Appendix F
Flow Management System Operating Analysis

TABLE OF CONTENTS
APPENDIX F

APPENDIX F: FLOW MANAGEMENT SYSTEM OPERATING ANALYSIS

F.1 Introduction

This appendix includes additional information concerning the Oklahoma and Arkansas systems operations and provides a model that explains the procedures used in the development and screening of alternative operating plans for the flow management feature of the study.

The report that comprises Appendix F is entitled “Arkansas River Basin, Arkansas and Oklahoma System Operating Plans” and was prepared by Clinton Word for the USACE Tulsa District.

F.2

Flow Management System Operating Analysis

ARKANSAS RIVER BASIN, ARKANSAS AND OKLAHOMA
SYSTEM OPERATING PLANS

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

TABLE OF CONTENTS (CONT.)

APPENDIX TABLE OF CONTENTS

ARKANSAS RIVER BASIN, ARKANSAS AND OKLAHOMA
SYSTEM OPERATING PLANS

ACKNOWLEDGMENTS

The format for this report is patterned after the System Operations section of the May 1991 Feasibility Report. Much of the description is an updated version of this report reflecting current reservoir system simulations and resulting analysis.

The project and system descriptions are modifications of the Arkansas River Master Manual (dated July 1980) with updated information from the individual operation manuals for each multipurpose project.

The description of the Regulation Simulation Program and methodology of analysis used is a consolidation of Ron Hula's write-up "Southwestern Division Modeling System for the Simulation of the regulation of a Multipurpose Reservoir System" dated January 2000. The full write-up is found in Appendix 24 of Volume II.

1. INTRODUCTION

1.1 Challenges

1.1.1 Farming interest in western Arkansas requested that the Corps of Engineers (Corps) investigate the possibility of reducing the flooding of fields along the lower Arkansas River. It has been determined that flows of 75,000 cfs cause flooding of some fields along the river in western Arkansas. It is believed that a target of 60,000 cfs in place of the present 75,000 cfs bench would relieve much of this damage.

1.1.2 It has also been noted that the 75,000 cfs bench at Van Buren hampers channel recovery operations (dredging) in the lower reaches of the Arkansas River where intervening runoff increase the flows to 85,000 cfs to 90,000 cfs. Operations has requested an investigation to lower the bench from 75,000 cfs to 60,000 cfs to assist in the maintenance dredging of the system.

1.1.3 Navigation interest also requested that the Corps investigate the possibility of decreasing the number of days the flows in the lower Arkansas River excees 100,000 cfs. It is believed that even though flows this high are a hindrance to navigation, any flow above 100,000 cfs will cause a total shutdown of the system.

2. WATER MANAGEMENT BACKGROUND

2.1 The Arkansas River Basin comprises about 138,000 square miles of contributing drainage area; about 128,000 square miles of this area are above Van Buren, Arkansas. The Arkansas River system currently consists of 48 federally-constructed reservoirs operated for flood control, hydropower, water supply, water quality, sediment control, navigation, recreation, and fish and wildlife. Ten reservoirs were completed by early 1950, 2 more by 1960, 12 more by 1970, and 7 more during the 1980's. In addition to these reservoirs, the Grand River Dam Authority, an Oklahoma State agency, has constructed two projects in the Lower Grand River Basin for hydroelectric power and flood control. Those projects are Pensacola Dam (completed in 1940) and Lake Hudson (completed in 1964). The US Army Corps of Engineers is responsible for prescribing flood control operations at these projects.

Seventeen of the 48 projects in the Arkansas River system are locks and dams constructed to provide navigation from the mouth of the Arkansas River to the Port of Catoosa near Tulsa, Oklahoma. Construction on the Arkansas River navigation project began in 1957. Navigation reached Little Rock, Arkansas, in December 1968 and the Port of Catoosa, Oklahoma in December 1970.

2.2 LOCK & DAM OPERATION

2.2.1 General – Lock & Dam Reservoirs are operated for navigation and hydroelectric power production (when applicable) in conjunction with the other authorized system of locks and dams as well as multipurpose reservoirs in the Arkansas River Basin.

