extends from Cordova County Park to Pella. The Lake Red Rock Water Trail is designated as a National Water Trail by the National Park Service.

The major recreation sites are as follows:

Corps of Engineers - Rock Island District – Lake Red Rock
Whitebreast Recreational Area
Wallashuck Recreation Area
Hickory Ridge Wilderness Campground (primitive and/or paddle in)
South Overlook
Howell Station
Ivan's
North Tailwater Area
South Tailwater Area
North Overlook
Fifield Recreation Area
Lake Red Rock Archery Range
Volksweg Trail (jointly managed with Marion CCB)

State of Iowa
Elk Rock State Park

Marion County
Roberts Creek Park

Private Concessionaire
Lake Red Rock Marina

V – DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. General. Operation of Saylorville and Red Rock dams are directly dependent on the availability of hydrologic and meteorological data for both daily operation and long-range forecasts within the Des Moines River Basin. This information directly reflects anticipated hydrologic conditions on the Des Moines and Mississippi Rivers. The Water Control Section of the Rock Island District (MVR) maintains a continuous record of hydrologic data allowing Red Rock and Saylorville reservoirs to be operated in a manner to fulfill all authorized purposes which include flood risk management, low flow augmentation, water supply (Saylorville), fish and wildlife management, and recreation.

5-02. Hydrometeorlogical Data Collection. The Water Control Section monitors data from over 180 gage locations along rivers and streams in MVR. The gages measure and transmit water levels and cumulative precipitation hourly via satellite at most of the locations. Of these sites, 48 are located within the Des Moines River Basin along with Burlington, Iowa, and Quincy, Illinois, on the Mississippi River. Data collected at these sites is analyzed and ingested into operational models that provide decision support for the operation of Saylorville and Red Rock reservoirs. A list of these gaging stations is shown below in Table 5-1.

Table 5-1
Des Moines River Basin Gaging Stations

River	Location	Parameters Collected*	NWS I.D.
West Fork Des Moines River	Windom, Minnesota	HG, PC	WDOM5
West Fork Des Moines River	Jackson, Minnesota	HG	JCKM5
West Fork Des Moines River	Estherville, Iowa	HG, PC	ESVI4
West Fork Des Moines River	Emmetsburg, Iowa	HG, PC	EMTI4
Pilot Creek	Rolfe, Iowa	HG, PC	RLFI4
West Fork Des Moines River	Humboldt, Iowa	HG, PC	HBTI4
East Fork Des Moines River	Dakota City, Iowa	HG, PC	DAKI4
Lizard Creek	Fort Dodge, Iowa	HG	FLZI4
Des Moines River	Fort Dodge, Iowa	HG, PC	FODI4
Boone River	Goldfield, Iowa	HG, PC	GLDI4
Boone River	Webster City, Iowa	HG, PC	WBCI4
Des Moines River	Stratford, Iowa	HG, PC	STRI4
Big Creek Lake	Polk City, Iowa	HG	PLKI4
Big Creek Ponding Area	Polk City, Iowa	HG, PC	BIGI4
Saylorville	Pool	HG, PC	SAYI4
Saylorville	Tailwater	HG	STWI4

Table 5-1 con't
Des Moines River Basin Gaging Stations

Beaver Creek	Woodward, Iowa	HG, PC	WWDI4
Beaver Creek	Grimes, Iowa	HG, PC	GRMI4
Des Moines River	2nd Ave Des Moines, Iowa	HG	DMOI4
North Raccoon River	Sac City, Iowa	HG, PC	SCRI4
North Raccoon River	Lanesboro, Iowa	HG, PC	LKCI4
North Raccoon River	Jefferson, Iowa	HG, PC	EFWI4
Buttrick Creek	Grand Junction, Iowa	HG, PC	GJTI4
North Raccoon River	Perry, Iowa	HG, PC	PROI4
Middle Raccoon River	Bayard, Iowa	HG, PC	BAYI4
Middle Raccoon River	Panora, Iowa	HG, PC	PANI4
South Raccoon River	Redfield, Iowa	HG, PC	REDI4
Raccoon River	Van Meter, Iowa	HG, PC	VNMI4
Raccoon River	West Des Moines, Iowa	HG, PC	WDMI4
Raccoon River	63rd St. Des Moines, Iowa	HG, PC	DMWI4
Walnut Creek	Des Moines, Iowa	HG, PC	DOSI4
Raccoon River	Fleur Drive Des Moines, Iowa	HG, PC	DEMI4
Des Moines River	S.E. 6th St. Des Moines, Iowa	HG, PC	DESI4
Fourmile Creek	Des Moines, Iowa	HG, PC	DFMI4
North River	Norwalk, Iowa	HG, PC	NRWI4
Middle River	Indianola, Iowa	HG, PC	INDI4
South River	Ackworth, Iowa	HG, PC	AKWI4
Des Moines River	Swan, Iowa	HG, PC	SWNI4
Whitebreast Creek	Dallas, Iowa	HG, PC	DLLI4
Lake Red Rock	Pool	HG, PC	PELI4
Lake Red Rock	Tailwater	HG	RRDI4
English Creek	Knoxville, Iowa	HG, PC	KECI4
Des Moines River	Tracy, Iowa	HG, PC	TRCI4
Cedar Creek	Bussey, Iowa	HG, PC	BSSI4
Des Moines River	Eddyville, Iowa	HG	EDYI4
Des Moines River	Ottumwa, Iowa	HG, PC	OTMI4
Des Moines River	Keosauqua, Iowa	HG, PC	KEOI4
Des Moines River	St. Francisville, Missouri	HG	SFLM7
Mississippi River	Burlington, Iowa	HG, PC	BRLI4
Mississippi River	Quincy, Illinois	HG, PC	UNII2

* HG = Gage Height PC=Cumulative Precipitation

5-03. Gages. At gage sites, floats installed in a gage well (pool level at project sites) or pressure transducers (remote gage sites) measure water levels. Tipping bucket rain gages collect cumulative precipitation data at most gage locations. In addition to water level and precipitation data, wind speed

and direction, and temperature data are collected at the project offices. Data collection platforms (DCP's) installed at each gage site consisting of a data logger and satellite radio, record and transmit this data hourly to the GOES satellite. The data are then relayed via a downlink to the District Water Control Data System (WCDS) where it is decoded and posted to the Corps of Engineers Water Management System (CWMS) data base. The NWS and the U.S. Geological Survey also receive the data. In addition to the gages listed above in Table 5-1, the city of Des Moines and the Iowa Flood center monitor river levels at a number of locations within the Des Moines River Basin. However, these gages are not used for reservoir regulation.

5-04. Reservoir Data. At Saylorville Lake, the lake level gage is located in a gage well inside the operating gate control tower. The tailwater gage is located downstream in the U.S. Geological Survey's (USGS) gage house at Fisher Bridge on N.W. 66th Avenue. The data from these two locations is uplinked to the GOES satellite every hour as described above. There are also manually read gages that can be used to verify water levels, e.g. a wire weight gage at Fisher Bridge and a porcelain staff gage on the intake structure at the dam. If discrepancies exist, staff from the Water Control Section performs the necessary maintenance on the gages to correct the discrepancies. There is also a gage located at the Big Creek ponding area that is monitored to allow reservoir staff to activate pumps when the ponding area rises to critical levels.

At Lake Red Rock the lake level gage is located in a gage well in Monolith 4 of the spillway structure at the dam. The tailwater gage is located 0.5 miles downstream from the dam at the former Marion County Road "P" bridge. Wind direction and velocity are gaged by an anemometer mounted on a mast located on high ground near the Administration Building.

5-05. Cooperative Programs with Other Agencies. The Corps of Engineers (USACE) is a major participant in the USGS Cooperative Streamgaging Program. Through a cooperative agreement, participants in the program provide funding for the operation and maintenance of streamgages located throughout the United States. Thirty-nine gages within the Des Moines River basin are operated and maintained through this program. The cooperative agreement with the Iowa USGS has been in effect for many years. This cooperative arrangement provides much of the necessary streamflow data for the operation of Saylorville and Red Rock dams.

5-06. Water Quality and Sedimentation. The Corps of Engineers has been obtaining water quality data since July, 1967. A contract for data collection and analysis is managed by the Water Quality and Sedimentation Section. Annual reports are provided by the contractor and the data is maintained in a database in the section. The current program monitors water quality conditions at Saylorville Lake and Lake Red Rock as well in the Des Moines River upstream and downstream of the projects.

Suspended sediment data was previously collected upstream and downstream of both projects and at inflow tributaries in order to obtain an estimate of sediment entrapment in the reservoirs. In the Des Moines River basin as much as 35 years of data has been collected at many of the monitoring locations. However, due to funding constraints and the large volume of data that has been collected over the years, the suspended sediment program has been discontinued. Reservoir sediment surveys continue to be conducted on a periodic basis, every 10 years on average.

Additional details related to water quality and sedimentation are discussed in Section IX, System Water Control Management.

5-07. Maintenance of Instrumentation. Stream gages operated by the U.S. Geological Survey are routinely visited by USGS field parties. Required maintenance and discharge measurements are performed during those visits. Gages not maintained by the USGS are maintained by the Corps of Engineers and are visited throughout the year by field parties from the Water Control Section. Gages and instruments at Saylorvillle and Red Rock are under constant surveillance by both reservoir and Water Control staff. Personnel from Army Corps of Engineers Information Technology (ACEIT) perform computer and phone maintenance. Maintenance of all other gage equipment is performed by Water Control Section personnel.