2.2.2 Normal regulations. — The navigation pool is regulated to provide a navigable channel from one Lock and Dam through the next upstream Lock and Dam. Storage for hydroelectric power is included in several of these projects and is used to maintain head for the hydroelectric units.

2.2.3 Flood Control – There is no storage allocated for flood control in the Lock & Dam Reservoirs. During large flood events it is possible to slightly reshape the peak of the flood in some cases by manipulating releases but this can make minimal change at best.

2.3 MULTIPURPOSE STORAGE PROJECTS OPERATION

2.3.1 General. – Most of the lakes under the control of the Corps of Engineers in the Arkansas River Basin have multiple purposes. These purposes include hydropower, irrigation, recreation, fish and wildlife, water supply, navigation, flood control, and water quality. The following paragraphs describe the general guidelines set forth for the regulation of the lakes for the various project purposes. More detailed information on the current flood control and navigation system regulation plan will be presented later in this write-up.

2.3.2 Hydroelectric Power. – The hydroelectric power produced at the Corps of Engineers power projects is marketed by the Southwestern Power Administration (SWPA). This marketing is done in accordance with contractual agreements which SWPA has developed with various power companies or CO-Ops. The availability of water for hydroelectric power production is determined by the Corps.

2.3.2.1 Constraints – The production of hydroelectric power is coordinated with the other project purposes. Available channel capacities, navigation flow requirements, water in storage and equipment conditions can effect the hydroelectric power production schedules. SWPA has the responsibility for scheduling power within the limits of the projects and system constraints as determined by the Corps. SWPA determines the distribution of the power loading within the system. Coordination between the Corps and SWPA is accomplished in two ways:

1. **Monthly allocation. – Each month the Corps provides SWPA with a declaration of energy which will be available for the next month. This declaration is based on a forecast which takes into consideration energy in storage, predicted inflow, time of year, downstream conditions and mechanical condition of the power equipment at the projects. The normal declaration of energy furnished to SWPA includes a minimum, maximum, and recommended allocation for the month. The 30-day operational plan for the coming month is discussed at a meeting between SWPA and Corps personnel. This meeting is normally held in the SWPA offices located in Tulsa, OK. The available energy, outages, transmission, limitations, energy needs, etc. are discussed at this meeting and the hydroelectric power generation for the month is agreed on.**

2. **Daily regulation. – The corps district offices normally furnish SWPA, each workday, three to four-day forecasts of inflow at each power project. SWPA provides the Corps, each workday, with a 24-hour generation schedule, including weekends, at each power project. Any required restrictions on generation is also furnished as required. Normal changes in power projection limits should be furnished 48 hours in advance except for emergency conditions. Flood control releases are made through the turbines whenever possible, in order to make maximum use of the power. Hydroelectric power generation may be constrained, if necessary, to minimize downstream flooding.**

2.3.3 Irrigation. — Canton Lake in Tulsa District is the only operational Corps of Engineers project with irrigation as a project purpose; however, irrigation storage has not been utilized to date.

2.3.4 Water supply. — Water supply, when included in Corps of Engineers lakes, is contracted by the Corps with nonfederal entities or individuals. Normally, water is taken directly from storage in the lake; however, in some cases, the water user may pump from the stilling basin or river downstream, in which case releases are maintained for water supply purposes. Since the water supply demands have been limited to individual projects,

a system water supply plan has not been developed. Water supply withdrawals, from Corps of Engineers projects, used in this study are shown in *Table 2-1.*