5-08. Communication Network. Data is recorded at the stream gages using data collection platforms (DCPs) and is transmitted hourly to the GOES-East satellite. The GOES satellite retransmits the data to a Direct Readout Ground Station (DRGS) at the District Office. In addition, the District utilizes a domestic satellite service to obtain a separate rebroadcast of the same DCP information. Redundancy for the entire system is accomplished by a network connection to similar systems throughout the USGS, USACE, and NOAA. This data is then processed and transferred to the District's Corps of Engineers Water Management System (CWMS) where it is stored and available for retrieval. For database redundancy a separate dedicated data acquisition server is maintained that feeds data to the RiverGages.com website. All current data and data recorded for the previous 7-days is posted on the District's Internal Water Control website and on the public website Rivergages.com.

a. Communication with the Projects. For normal day-to-day operations, the Water Control Section sends an email with inflow and outflow information along with instructions on gate changes if necessary, and estimated future releases directly to the project offices. If email communications are not functioning, verbal instructions are issued over the telephone. When the Water Control Section is unable to reach the projects by email, telephone, or the project operation manager's home, arrangements have been made to communicate through the county Sheriff's office. The Sheriff's office has agreed to relay messages by radio or in person. The Water Control Section and project offices can share information by internet, e-mail, and cellular telephone. Reservoir project personnel and Water Control staff can use cell phone to reach each other during non-work hours.

b. Project Communications with others. The Operations Project Manager and Lake Managers will advise affected local stakeholders of impending release rates or forecasted lake levels which may affect them directly or indirectly. Park Rangers will apprise campers in areas where the operation would affect their activities. The National Weather Service Office in Des Moines has responsibility for issuing flood warnings for all rivers within the Des Moines River Basin. All weather and flood related warnings are via the Internet at https://www.weather.gov, on radio and television and over NOAA Weather Radio allowing project staff to contact boaters and recreational interests of impending flash flood or severe weather conditions during non-duty hours.

5-09. Interagency Communication.

a. Communication with state agencies is required on an irregular basis predicated on hydro-meteorological conditions and their impact on these agencies missions.

b. Communication and coordination with the NWS occurs on a daily basis. The North Central River Forecast Center (NCRFC) provides daily forecasts for the Des Moines River and its' tributaries as well as reservoir inflow forecasts that are ingested into the MVR RESSIM model. Similarly MVR provides reservoir outflow forecasts to the NCRFC so they can be incorporated into downstream river forecasts.

c. The Corporate Communications Office (CC) of MVR coordinates and disseminates press releases during periods when major operational changes are required that could impact stakeholders and answers rudimentary questions regarding the dam's operation. Technical questions are responded to by the Water Control Section.

d. U.S. Geological Survey. The Water Control Section contacts the Iowa City and Fort Dodge Offices of the USGS regarding gages needing maintenance and streamflow measurements desired during flood events. The USGS disseminates streamflow information on their website.

VI - SYSTEM HYDROLOGIC FORECASTS

6-01. General. The operation of Saylorville Lake and Lake Red Rock requires a thorough analysis of hydrologic conditions in the Des Moines River Basin. The Water Control Section of the Rock Island District (MVR) monitors, records and analyzes weather and streamflow conditions in the Des Moines River Basin on a daily basis in order to make operational decisions and provide forecasts of lake levels and outflows. The North Central River Forecast Center (NCRFC) of the National Weather Service (NWS) provides reservoir inflow forecasts as well as stage and flow forecasts for most of the gages in the Des Moines River Basin. A more detailed description of the forecasting procedure for the reservoirs is contained in the following paragraphs.

6-02. Role of the Corps of Engineers. The Corps of Engineers (USACE) has direct responsibility for project operation, forecasting of reservoir pool levels and outflow changes, and coordination with other agencies. The forecasting capability for operating the project is in the Water Control Section at MVR. The district cooperates with the NWS by furnishing it forecasts of reservoir releases.

6-03. Role of Other Agencies. The NWS is responsible for weather, flood, and drought forecasts. Current water resources forecasting techniques make limited use of growing skill in short to long-range weather and climate forecasts. The National Weather Service Advanced Hydrologic Prediction System (AHPS) produces hydrologic forecasts with lead times of a few days to several months. It provides river forecasts that not only account for precipitation already on the ground but also probabilistically accounts for estimates of future precipitation. The AHPS system provides specific forecasts at established forecast locations within the Des Moines watershed, as well as short-term and long-term inflow forecasts for Saylorville and Red Rock reservoirs.

6-04. Daily Forecast Preparation. Reservoir stage and outflow forecasts for Saylorville Lake and Lake Red Rock are prepared daily and extend 14 days into the future. Downstream forecasts at control points are an integral part of the decision making process for the operation of each reservoir. Forecasts also indicate when various target storage levels will be exceeded (see tables A-1 and A-2 in Exhibit A) indicating when to change reservoir regulation schedules.

As mentioned above, it is the responsibility of the National Weather Service (NWS) to issue flood forecasts and warnings. With regard to reservoir operations, forecast refers to the operational reservoir forecast issued daily (or more often as needed) by the Water Control Section. The operational forecast includes one or more days of predicted rainfall that is included in the official NWS flow forecast utilized in the District's reservoir simulation model. The number of days of predicted rainfall that is included in the NWS flow forecasts varies seasonally and is occasionally lengthened for specific storm events when the NWS deems it appropriate to do so due to the significance and level of confidence in the predicted rainfall. The Water Control Section provides pertinent information pertaining to Saylorville Lake and Lake Red Rock regulation to the NWS.

Each morning the Water Control Section automatically receives a 14 day inflow forecasts for each reservoir from the NWS. The forecaster compares this forecast to the forecast generated at CEMVR and determines a 14 day release forecast for both Lake Red Rock and Saylorville Lake. The outflow at each reservoir is determined initially using the criteria from the regulation schedules for each project. The flow and stage at the downstream control points ultimately determine the releases. The Water Control

Section determines both the short-term release as well as the extended release based on hydrologic conditions. After final forecasts are prepared, the information is automatically transmitted to the NWS North Central River Forecast Center (NCRFC) at Chanhassen, Minnesota. The NCRFC incorporates the reservoir outflow forecasts into downstream stage and flows forecasts that are then provided to the Des Moines NWS Forecast Office (WFO) for public dissemination.

In preparing reservoir forecasts, Water Control staff compute daily inflow based on outflow and change in storage at each reservoir. In addition, discharges in the Des Moines River as well as the small tributaries upstream of the reservoirs are compared to the computed inflow to verify inflow into the reservoirs. Once the current inflow has been validated, reservoir release and lake level forecasts are developed using the HEC-ResSim model. The Des Moines River Basin currently utilizes several different ResSim v2.1 models for the Des Moines basin. For most daily operations the use of models that only include each individual reservoir are used. These simply use the known changes in pool elevation and the outflow, along with an estimated inflow to project pool changes over a 14 day period. The Rock Island district also has a full Des Moines Basin ResSim model. This model is utilized to make operational decisions and forecasts in times of high-water. This model includes both of the basin reservoirs as well as all of the constraint locations within the basin and tributary flows.

Currently, MVR utilizes reservoir inflow forecasts provided by the NCRFC. However, the MVR Water Control Section has the option of editing these forecasts based on current calculated inflow at the time of forecast and observed flows at the gages witinin the basin. Data acquisition and validation software are used to ingest and perform quality control of incoming data prior to ingesting the data into ResSim and running the model. Once the ResSim model is initiated, the model routes flow downstream of the reservoir using specified rules to determine forecasted lake levels and releases. Upon completion of the model runs and verification of the results, forecasted releases and pool levels for each lake are made available internally through the Water Management Website at http://155.76.213.69 and publically through Rivergages.com.

MVR recently completed development of a full Corps of Engineers Water Management System (CWMS) model which includes hydrologic modeling capability using the Hydrologic Modeling System HEC-HMS which allows gridded rainfall to be used to calculate runoff. Runoff calculated using HMS can then be used to validate NWS inflow forecasts prior to running ResSim. During major flood events, reservoir outflow calculated by ResSim can be provided as input to the HEC River Analysis System HEC-RAS to develop water surface profiles which can ultimately be used to develop inundation mapping and develop consequence information using the HEC Flood Impact Analysis (HEC-FIA) program.

6-05. Long Range Forecasts. Long-range forecasts are prepared primarily to determine flood potential (including snowmelt), resulting pool fluctuations, and for drought conditions. The NWS Advanced Hydrologic Prediction System (AHPS) produces hydrologic forecasts with lead times of a few days to 90 days for the Des Moines Basin. It provides river forecasts that not only account for precipitation already on the ground but probabilistically account for future precipitation. This coupled prediction system improves the capability to take timely and effective actions that will significantly mitigate the impact of major floods and droughts. The AHPS system provides information for use in managing competing water demands for all project purposes.

6-06. Drought Forecasts. Drought forecasts are prepared weekly during a severe drought. Forecasts consider recent streamflow and precipitation data as well as long-term monthly data and climatological

outlooks. Drought management considers both Saylorville and Red Rock Reservoirs. While the operation of the reservoirs during a drought is determined by the amount of water in storage, drought forecasts give the Water Control Section lead-time to convene the "Corps Drought Management Committee" and the "Interagency Drought Management Committee".

The Water Control Section monitors the Palmer Drought Severity Index and the U.S. Drought Monitor furnished by the NWS on a monthly basis. This information combined with daily streamflow and change in storage indicate the onset of drought conditions. More detailed forecasts are created by analyzing or including assessments of current inflow conditions, the long-term monthly inflow non-exceedance probability based on the period of record, and the three month seasonal precipitation outlook from the Climate Prediction Center (CPC). The situation at the start of the forecast is evaluated using the latest months average inflow to determine the non-exceedance probability. A three-month history of precipitation is compared to long-term normals to determine what level of precipitation caused the current low flow level. The seasonal precipitation outlooks are used to determine the probability of future precipitation, which is used to estimate the future non-exceedance probability of the inflow. The period of record non-exceedance record is then used to forecast the expected monthly inflow. The RESSIM model then routes the inflow through the reservoir to predict future reservoir levels.

The drought contingency plan for Lake Red Rock and Saylorville Lake is on file in the Water Control Section. The plan is titled: *Appendix C Master Reservoir Regulation Manual Drought Contingency Plan for Lake Red Rock and Saylorville Lake, Oct 1992*.

VII - SYSTEM WATER CONTROL PLAN

7-01. General Objectives. The major objectives of the water control projects on the Des Moines River are to provide a comprehensive plan for flood risk management and water conservation in the Des Moines River Basin. Two major components of this plan are the Red Rock and Saylorville Reservoirs.

The Lake Red Rock project was originally authorized for the primary purposes of flood risk management and low flow augmentation along with later authorizations for fish and wildlife management and recreation. However, while the lake provides recreational opportunities and access to facilities, the project is not regulated for that purpose.

The project began operation in 1969. Previous modifications to the regulation of Lake Red Rock have primarily been to raise the permanent pool levels to offset the effects of sedimentation in order to maintain conservation storage to meet low-flow requirements on the Des Moines River. Increased sediment deposition and the requirement of a 50,000 acre-feet permanent conservation storage volume have required periodic pool level adjustments. The current water control plan calls for maintaining the conservation pool at elevation 742 feet with a potential increase to 747 during fall and winter for fish and wildlife purposes as requested by the Iowa Department of Natural Resources (IDNR).

The Saylorville Lake project was originally authorized for the primary purposes of flood risk management, low-flow augmentation, with later authorizations for fish and wildlife management and recreation. As in the case of Lake Red Rock, while the lake provides recreational opportunities and access to facilities, water is not managed for that purpose. The dam was closed in 1975 but did not reach the authorized conservation pool level until September, 1977. A study completed in December, 1981, recommended that Saylorville Lake could be used for water supply without significantly affecting flood control or low flow augmentation. In August, 1982, a contract between the State of Iowa and the Federal Government was entered into which allowed the state to withdraw an average annual flow of 75 cfs for water supply. The new plan provided for an increase in the conservation pool level to elevation 836 feet in order to provide 18.86 percent of the usable conservation storage for water supply with an optional raise to elevation 838 feet in the fall to provide habitat for migrating water fowl and shorebirds. The conservation pool of 836 feet was three feet higher than the original conservation level of 833 feet for Saylorville Lake.

Operation of the Lake Red Rock project in conjunction with the Saylorville Lake project provides flood risk management benefits for communities downstream of these projects along the Des Moines River as well as communities along the Mississippi River. Low-flow augmentation for downstream water supply and water quality provides for a minimum flow of 200 cfs at Saylorville Dam, 270 cfs at S.E. 6th Street in Des Moines and 300 cfs at Ottumwa. A final objective was to implement a drought contingency operation which constructively rations water during extreme drought periods.

In order to meet flood risk management objectives, the adopted plan of regulation considers several constraints related to downstream channel capacity along the Des Moines River at Des Moines, Ottumwa and Keosauqua, Iowa, and along the Mississippi River at Burlington, Iowa, and Quincy, Illinois. In addition the plan considers major flood operation reservoir levels, maximum rate of change of flood releases and minimum low-flow requirements.

About 75 percent of the flood damage in the Des Moines River Basin occurs along the river between the mouth and the city of Des Moines, inclusive. Adoption of a flood-release rate higher than channel capacity immediately downstream of the Saylorville Dam necessitated the acquisition of a floodway corridor between the dam and the city of Des Moines. For conservation storage, the plan of operation is to provide the minimum low-flow in the downstream reaches and to furnish water to the state of Iowa for consumptive use (Saylorville Lake).

Integrated components of the Des Moines River-Reservoir System are as follows:

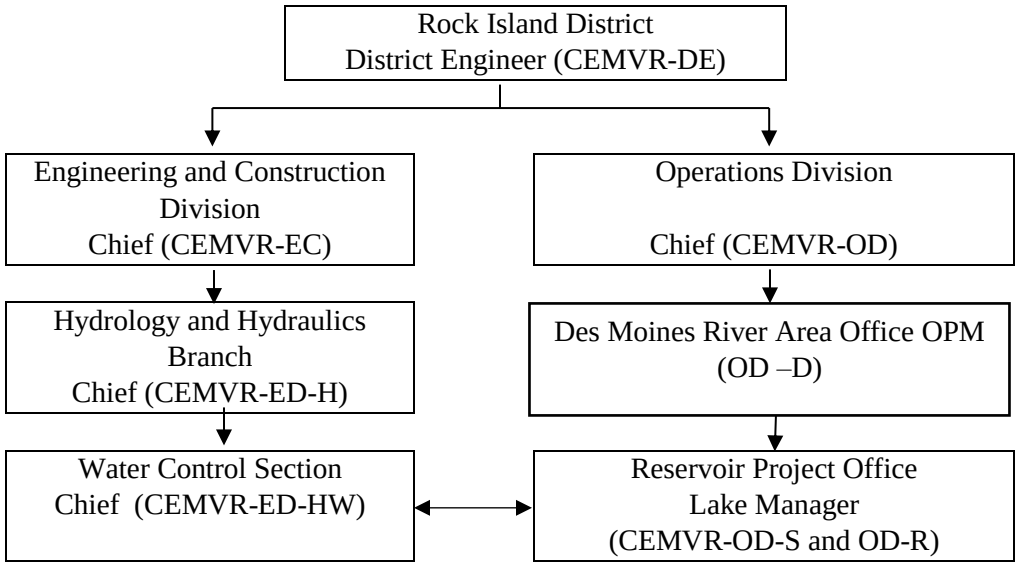
1. Saylorville Lake for flood risk management.
2. Lake Red Rock for flood risk management.
3. Des Moines Local Flood Protection Works for flood risk management.
4. Floodway corridor for flood risk management and recreation.
5. Big Creek Remedial Works for flood risk management and recreation (Saylorville Lake).
6. SE Des Moines and Pleasant Hill Remedial Works (Lake Red Rock)
7. Avon Station Remedial Works for flood risk management (Lake Red Rock).
8. Carlisle Remedial Works for flood risk management (Lake Red Rock).
9. Saylorville Lake conservation pool for water supply and low-flow augmentation.
10. Lake Red Rock conservation pool for low-flow augmentation.

In the regulation of the conservation pools, low-flow augmentation has priority over recreation needs. For Saylorville Lake, water supply has priority over both recreation and water quality needs.

7-02. Organization for Reservoir Regulation. The responsibility for water control regulation of Saylorville and Red Rock Reservoirs rests with the Rock Island District Commander. Within the District Office, the principal responsibility for planning and administration of reservoir regulation is assigned to the Water Control Section of the Hydrology and Hydraulics Branch, Engineering and Construction Division, with support from other branches of the Engineering and Construction Division. Verbal and written regulation orders are issued by the Water Control Section to each Lake Manager. Figure 7-1 shows the District organization pertinent to reservoir regulation.

Project operation of Saylorville and Red Rock Dams is under the jurisdiction of the Operations Project Manager at the Des Moines River Area Office and the Lake Managers located at each reservoir site. Periodically, it is necessary to apprise the general public of reservoir operations. Downstream areas can be affected by changes in release rates. Persons living in areas surrounding the reservoir are interested in changes in reservoir levels. The Corporate Communications Office for the District is responsible for issuing information releases to area news media for public dissemination. Technical information for the releases is furnished by the Water Control Section. Under certain emergency conditions, as described under flood warnings in the Standing Instructions listed in Exhibit A of this manual, the Lake Manager will keep the public informed of changes in reservoir outflow rates.

Figure 7-1 Organization of Reservoir Regulation within Rock Island District



The Standing Instructions, as listed in Exhibit A of this manual, Exhibit B in Appendix A (Lake Red Rock), and Exhibit C in Appendix B (Saylorville Lake), are furnished to each Lake Manager. They outline the steps to be taken by the project manager for collecting and transmitting hydrologic data and reading and recording of all gages and gate settings on the dam when communications with the Water Control Section are disrupted. It is the responsibility of the project manager to understand these instructions and to train project staff. These instructions will be reviewed periodically with the Water Control Section.

An "emergency" is considered to exist when communication either by email or telephone cannot be established between the Lake Manager at each lake and the Water Control Section during a significant period of time and gate changes are necessary. Emergency situations can be minor in nature or of a magnitude demanding immediate action. During such situations, the operation of the reservoirs is in accordance with provisions contained in the Standing Instructions listed in Exhibit A of this Manual.

7-03. Conservation Regulation. Conservation objectives of Saylorville and Red Rock Reservoirs are to augment Des Moines River flows during low-flow periods and provide habitat for fish and wildlife. In order to meet these objectives, the Saylorville Reservoir pool is normally maintained between elevation 836 feet and 837 feet during the spring and summer. In the fall the pool can be raised to an allowable elevation as high as 840 feet at the request of the IDNR for the benefit of waterfowl and shorebirds and can be held at that level until 01March when it is returned to the normal level of 836 feet after the ice cover on the lake has melted. Similarly, the Red Rock pool is normally maintained between elevations 741.5 feet and 743 feet and can be raised to an allowable elevation of 746 feet in the fall as requested by the IDNR for the benefit of waterfowl and shorebirds. The pool can be held at that level until 01 March when it is returned to the normal spring/summer conservation level.

This Master Water Control Manual update incorporates environmental sustainability by integrating environmental objectives into the day-to-day water control operations. During non-flood periods, the District can operate within various reservoir heights and releases geared toward environmental benefits. Operating the reservoirs with a band of lake elevations for conservation was a result of close planning with The Nature Conservancy (TNC), IA DNR, U.S. Fish and Wildlife Service (USFW), and academics through a Sustainable Rivers Project (SRP) partnership with the TNC. The Des Moines River SRP helped identify environmental flow requirements for the Des Moines River, and develop hypotheses for alternative flow releases from the Red Rock and Saylorville dams that might establish more natural flow regimes and/or enhance multiple benefits within the project area. The goal of the project was to explore whether it is possible to modify the District's dam operations to manage for a more "naturalized" flow regime benefiting fish and wildlife populations, ecosystem function, river and floodplain habitat, and water quality.

Implementing a conservation band allows the reservoirs to operate within a range of elevations during both the "summer" and "winter" seasons.

The District and TNC determined those bands to be the following:

September 1 – March 1 ("winter" season)
- Saylorville Lake: Elevations 836 – 840 feet
- Lake Red Rock: Elevations 741.5 – 747 feet

March 1 – September 1 ("summer" season)
- Saylorville Lake – Elevations 836 – 838 feet
- Lake Red Rock: Elevations 741.5 – 743 feet

Model Simulations were run to evaluate the effects of operating the reservoirs under the band concept. The results of the simulations showed little to no effect on peak reservoir elevations at either the low or high ends of the proposed operating bands.

During low-flow periods, Saylorville Reservoir will attempt to maintain flows for water quality and water supply. Water quality releases for low-flow augmentation are intended to be met at least 90 percent of the time. Water quality objectives are part of the authorized project purposes. The objectives are met by maintaining a minimum flow of 200 cfs plus water supply demand from Saylorville Dam to the confluence with the Raccoon River, 270 cfs at the confluence to the sewage treatment plant (Des Moines River Mile 199) and 300 cfs at Ottumwa. Since a portion of the conservation storage at Red Rock Reservoir was reallocated to Saylorville Reservoir, low-flow releases from Saylorville Reservoir need to be adjusted such that minimum low-flow requirements in each index reach are satisfied. Therefore, more than 200 cfs will be released if necessary so as to keep a flow of 270 cfs at S.E. 6th Street in Des Moines and maintain a flow of 300 cfs at Ottumwa. These minimum releases will be met until the Saylorville pool falls to elevation 827.0 feet or the Red Rock pool falls to elevation 727.0 feet, at which time the Drought Contingency operations will begin for water quality releases. Schedule D of Exhibit A - Part I (Saylorville Lake) or Schedule C of the Water Control Plan of Exhibit A - Part II (Lake Red Rock).

The regulation schedule for the conservation operation of Saylorville Reservoir was developed using a computer model to simulate reservoir operation between 1921 and 1980. Although the regulation plan proved to be effective for historic droughts, it does not guarantee that it will be the most effective plan of

operation for future droughts. In order to assess the effects of an extended drought, the Rock Island District, Corps of Engineers, will assemble the views of federal and state agencies, plus local governments. The Rock Island District will initiate this contact when the pool has reached or forecast to reach elevation 828.0 feet at Saylorville Lake or 735.0 feet at Lake Red Rock. Possible changes in the drought contingency sections of the water control plan might be to advance or delay the point where rationing begins. State organizations to be contacted include the Iowa Department of Natural Resources and the office of Iowa Homeland Security and Emergency Management. Other organizations which may be contacted include the cities of Des Moines, Ottumwa, Pella and Knoxville, Alliant Energy and the Des Moines Water Works. In addition to drought contingency releases for water quality, a Water Supply Contract between the State of Iowa and the federal government allows the State of Iowa to request releases for water supply.

7-04. Regulation for Flood Risk Management. Techniques pertaining to the regulation of storage allocated to flood control in the reservoirs may be classified as Method C as defined in EM 1110-2-3600. This provides for maximum damage reduction during ordinary flood events until the lower part of the storage is filled and then provides a fixed schedule of releases to assure greater control of larger flood volumes. The normal flood operation of Saylorville Reservoir is accomplished by regulation of releases through a circular conduit controlled by 3 sluice gates. Normal flood control operation of Red Rock Reservoir is accomplished by regulation of releases through 14 rectangular conduits controlled by sluice gates. The reservoir regulation plans for the Saylorville and Red Rock Reservoirs are located in Exhibit A, Part I and Part II, respectively. The basic objective for both reservoirs is to release the maximum permissible outflow as limited by the conduit capacity and other constraints described below.

Saylorville Reservoir is operated with downstream control points at 2nd Avenue and S.E. 6th Street in Des Moines. The control stage at 2nd Avenue is 21.0 feet and the control stage at S.E. 6th Street immediately downstream of the confluence with the Raccoon River is 26.5 feet. If the lake level is forecast to remain between conservation pool (836/840 feet) and 875 feet, regulation of the flood storage will be made to limit the stage at the control points to the prescribed levels. In any case, the maximum allowable release is 16,000 cfs. However, changes in releases are limited to 6,000 cfs per day for openings and 3,000 cfs per day for closures with a maximum change of 3,000 cfs per gate setting. Normal flood control operation is described in Part I, Schedule A.

When the pool level is forecast to exceed 875 feet the Intermediate Magnitude Flood Schedule (Part I, Schedule B) is followed when the pool is forecast to peak between elevations 875 and 884 feet. This schedule increases the outflow rates from 16,000 cfs at 875 feet to 21,000 cfs at 884 feet with all other constraints being disregarded. When the pool is forecast to exceed elevation 884 feet, the Large Magnitude Flood Schedule (Part I, Schedule C) is followed with the pneumatic crest gates along the spillway being raised to prohibit spillway flow until elevation 890 feet is reached. The release rate above 884 feet NGVD is held at 21,000 cfs (fully open conduit) until pool elevation 889 feet NGVD is reached. At 889 feet, if the pool is forecast to exceed elevation 890 feet, the pneumatic crest gates are gradually lowered, as necessary, so that the combined outflow from the fully open conduit and the spillway is 42,000 cfs at elevation 890 feet. Above 890 feet, no further regulation is attempted. After the reservoir has peaked, uncontrolled spillway flow and fully opened conduit flow will be maintained to elevation 884 feet. Below the spillway crest, full conduit flow will be maintained to elevation 875 feet when release rates gradually transition to normal flood operation.

Red Rock Reservoir is operated with the downstream control points at Ottumwa and Keosauqua, Iowa, on the Des Moines River and Burlington, Iowa, and Quincy, Illinois, on the Mississippi River. The control stage at the Ottumwa gage is 8.7 feet (pool below 750 feet) or 9.1 feet (pool above 750) during the growing season (May 1 –December 15) and 10.8 feet during the non-growing season. The control stage at the Keosauqua gage is 18.4 feet (pool below 750 feet) or 18.8 feet (pool above 750) during the growing season and 19.6 feet during the non-growing season. If the lake level is forecast to remain between conservation pool (741.5/747 feet) and 770 feet, regulation of the flood storage will be made to limit the stage at these control points to the designated control stages. In any case, growing season releases are limited to 22,000 cfs (pool below 750 feet), and 25,000 cfs (pool between 750 and 770 feet). During the non-growing season releases up to 30,000 cfs are permitted when the pool is below 770 feet. For the Mississippi River when control stages at either Burlington, Iowa, or Quincy, Illinois, exceed 18.5 feet or 20.0 feet respectively, releases are limited to reduce the peak flow on the Mississippi River for up to 7 days. Normal flood control operation for Lake Red Rock is described in Part II, Schedule A.

When reservoir levels are forecast to exceed elevation 770 feet, the Large Magnitude Flood Schedule as specified in Part II, Regulation Schedule B, will be followed. When the conduits no longer have the capacity to pass the inflow, releases are transitioned to the spillway tainter gates and the sluice gates are closed. Schedule B specifies discharges to be initiated based on forecasted pool elevations above elevation 770 feet. At pool elevation 785, the spillway tainter gates will be opened sufficiently to allow unrestricted spillway flow to prevail.

The reservoir regulation schedules for Saylorville and Red Rock have been prepared to achieve the objectives outlined above, insofar as possible. Maximum reduction in discharge at downstream control stations is provided during periods when there is less utilization of the flood control storage. As more storage capacity is utilized, the degree of downstream protection is reduced. For reduction of flooding at Des Moines, about 62 percent of the Saylorville Reservoir flood storage capacity is utilized prior to reaching the intermediate and large magnitude flood level of 875 feet. For reduction of flooding along the Des Moines River below Red Rock Reservoir during the growing and non-growing seasons, approximately 60 percent of the Red Rock Reservoir flood storage capacity is utilized prior to reaching the large magnitude flood level of 770 feet.

During large magnitude floods when the cumulative inflow volume to the reservoirs exceeds the designated flood pool capacity, uncontrolled conduit and spillway discharge will prevail.

7-05. Emergency Drawdown. If emergency drawdown is warranted, the basic guidelines for such operations will be in accordance with ER 1110-2-50, dated 22 August, 1975. Drawdown time requirements for various average inflow rates for Red Rock and Saylorville reservoirs are displayed in Appendices A and B of this manual.

7-06. Emergency Action Plans. A report entitled "Emergency Plan for Saylorville Dam and Big Creek Remedial Works," dated February, 2012, addresses extremely rare flow events from the Saylorville Dam. Flood flows and dam failure flows in the range of 213,700 to 1,721,000 cfs are considered. A maximum pool 13 feet above the design flood pool of elevation 890.0 feet is considered. A spillway design flood would inundate much non-federal land surrounding the lake and would be a hazard to life and property in downstream areas.

The emergency plan for Red Rock Dam is addressed in a report entitled "Emergency Plan for Red Rock Dam and Lake," dated August, 1985. Flood flows and dam failure flows in the range of 314,000 to 1,693,000 cfs are considered. A maximum pool 11.6 feet above the design flood pool of elevation 780 feet is considered. As was the condition at Saylorville Lake, a spillway design flood would inundate considerable nonfederal land surrounding Lake Red Rock and would be a hazard to life and property to downstream areas. The referenced emergency plans are used as a guide to identify various types of dam emergencies which could occur and the actions to be taken. The emergency plans are applicable to all state of Iowa, Corps elements and field offices concerned with operation of the Saylorville and Red Rock Dams. The plans address emergencies related to above normal reservoir water levels and/or rapid release of large volumes of water past the dam. They cover identification of impending or existing emergencies, notification of other parties concerning impending or existing emergencies, and emergency operation and repairs. Examples of potential emergencies are identified for the cases of Spillway Design Flood without dam failure, Spillway Design Flood with dam failure, failure of the dam at full flood pool as well any dam failure during normal operations. The Spillway Design Flood for both Saylorville and Red Rock Dams is the probable maximum flood (PMF). The Emergency Action Plan for Lake Red Rock is currently being updated.

VIII - EFFECT OF SYSTEM WATER CONTROL PLAN

8-01. General. The Saylorville and Red Rock Reservoirs are units of a comprehensive plan for flood risk management in the Upper Mississippi River Basin. Red Rock Dam, Saylorville Dam and the Des Moines Flood Protection Project are operated as a system for flood protection on the Des Moines and Mississippi Rivers. Other benefits from the reservoirs include low flow augmentation, water supply, fish and wildlife management, and recreation. A more detailed discussion of the effects and benefits of the reservoirs is contained in the following paragraphs.

8-02. Flood Risk Management. The following paragraphs summarize the analysis used in both the design of the Saylorville and Red Rock Reservoirs and the updated water control plans. A more detailed discussion on the development of these flood hydrographs can be found in Appendices A and B of this manual.

The hydrology and hydraulics of the Des Moines River Watershed was analyzed to facilitate the evaluation of water control plan alternatives. A detailed Hydrologic Engineering Center (HEC) Reservoir Simulation (HEC-ResSim) model was developed and calibrated to the observed record at Saylorville Lake and Lake Red Rock. This model was used to evaluate the 100-year period of record from 1917 to 2016 for all alternatives considered during the 2019 feasibility study to update the water control plans for Saylorville Lake and Lake Red Rock. These simulations included floods before and after the reservoirs went into operation.

During the design phase of Saylorville and Red Rock Reservoirs, spillway design storms derived by the National Weather Service (NWS) were based on studies of probable maximum precipitation over the Des Moines River Basin above each reservoir site. The inflow hydrograph for design of the Lake Red Rock spillway is based on the assumption that this flood would occur with Saylorville Lake in operation. The respective Spillway Design Flood hydrograph was routed through each reservoir on a full flood pool to yield the maximum reservoir elevations and outflows. These hydrographs are shown in Appendices A and B of this manual.

Both the Saylorville and Red Rock Reservoirs' Standard Project Floods were based on the May-July, 1947, storm. Runoff was estimated to be about 9.0 inches at Saylorville and 7.69 inches at Red Rock. The Standard Project Flood for the Saylorville Reservoir was routed on a full pool. The inflow hydrograph of the Standard Project Flood at Red Rock Reservoir is based on the assumption that this flood would occur with Saylorville Lake in operation. The Standard Project Flood was routed through Lake Red Rock, starting with the flood control storage half full. The hydrographs are shown in the individual appendices, B and C.

8-03. Low-Flow Augmentation. The State of Iowa sets low flow levels at gaging stations around the state. This requirement improves downstream water quality for aquatic and riverine habitat at a time that they are greatly stressed. The normal minimum release at Saylorville is 200 cfs plus water supply demand. More than 200 cfs will be released to maintain a flow of 270 cfs at SE 6th Street Gage in Des Moines and a flow of 300 cfs at Ottumwa. The normal minimum release at Red Rock is 300 cfs. These minimum releases will be met until the Saylorville pool elevation falls to 827.0 feet NGVD and the Red Rock pool falls to elevation 734.0 feet NGVD, at which time rationing will begin for water quality releases.

8-04. Water Supply. At Saylorville Lake, an agreement signed in 1982 between the Federal Government and the State of Iowa provides 18.86 percent of the usable storage space in the reservoir (estimated to be 11,940 acre-feet) between elevations 812 feet and 836 feet for water supply. The state has sub-allocated that water to the Des Moines Water Works and Alliant Energy. There are no direct water intake structures in Saylorville Lake, but water is withdrawn downstream from releases made through the Saylorville Dam. During droughts, water supply has priority over other uses when the conservation pool is below 823.5.

8-05. Fish and Wildlife. The Des Moines River reservoirs provide varied habitat in the area in and around the reservoirs. The lakes provide habitat for fish, waterfowl, shorebirds, and aquatic plants. The fringe areas surrounding the lakes provide good wetland habitat for plants and animals. In the fall, these areas are sometimes seeded with grasses and then flooded creating ideal habitat for migrating waterfowl. Low flow augmentation of the reservoirs provide a minimum amount of water downstream of the reservoirs to preserve riverine habitat.

8-06. Recreation. The operation of the Saylorville and Red Rock dams enhance recreation in many ways. The stilling basins aerate the tailwater areas below each dam increasing dissolved oxygen used by fish and other aquatic life, thus improving recreational fishing. Similarly, the conservation pools are used for swimming, fishing, and boating as well as a backdrop for bicycling, hiking and camping. The fall pool raises enhance migratory waterfowl habitat, which creates opportunities for bird watching and hunting. While recreation is an authorized purpose at both reservoirs, water at the reservoirs is not regulated for that purpose.

IX - SYSTEM WATER CONTROL MANAGEMENT

9-01. General. Both reservoirs on the Des Moines River are owned by the Federal Government and operated and maintained by the U.S. Army Engineer District, Rock Island, Illinois (CEMVR). The dams are attended during regular working hours on a daily basis. During the recreation season, Park Rangers are on duty on weekends and evenings and may be reached by email, office telephone or cell phone. Gate operations are made by the Park Rangers during those periods. During normal business hours, regulation instructions and hydrologic forecasts are furnished by the Water Control Section to project staff via email and posted to the Water Control Section internal website 155.76.213.69 and www.Rivergages.com. In an emergency, the Lake Manager or any of his subordinates, may be called by telephone to make gate operations or activate the pumping stations as necessary.

9-02. Functional Responsibilities. As stated in paragraph 9-01, the Water Control Section has the regulatory responsibility for water management at the reservoirs. On a daily basis, upon receipt of instructions from the hydrologic forecaster on duty in the Water Control Section, Corps of Engineers project staff will execute gate operations at the reservoirs as required. Standing Instructions to the dam tenders are outlined in Exhibit A.

9-03. Interagency Coordination. Unusual operations and important events or noteworthy news items regarding regulation of Saylorville or Red Rock Reservoirs will be made to the local news media by the Corporate Communications Office, Rock Island District. In some instances, public meetings will be held to inform the public of important decisions or to hear the views of interested persons.

Close coordination with the National Weather Service is maintained in the forecasting of stages at NWS forecast points within the basin. The NWS-NCRFC provides forecasts of flow on the Des Moines River both upstream and downstream of the reservoir projects. Inflow forecasts provided by the NWS are analyzed and edited prior to being provided as input to the HEC-ResSim operational model for the Des Moines River reservoirs. Preliminary forecasts at downstream control points are also considered in the forecast process. Once final regulation decisions have been made regarding outflow, they are transmitted to the NCRFC via Local Data Manager software (LDM) so they can be incorporated into their final downstream forecasts that are disseminated to the public.

Coordination is also maintained with the U.S. Geological Survey (USGS) in the making of discharge measurements at gage sites in the basin. The Iowa Department of Natural Resources is also kept informed about project operations and, in times of emergency, the Iowa office of Emergency Management is informed. During extended periods of low flow or drought, coordination will be established between the State of Iowa and other water users to collectively evaluate runoff conditions and possible regulation responses.

9-04. Sedimentation. Sediment studies at both Saylorville Lake and at Lake Red Rock have been conducted periodically since the reservoirs began operation. Reservoir sedimentation is an important issue with regard to meeting authorized purposes and reservoir life. The rate of sedimentation varies based on watershed characteristics. As sediment deposition occurs, reservoir storage capacity for both water conservation and flood risk management is reduced.

At Saylorville Lake, results from the 2014 re-survey, indicated the amount of sediment deposition between elevations 836 feet and 890 feet (flood control pool) amounted to 13,185 acre-feet or 2.3 percent of the available capacity in this elevation range since operation of the reservoir began in April 1977. This equates to about 335 acre-feet of flood control storage loss per year. Storage at elevation 890 feet and below decreased by 39,535 acre-feet or approximately 6 percent over the 37 year life of the project. The rate of deposition within the reservoir is 1,066 acre-feet per year, which is higher than the predicted rate from 1979 of 800 acre-feet per year and lower than the 1998-1999 re-survey's calculated rate of 1,135 acre-feet per year. The amount of sediment deposition below elevation 836 feet (conservation pool level) amounted to 67 percent of the total deposition in the reservoir (elevation 890 feet and below) since April 1977. With a capacity reduction of 31 percent for the elevation increment of 835 feet to 836 feet NGVD, this 1 foot increment has been one of the highest rates of filling since project inception, which is expected due to the amount of time the reservoir water surface elevation is within that range. Wave action and erosion along the shoreline followed by deposition in low flow areas with shallow depths, such as, coves and slack water areas, could also help explain the amount of deposition.

At Lake Red Rock, results of the 2011 re-survey indicated the amount of deposition below elevation 780 (flood control pool elevation) amounted to 181,300 acre-feet since operation of the reservoir began in March of 1969. This equates to about 4,250 acre-feet of storage loss per year. Based on the 2011 re-survey, the amount of sediment deposition below the historic conservation pool elevation of 725 amounted to 60 percent of the total deposition in the reservoir since commencing operation. With the latest Red Rock Reservoir Regulation Schedule change in 1992, the conservation pool elevation was raised to 742, thus the flood pool now consists of capacity between elevations 742 and 780. Comparing the current conservation pool capacity to the estimated 1969 capacity, the conservation pool has lost 147,850 acre-feet or 44 percent. At the new regulated elevations, the 2011 re-survey shows Red Rock Reservoir flood pool capacity at 1,463,250 acre-feet. The flood pool capacity between 1969 and 2011 has decreased by 34,120 acre-feet or 2.3 percent.

9-05. Water Quality. The Des Moines and Iowa River Water Quality Monitoring Network is a collaborative effort between the Rock Island District and Iowa State University, to conduct water quality observations and data collection at locations along the Des Moines River and Iowa Rivers. Along the Des Moines River, data is collected from above Saylorville Lake to below Lake Red Rock. There are 23 Des Moines River and associated reservoir locations of which six are currently monitored by Iowa State University (with one high water alternative site) and one Raccoon River site that is monitored by the Des Moines Waterworks. Four beach-only sampling locations are monitored by Iowa State University. The reservoir water quality data is published annually and covers over 50 water quality parameters as well as fish tissue sampling results for mercury and select pesticides.

9-06. Hydropower. Missouri River Energy Services (MRES) is currently constructing a new 36.4 megawatt hydroelectric facility at Lake Red Rock. The plant is being constructed on the left envelopment of the existing dam adjacent to the spillway and outlet works. Upon completion, normal releases up to 10,200 cfs will be routed through the turbines before utilizing the sluice gates. Power production at Red Rock Dam is not an authorized purpose of the project therefore, a "power pool" will not be established to guarantee water for the hydropower plant. Although the addition of the hydropower plant to the existing condition model increases release capacity at lower elevations, the magnitude of the prescribed flows released by Red Rock Dam does not change. It does, however, change the location from which releases are made. Additional details regarding hydropower operation can be found in the Lake Red Rock Water Control Manual, Appendix A.

EXHIBIT A – PART I

SAYLORVILLE LAKE

STANDING INSTRUCTIONS TO PROJECT OPERATOR

A-01. Instructions to Lake Manager. All regulation instructions shall be furnished by the reservoir forecaster, Water Control Section, Hydrology and Hydraulics Branch. The reservoir forecaster is designated to analyze hydrologic data and issue instructions to the reservoir operations manager for all gate operations. Normally, regulation instructions will be furnished by email or telephone. Under emergency conditions, the Lake Manager is authorized to operate the gates as outlined in the regulation schedules of this exhibit and record all the details of operation. In addition to this exhibit, all information pertinent to regulation shall be furnished to the Lake Manager.

A-02. Non-Duty Hours of Operation. Gate changes will be made during normal working hours, insofar as possible. In the event that conditions require immediate action, gate instructions may be given for any hour. If unusual conditions arise during non-duty hours, reservoir personnel should contact the forecaster at the phone number listed on the daily instructions email or the Chief, Water Control Section, at [redacted].

A-03. Pool Regulation.

a. Normal Operation. Seasonal conservation pool levels will be maintained following Schedule A except as described in Appendix B of the Saylorville Water Control Manual which discusses deviations from normal operation.

b. Intermediate Magnitude Flood Operation. An intermediate magnitude flood is said to exist when the pool level is above or forecast to exceed elevation 875 feet NGVD but peak below elevation 884 feet NGVD. Under these conditions, the Intermediate Magnitude Flood Operation Schedule B will be followed.

c. Large Magnitude Flood Operation. A large magnitude flood is said to exist when the pool level is above or forecast to exceed elevation 875 feet NGVD and peak above elevation 884 feet NGVD. Under these conditions, the Large Magnitude Flood Operation Schedule C will be followed. When the pool rises above 890 feet NGVD, uncontrolled discharge prevails.

d. Inflow Less than 200 cfs. For all inflows below 200 cfs, a minimum release of 200 cfs plus water supply releases will be made from the conservation storage. However, if the gage at the SE 6th Street indicates flows less than 270 cfs plus water supply releases, additional releases will be made to make up the difference. These release rates will continue until the pool is forecast to be below elevation 827 feet NGVD at which time release rates will be made in accordance with Drought Schedule D.

e. Drought Contingency Pool. During declared droughts between July 1 and March 1 the conservation pool may be increased to elevation 838 ft NGVD to conserve water.

A-04. An "emergency" exists when communications cannot be established between Lake Manager and the Water Control Section and gate changes are necessary. During an emergency the Lake Manager will follow the Water Control Plan. A summary of the various schedules appears in table A-1. Records will be kept of all gate changes, pool levels, and all other gaged data. The reservoir Lake Manager will continue to provide the public information on reservoir releases.

Table A-1. Summary of Reservoir Water Control Plan Schedules

Situation	Pool Condition	Forecast	Schedule	Page
Normal Operation	Above 836 Below 875	Peak below 875	A	A-3
Intermediate Magnitude Flood	Above 875 Below 884	Peak below 884	B	A-4
Large Magnitude Flood	Above 875	Peak above 884	C	A-5
Drought	Below 836	Low Inflow	D	A-7

A-05. Flood Warnings and Forecasts. It is the responsibility of the National Weather Service (NWS) to issue flood forecasts and warnings. With regard to reservoir operations, forecast refers to the operational reservoir forecast issued daily (or more often as needed) by the Water Control Section on RiverGages.com. The operational forecast includes one or more days of predicted rainfall that is included in the official NWS flow forecast utilized in the District's reservoir simulation model. The number of days of predicted rainfall that is included in the NWS flow forecasts varies seasonally and is occasionally lengthened for specific storm events when the NWS deems it appropriate to do so due to the significance and level of confidence in the predicted rainfall. The Water Control Section provides pertinent information pertaining to Saylorville Lake regulation to the NWS.

Under emergency conditions, when there is not time for the National Weather Service to issue flood warnings, the Operations Project Manager and Lake Manager is responsible for warning the public regarding sudden changes in release rates, which may adversely affect interests downstream.

SAYLORVILLE LAKE REGULATION

SCHEDULE A Normal Flood Control Operation Pool Elevation: at or forecast between 836 and 875 ft NGVD Maximum daily increase in outflow: 6,000 cfs (3,000 cfs/gate change) Maximum daily decrease in outflow: 3,000 cfs

Condition	Operation
A-I Any Date	Maintain permanent pool level by releasing inflow up to 16,000 cfs. Outflow is limited by the conduit capacity.
A-II Any date Stage Above or Forecast to exceed: 2nd Ave. (Des Moines) 21.0 ft. SE 6th St (Des Moines) 26.5 ft.	Provided inflow is in excess of 2,000 cfs, release not less than 2,000 cfs to avoid exceeding control stages at respective stations insofar as possible. Otherwise release not less than inflow.
A-III 01 Mar. thru 01 Sept. Maintain reservoir between 836 ft and 837 ft (NGVD).	Pool levels may be maintained within the specified bands to accommodate operations and maintenance and stakeholder requests outside of flood operations.
A-IV 01 Sept. thru 01 Mar. Maintain reservoir between 836 ft and 840 ft (NGVD).	Pool levels may be maintained within the specified bands to accommodate operations and maintenance and stakeholder requests outside of flood operations. The fall pool raise is in coordination with the Iowa DNR.

SAYLORVILLE LAKE REGULATION

SCHEDULE B
Intermediate Magnitude Flood Operation

Pool above elevation 875 ft NGVD and forecast to peak below elevation 884 ft NGVD

Condition	Operation
B-I Any date reservoir is rising and pool is forecast to peak between elevation 875 and 884 feet NGVD	When forecasts indicate that anticipated runoff will produce a peak reservoir elevation between 875 feet and 884 feet NGVD if operated under Schedule A, the schedule listed below will be adopted with the purpose of minimizing releases. Pool Elev — Outflow (cfs) 880 — 16,000-17,000 881 — 16,000-18,000 882 — 16,000-19,000 883 — 16,000-20,000 884 — 16,000-21,000 Shift to Schedule C when predictions indicate runoff will cause pool elevation to exceed elevation 884 feet NGVD when operated under the above Schedule B-I.
B-II Any date Reservoir has peaked and is falling. Pool is between elevation 875 feet and 884 feet NGVD	Hold outflow to the maximum rate reached in B-I (above) until elevation 875 feet NGVD is reached or until rate of recession is 1 ft per day; at elevation 875 ft transition to Schedule A. Outflow should be maintained to limit rate of recession in reservoir to 1 ft per day.

SAYLORVILLE LAKE REGULATION

SCHEDULE C
Large Magnitude Flood Operation

Pool above elevation 875 ft NGVD and forecast to peak above elevation 884 ft NGVD

Condition	Operation
C-I Any date reservoir is rising and pool is forecast to peak between elevation 884 and 890 feet NGVD	Raise the top of the pneumatic crest gates to elevation 890 feet NGVD. Fully inflated bladders require a pressure of 27 psi. Release rates through the conduit are made according to following schedule: Pool Elev — Outflow (cfs) 884 — 21,000 885 — 21,000 886 — 21,000 887 — 21,000 888 — 21,000 889 — fully open 890 — fully open
C-II Any date reservoir is rising and pool is forecast to exceed elevation 890 feet NGVD	As necessary, deflate bladders of the pneumatic crest gates gradually according to the schedule shown on page C-6 to achieve a combined uncontrolled spillway and conduit discharge of 42,000 cfs at pool elevation 890 feet NGVD. Allow the pool to rise with uncontrolled spillway and conduit discharge above 890 feet NGVD.
C-III. Any date reservoir has peaked and pool is between elevation 884-890 ft NGVD	Maintain uncontrolled spillway and conduit flow to elevation 884 feet (spillway crest elevation) if peak resulted in lowering pneumatic crest gates. Otherwise, maintain maximum outflow established in C-I.
C-IV. Any date reservoir has peaked and pool is between elevation 875-884 ft NGVD	Maintain fully open conduit. Upon reaching elevation 875 feet NGVD, transition to Schedule A. Outflow should be maintained to limit rate of recession in reservoir to 1 ft. per day.

SAYLORVILLE LAKE REGULATION

Pool Elev	# of Control Section 1	2	3	4	5	Spillway Discharge in cfs
	Gate Position Elev/Bladder Pressure in P.S.I					
889.0	890.0 27.0	890.0 27.0	890.0 27.0	890.0 27.0	890.0 27.0	0
889.1	890.0 27.0	890.0 27.0	885.3 6.0	890.0 27.0	890.0 27.0	2000
889.2	890.0 27.0	888.1 11.0	884.0 2.0	888.1 11.0	890.0 27.0	4000
889.3	890.0 27.0	886.6 9.0	884.0 2.0	886.6 9.0	890.0 27.0	6000
889.4	890.0 27.0	885.3 6.0	884.0 2.0	885.3 6.0	890.0 27.0	8000
889.5	890.0 27.0	884.3 4.0	884.0 2.0	884.3 4.0	890.0 27.0	10000
889.6	888.0 11.0	884.0 2.0	884.0 2.0	884.0 2.0	888.0 11.0	12000
889.7	886.7 9.0	884.0 2.0	884.0 2.0	884.0 2.0	886.7 9.0	14000
889.8	885.4 7.0	884.0 2.0	884.0 2.0	884.0 2.0	885.4 7.0	16000
889.9	884.4 4.0	884.0 2.0	884.0 2.0	884.0 2.0	884.4 4.0	18000
890.0	884.0 2.0	884.0 2.0	884.0 2.0	884.0 2.0	884.0 2.0	20000

SAYLORVILLE LAKE REGULATION

SCHEDULE D

Drought Operation For Water Supply and Water Quality

Pool Elevation: below 836 ft NGVD and inflow is less than 200 cfs.
Max daily change in outflow does not apply.

Condition	Operation
Pool is above elevation 827 ft NGVD	Release 200 cfs meeting all water supply and water quality demands.
Pool is between elevation 827 and 826 ft NGVD	Release 100 percent of water supply. Maintain 175 cfs at dam and 245 cfs at SE 6th Street.
Pool is between elevation 826 and 825 ft NGVD	Release 100 percent of water supply. Maintain 150 cfs at dam and 220 cfs at SE 6th Street.
Pool is between elevation 825 and 824 ft NGVD	Release 100 percent of water supply. Maintain 125 cfs at dam and 195 cfs at SE 6th Street.
Pool is between elevation 824 and 823.5 ft NGVD	Release 100 percent of water supply. And maintain 100 cfs at dam, and 170 cfs at SE 6th Street.
Pool is between elevation 823.5 and 819 ft NGVD	Release 100 percent of water supply. Make no water quality release.
Pool is between elevation 819 and 816 ft NGVD	Release 75 percent of water supply. Make no water quality release.
Pool is below elevation 816 ft NGVD	Release 50 percent of water supply. Make no water quality release.

EXHIBIT A – PART II

LAKE RED ROCK

STANDING INSTRUCTIONS TO RESERVOIR PERSONNEL

B-01. Instructions to Lake Manager. All regulation instructions shall be furnished by the reservoir forecaster, Water Control Section, Hydrology and Hydraulics Branch. The reservoir forecaster is designated to analyze hydrologic data and issue instructions to the Lake Manager for all gate operations. Normally, regulation instructions will be furnished by email or telephone. Under emergency conditions, the Lake Manager is authorized to operate the gates as outlined in the regulation schedules of this exhibit and record all details of the operation. In addition to this exhibit, all information pertinent to regulation shall be furnished to the Lake Manager.

B-02. Off-Duty Hours of Operation. Gate changes will be made during normal working hours, insofar as possible. In the event that conditions require immediate action, gate instructions may be given for any hour. If unusual conditions arise during non-duty hours, reservoir personnel should contact the duty forecaster at the phone number listed on the daily instructions email or the Chief, Water Control Section, [redacted].

B-03. Pool Regulation.

a. Normal Operation. Seasonal conservation pool levels will be maintained following schedule A, except as described in paragraph 7-12 of the Lake Red Rock Water Control Manual which discusses deviations from normal operation.

b. Large Magnitude Flood Operation. A large magnitude flood is said to exist when the pool level is above or forecast to exceed 770 feet NGVD. Under these conditions, the Large Magnitude Flood Operation Schedule B will be followed. When the pool rises above 785 feet NGVD, uncontrolled discharge prevails.

c. Inflow Less than 300 cfs. For all inflows below 300 cfs, a minimum release of 300 cfs will be made from the conservation storage at Lake Red Rock. This release rate will continue until the pool is at or forecast to be below 734.0 feet NGVD, at which time release rates will be made in accordance with Drought Schedule C.

d. Flash Flood Operation. From 1 April thru 31 October, when the stage at Ottumwa is above, or forecast to exceed 10.8 feet, provided the reservoir elevation is at or below 760.0, release not less than 500 cfs for a period not to exceed 48 hours in accordance with the flash flood operation Schedule D.

B-04. Emergency Flood Control Regulation. An "emergency" exists when communications cannot be established between the Lake Manager and the Water Control Section and gate changes are necessary. During an emergency the Lake Manager will follow the Regulation Schedule. A summary of the various schedules appears in table B-2. Records will be kept of all gate changes, pool levels, and other gage data. The Lake Manager will continue to provide public information on reservoir releases.

Table A-2 Summary of Reservoir Regulation Schedules

Situation	Pool Condition	Forecast	Regulation Schedule	Page
Normal Operation	Above 742 Below 770	Peak below 770	A	A-10
Large Flood	Above 770	Peak above 770	B	A-12
Drought	Below 742	Low inflow	C	A-13
Flash Flood	Above 742 Below 760	Peak below 760	D	A-14

B-05. Flood Warnings and Forecasts. It is the responsibility of the National Weather Service (NWS) to issue flood forecasts and warnings. With regard to reservoir operations, forecast refers to the operational reservoir forecast issued daily (or more often as needed) by the Water Control Section on RiverGages.com. The operational forecast includes one or more days of predicted rainfall that is included in the official NWS flow forecasts utilized in the District's reservoir simulation model. The number of days of predicted rainfall that is included in the NWS flow forecasts varies seasonally and is occasionally lengthened for specific storm events when the NWS deems it appropriate to do so due to the significance and level of confidence in the predicted rainfall. The Water Control Section provides pertinent information pertaining to Lake Red Rock regulation to the National Weather Service.

Under emergency conditions, when there is not time for the National Weather Service to issue flood warnings, the Operations Project Manager and the Lake Manager is responsible for warning the public regarding sudden changes in release rates, which may adversely affect interests downstream.

LAKE RED ROCK REGULATION

SCHEDULE A Normal Flood Control Operation Pool elevation at or forecast to be between conservation pool and below elevation 770 ft NGVD	CONSERVATION POOL SCHEDULE Date — Pool 01 Mar – 31 Aug — 741.5 – 743.0 01 Sep – 01 Mar — 741.5 – 747.0 Conservation pool bands provide flexibility to accommodate maintenance activities and achieve environmental objectives when the projects are not in flood operations

Condition	Operation
A-I 16 Dec. thru 30 Apr.	Maintain conservation pool by releasing up to 30,000 cfs. Outflow is limited by conduit capacity.
A-II 16 Dec. thru 30 Apr. Stage at Ottumwa or Keosauqua above or forecast to exceed 10.8 ft. and 19.6 ft respectively.	Provided inflow is in excess of 5,000 cfs, release not less than 5,000 cfs to avoid exceeding control stage at respective stations insofar as possible. Otherwise release not less than inflow except as permitted in Schedule D.
A-III 01 May thru 15 Dec. Reservoir at or forecasted to exceed conservation pool but peak below elevation 770 ft NGVD.	Maintain conservation pool level by releasing up to the specified outflow except as limited by A-IV and A-V. Pool Elev (ft) — Outflow (cfs) Below 750 — 22000 750 to 770 — 25000
A-IV 01 May thru 15 Dec. Stage at Ottumwa or Keosauqua above or forecast to exceed 8.7 ft and 18.4 ft, respectively. If pool is higher than 750 use stage of 9.1 ft and 18.8 ft, respectively.	Provided inflow is in excess of 5,000 cfs, release not less than 5,000 cfs to avoid exceeding control stage at respective stations insofar as possible. Otherwise release not less than inflow except as permitted in Schedule D.

LAKE RED ROCK REGULATION

SCHEDULE A (cont.) Normal Flood Control Operation Pool elevation at or forecast to be between conservation pool and below elevation 770 ft NGVD	CONSERVATION POOL SCHEDULE Date — Pool 01 Mar – 31 Aug — 741.5 – 743.0 01 Sep – 01 Mar — 741.5 – 747.0

Condition	Operation
A-V Any Date Stage above or forecast to exceed 18.5 ft on Mississippi River gage at Burlington, IA, or 20.0 ft at Quincy, IL.	Set release to reduce flooding for up to seven days corresponding to peak flow along the Mississippi River with due allowance for travel time. Release maximum allowable outflow considering all the constraints as follows: If pool elevation is at or forecast to be between conservation pool and elevation 760.0 and inflow is less than 5,000 cfs, release not less than inflow, otherwise release not less than 5,000 cfs. If pool elevation is at or forecast to be between elevation 760.0 and 766.5, and inflow is less than 15,000 cfs, release not less than inflow otherwise release not less than 15,000 cfs, except as limited by Conditions A-II and A-IV. If pool elevation is at or forecast to be between elevation 766.5 and 770.0, and inflow is less than 25,000 cfs, release not less than inflow, otherwise release not less than 25,000 cfs except as limited by Conditions A-II and A-IV.
A-VI Any Date Pool Receding	As the pool approaches conservation level, reductions in outflow should be limited to 3,000 cfs per day.

LAKE RED ROCK REGULATION

SCHEDULE B
Large Magnitude Flood Operation

Pool Elevation:
At or forecast to be above 770 ft. (NGVD)

<table>
<tr><th>Condition</th><th>Operation</th></tr>
<tr><td>B-I

Any date

Reservoir elevation is above or forecast to exceed elevation 770 ft NGVD.</td><td>When forecasts indicate that anticipated runoff will produce a peak reservoir elevation above 770 feet if operated under Schedule A, release rates will be made in accordance with the following schedule when the reservoir is at or forecasted to reach the levels listed:

<table>
<tr><th>Pool Elev</th><th>Outflow (cfs)</th></tr>
<tr><td>770</td><td>30,000</td></tr>
<tr><td>775</td><td>50,000</td></tr>
<tr><td>780</td><td>60,000</td></tr>
<tr><td>780.5</td><td>80,000</td></tr>
<tr><td>781</td><td>100,000</td></tr>
<tr><td>781.5</td><td>115,000</td></tr>
<tr><td>782</td><td>130,000</td></tr>
<tr><td>783</td><td>130,000</td></tr>
<tr><td>784</td><td>130,000</td></tr>
</table>

At elevation 785 open spillway tainter gates as necessary to maintain reservoir elevation 785 until uncontrolled spillway discharge prevails, then allow reservoir to continue rising with uncontrolled spillway and outlet conduit discharge.</td></tr>
<tr><td>B-II

Any date

Reservoir has peaked above 770 ft NGVD. and is falling</td><td>Release maximum outflow reached in B-I until reservoir elevation rate of fall begins to exceed 1-ft per day. Then adjust release accordingly to maintain recession rate of 1-ft per day to conservation pool. Once recession is established and outflow is decreased, outflow will not be increased unless reservoir is forecasted to exceed elevation 770 ft NGVD. As the pool approaches conservation level, reductions in outflow should be limited to 3,000 cfs per day.</td></tr>
</table>

LAKE RED ROCK REGULATION

SCHEDULE C Drought Operation for Water Quality Low Flow Augmentation	Reservoir Any date reservoir is below conservation pool and inflow is less than 300 cfs

Condition	Operation
Pool is above elevation 734 ft NGVD	Release not less than 300 cfs.
Pool is between elevation 733 and 734 ft NGVD	Release 290 cfs.
Pool is between elevation 732 and 733 ft NGVD	Release 275 cfs.
Pool is between elevation 731 and 732 ft NGVD	Release 250 cfs.
Pool is between elevation 730 and 731 ft NGVD	Release 225 cfs.
Pool is between elevation 729 and 730 ft NGVD	Release 200 cfs.
Pool is between elevation 723 and 729 ft NGVD	Release 175 cfs.
Pool is between elevation 718 and 723 ft NGVD	Release 150 cfs.
Pool is below elevation 718 ft NGVD	Release 100 cfs.

LAKE RED ROCK REGULATION

SCHEDULE D Flash Flood Operation Pool Elevation: between 741.5 and 760.0 ft NGVD	Reservoir Pool: steady, rising, or falling

Condition	Operation
1 Apr thru 31 Oct Reservoir elevation at or below 760.0 and stage at Ottumwa above or forecast to exceed 10.8 ft	Release not less than 500 cfs to control flows at Ottumwa insofar as possible for a maximum of 48 hours.

EXHIBIT B
Related Reports and Studies

Many reports and studies have been published about Saylorville Lake, Lake Red Rock, and the Des Moines River. Those most relevant are listed in the following paragraphs.

Pool Raise and Release Rate Studies

Saylorville Lake

Proposed Project Modifications, Saylorville Lake, Des Moines River, Iowa, May 1974. U.S. Army Corps of Engineers, Rock Island District.

Effects of Alternate Release Rates from Saylorville Dam, Des Moines River, Iowa, Mar 1975. U.S. Army Corps of Engineers, Rock Island District.

Saylorville Dam, Spillway Chute Analysis, June 1979. U.S. Army Corps of Engineers, North Central Division Water Control Center.

Re-allocation of Reservoir Storage in Saylorville Lake for Municipal and Industrial Water Supply, Des Moines River Basin, Iowa, Apr 1982. U.S. Army Corps of Engineers, Rock Island District.

Spillway Design Analysis Report, Preliminary Draft, Saylorville Lake, Des Moines River, Iowa, 1989. U.S. Army Corps of Engineers, Rock Island District.

Spillway Improvement Design Analysis Report, Saylorville Lake, Des Moines River, Iowa, 1991. U.S. Army Corps of Engineers, Rock Island District.

Spillway Channel Repair Design Analysis Report, Saylorville Lake, Des Moines River, Iowa, 1996. U.S. Army Corps of Engineers, Rock Island District.

Lake Red Rock

Lake Level Re-evaluation Study, Technical Report, Lake Red Rock, Des Moines River, Iowa, Nov 1972. U.S. Army Corps of Engineers, Rock Island District.

Alternatives to the Regulation of Lake Red Rock, Des Moines, River, Iowa, Mar 1985. U.S. Army Corps of Engineers, Rock Island District.

Other

Supplement No. 1, Conservation Storage in Red Rock and Saylorville Reservoirs on Design Memorandum No. 3, Conservation Storage, Red Rock Reservoir, Howell Dam Site, Des Moines River, Iowa, Oct 1961. U.S. Army Corps of Engineers, Rock Island District.

Water Demand and Availability, Phase I, Technical Report, Des Moines River Basin, Jul 1978. U.S. Army Corps of Engineers, Rock Island District.

Inventory of Reservoir Sites, Des Moines River Basin, Iowa, Jan 1981. U.S. Army Corps of Engineers, Rock Island District.

Re-allocation of Reservoir Storage, Lake Red Rock and Saylorville Lake, Phase II, Technical Report, Des Moines River Basin, Iowa, Dec 1981. U.S. Army Corps of Engineers, Rock Island District.

Water Demand and Availability Study, Des Moines River Basin, Saylorville and Red Rock Reservoirs, Sep 1994. U.S. Army Corps of Engineers, Rock Island District.

Regulated Flow Frequency Study

Des Moines River Regulated Flow Frequency Study, 2010. U.S. Army Corps of Engineers, Rock Island District.

Original Design Documentation

Saylorville Lake

Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Saylorville Reservoir, Des Moines River, Iowa, 1960. U.S. Army Corps of Engineers, Rock Island District.

Design Memorandum No. 3, General Design Memorandum, Saylorville Reservoir, Des Moines River, Iowa, 1960. U.S. Army Corps of Engineers, Rock Island District.

Design Memorandum No.10, Spillway, Saylorville Reservoir, Des Moines River, Iowa, 1962. U.S. Army Corps of Engineers, Rock Island District.

Design Memorandum No. 1, General Design Memorandum, Des Moines River at Des Moines, Iowa, Local Flood Protection, 1963. U.S. Army Corps of Engineers, Rock Island District.

Design Memorandum No. 9, Dam Outlet Works, Saylorville Reservoir, Des Moines River, Iowa, 1964. U.S. Army Corps of Engineers, Rock Island District.

Real Estate – Reservoir Area, Saylorville Lake Project, 1964. U.S. Army Corps of Engineers, Rock Island District.

Real Estate – Modification of Design Flood Control Level, Saylorville Lake Project, 1966. U.S. Army Corps of Engineers, Rock Island District.

Review of Reports for Flood Control and Related Purposes on the Des Moines River, Iowa and Minnesota, 1970. U.S. Army Corps of Engineers, Rock Island District.

Proposed Project Modifications, Saylorville Lake, 1975. U.S. Army Corps of Engineers, Rock Island District.

Real Estate – Saylorville Corridor, Saylorville Lake Project, 1976. U.S. Army Corps of Engineers, Rock Island District.

Master Plan Design Memorandum 6B, Saylorville Lake, 1984. U.S. Army Corps of Engineers, Rock Island District.

Lake Red Rock

Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Red Rock Reservoir, Howell Dam Site, Des Moines River, Iowa, 1956. U.S. Army Corps of Engineers, Rock Island District.

Design Memorandum No. 3, Conservation Storage, Red Rock Reservoir, Howell Dam Site, Des Moines River, Iowa, 1957. U.S. Army Corps of Engineers, Rock Island District.

Design Memorandum No. 4, General Design Memorandum, Red Rock Reservoir, Howell Dam Site, Des Moines River, Iowa, 1958. U.S. Army Corps of Engineers, Rock Island District.

Resource Master Plan, Preliminary Master Plan, Lake Red Rock, 1959. U.S. Army Corps of Engineers, Rock Island District.

Real Estate Memoranda 5B., Lower Portion of Reservoir Area, 1960. U.S. Army Corps of Engineers, Rock Island District.

Real Estate Memoranda 5C, Upper Portion of Reservoir Area, 1960. U.S. Army Corps of Engineers, Rock Island District.

Design Memorandum No. 9, Dam – Overflow and Concrete Non-Overflow Sections, Exhibit 1, Hydraulic Design, Red Rock Reservoir, Howell Dam Site, Des Moines River, Iowa, 1960. U.S. Army Corps of Engineers, Rock Island District.

Spillway and Sluices, Red Rock Dam, Des Moines River, Iowa, Hydraulic Model Investigation, 1965. Sponsor: U.S. Army Corps of Engineers, Rock Island District. Conducted by: U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Environmental Assessment for Red Rock Flowage Easement Land Acquisition, Lake Red Rock, Marion County, Iowa, June 1989. U.S. Army Corps of Engineers, Rock Island District.

Other

Des Moines LFP Chief's Report, Des Moines River Iowa, 1941.

Supplement 1 - Conservation Storage in Red Rock and Saylorville Reservoirs, 1961. U.S. Army Corps of Engineers, Rock Island District.

Historical Regulation and Operation & Maintenance Manuals

Saylorville Lake

Master Reservoir Regulation Manual Appendix B, 1 Aug 76 - Saylorville Lake. U.S. Army Corps of Engineers, Rock Island District.

Master Reservoir Regulation Manual, Interim Plan, Saylorville Lake. U.S. Army Corps of Engineers. Jan 1977. U.S. Army Corps of Engineers, Rock Island District.

Master Reservoir Regulation Manual, Saylorville Lake. U.S. Army Corps of Engineers. Revised March, 1983. U.S. Army Corps of Engineers, Rock Island District.

Appendix B of the Des Moines River Master Reservoir Regulation Manual, Water Control Manual, Saylorville Lake, Des Moines River Basin, Sep 1983, U.S. Army Corps of Engineers, Rock Island District.

Operation and Maintenance Manual, Saylorville Lake, Des Moines River, Iowa, 1984. U.S. Army Corps of Engineers, Rock Island District.

Appendix B of the Des Moines River Master Reservoir Regulation Manual, Water Control Manual, Saylorville Lake, Des Moines River Basin, 3rd Revision, 2001, U.S. Army Corps of Engineers, Rock Island District.

Lake Red Rock

Master Reservoir Regulation Manual, Appendix A, Red Rock (Preliminary). US Army Corps of Engineers. Dated 26 June 1968.

Operation and Maintenance Manual, Red Rock Dam and Lake Red Rock, Des Moines River, Iowa, 1976. U.S. Army Corps of Engineers, Rock Island District.

Operation and Maintenance Manual, Red Rock Dam and Lake Red Rock, Des Moines River, Iowa, 1977. U.S. Army Corps of Engineers, Rock Island District.

Operation and Maintenance Manual, Lake Red Rock, Des Moines River, Iowa, Jan 1983. U.S. Army Corps of Engineers, Rock Island District.

Water Control Plan with Final Environmental Impact Statement Supplement, May 1988. U.S. Army Corps of Engineers, Rock Island District.

Des Moines River Basin Master Regulation Manual and Appendix A, Lake Red Rock, June 1988. U.S. Army Corps of Engineers, Rock Island District.

Water Control Plan with Supplemental Master Plan and Final Environmental Impact Statement Supplement II, May 1990. U.S. Army Corps of Engineers, Rock Island District.

Appendix A of the Des Moines River Master Reservoir Regulation Manual, Water Control Manual, Lake Red Rock, Des Moines River Basin, 2nd Revision, 2003, U.S. Army Corps of Engineers, Rock Island District.

Other

Upper Mississippi River Basin, Des Moines River Basin, Iowa and Minnesota, Master Regulation Manual, 1968. U.S. Army Corps of Engineers, Rock Island District.

Upper Mississippi River Basin, Des Moines River Basin, Iowa and Minnesota, Master Regulation Manual, 1989. U.S. Army Corps of Engineers, Rock Island District.

Appendix C Master Reservoir Regulation Manual, Drought Contingency Plan for Lake Red Rock and Saylorville Lake, 1992. U.S. Army Corps of Engineers, Rock Island District.

Sedimentation Surveys

Saylorville Lake

Saylorville Lake Report of Sedimentation, 2014. U.S. Army Corps of Engineers, Rock Island District.

Lake Red Rock

Lake Red Rock Report of Sedimentation, 2011. U.S. Army Corps of Engineers, Rock Island District.

Flood Damage Reduction Studies

Feasibility Report, Flood Damage Reduction for Des Moines and Raccoon Rivers Project, Des Moines, Iowa (with integrated Environmental Assessment), Volume 1, 2005. U.S. Army Corps of Engineers, Rock Island District.

Other Studies and Reports

Saylorville Lake

Saylorville – Backwater Effects, Backwater Envelope Curves, Saylorville Lake, 1986. U.S. Army Corps of Engineers, Rock Island District.

Implementation of HMR52 Procedures for Probable Maximum Precipitation and Flood (PMP/PMF) Estimates, 1990. Memorandum for Commander, U.S. Army Engineer Division, North Central.

Saylorville Water Supply Contract Summary, 2006. U.S. Army Corps of Engineers, Rock Island District.

Emergency Action Plan, Saylorville Dam and Big Creek Remedial Works, Des Moines, Iowa, 2011. U.S. Army Corps of Engineers, Rock Island District.

Saylorville Dam Semi-Quantitative Risk Assessment, Des Moines River, Embankment and Spillway, DQC Review 2015. U.S. Army Corps of Engineers, Rock Island District.

Lake Red Rock

Emergency Action Plan, Red Rock Dam and Lake, Des Moines, Iowa, 2012. U.S. Army Corps of Engineers, Rock Island District.

Other

Survey Report for Flood Control, Binder 1, Main Report and Appendix VII (Detailed Cost Estimates), Des Moines River, Iowa, Aug 1941. U.S. Army Corps of Engineers.

Survey Report for Flood Control, Binder 3, Des Moines River, Iowa, Aug 1941. U.S. Army Corps of Engineers.