TABLE 2-1
WATER SUPPLY DEMAND IN CFS

RESERVOIR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ELK CITY	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
OOLOGAH	184.8	190.3	193.0	198.4	203.8	266.4	320.7	299.0	250.0	217.4	198.4	195.7
HULAH	17.6	17.6	18.9	18.9	20.0	23.9	27.7	27.7	23.9	20.2	17.6	17.6
FT GIBSON	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
TENKILLER	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2
EUFAULA	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7
WISTER	28.7	28.9	29.0	29.5	29.7	32.7	35.2	34.3	31.9	30.3	29.5	29.4
KAW	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
SKIATOOK	18.7	19.0	19.3	19.8	20.1	24.5	28.4	26.8	23.4	21.1	19.8	19.5
COPAN	4.0	4.0	4.0	4.0	5.0	5.0	6.0	6.0	5.0	5.0	4.0	4.0
BIRCH	4.0	4.0	4.0	4.0	5.0	5.0	6.0	6.0	5.0	5.0	4.0	4.0
BIG HILL	1.0	1.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	2.0	2.0	1.0
ELDORADO	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
MARION	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

2.3.5 Navigation. — Hydroelectric power releases are considered sufficient for lockages along the Arkansas River Navigation system. Navigation water supply storage of 168,000 acre-feet is provided in Oologah Lake. Release of excess water from the upstream flood control projects are made at a rate, when possible, which does not jeopardize the navigation system facilities and their use by the public. Due to the natural characteristics of the Arkansas River, shoaling frequently occurs along the navigation channel. The shoaling causes insufficient depth and navigation hazards. The system regulation plan provides sufficient depth for continuing navigation while maintenance dredging is being accomplished (referred to as a taper operation). A more detailed discussion of the system regulation plan is presented later in this report.

2.3.6 Flood control. — The flood control regulation schedules for each lake are presented in the appropriate regulation manual. These regulations are based primarily on each lake acting as a unit in a system. The flood control regulations governing lakes built by the Corps of Engineers contain provisions for discharge of water when pool elevations are below the bottom of the flood control pool provided that the predicted inflow volume will be sufficient to restore the pool to the conservation regulating level. Regulating schedules for the Corps of Engineers projects provide that certain stages and/or discharges are not to be exceeded insofar as possible at specified locations downstream from the dams. Some of the regulating stations and discharges for the current system operations study are shown in *Table 2-2.*

TABLE 2-2

CONTROL POINT VS MAXIMUM ALLOWABLE NON-DAMAGING FLOW

RESERVOIR DISCHARGE	DISCHARGE(CFS)	CONTROL POINT	
COUNCIL GROVE	3,100	AMERICUS	16,000
MARION	4,000	FLORENCE	7,000
JOHN REDMOND	12,000	PLYMOUTH	9,000
PENSACOLA	100,000	IOLA	17,000
MARKHAM FRY	100,000	PARSONS	17,000
FORT GIBSON	100,000	COMMERCE	22,000
TORONTO	7,000	ALTOONA	10,000
FALL RIVER	8,000	FREDONIA	8,000
ELK CITY	9,000	INDEPENDENCE	20,000
BIG HILL	1,000	LENAPAH	30,000
OOLOGAH	30,000	BARTLESVILLE	10,700
HULAH	6,500	RAMONA	9,800
COPAN	3,000	CLAREMORE	35,000
BIRCH	2,000	SPERRY	9,400
SKIATOOK	4,000	INOLA	35,000
ELDORADO	4,200	AUGUSTA	11,700
KAW	40,000	WINFIELD	29,500
KEYSTONE	90,000	RALSTON	79,000
TENKILLER FERRY	13,500	HASKELL	124,000
EUFAULA	40,000	MUSKOGEE	138,000
WISTER	6,600	SALLISAW	150,000
		POTEAU	7,200
		PANAMA	10,000
		VAN BUREN	137,000
		DARDANELLE	800,000*
		LITTLE ROCK	800,000*

*** NOTE: Dardanelle and Little Rock targets were set at 800,000 cfs to allow Van Buren to be the sure and be the controlling point for this study.**

2.3.7 Water quality and low-flow. — Water quality releases are made on a regular basis from projects containing storage reserved for that purpose. Details concerning water quality requirements at the various regulating stations can be obtained from the appropriate regulation manual. Releases are made as needed for dilution of pollutants, preventing or disposing of fish kills, and to relieve other critical conditions when they occur. A schedule of current minimum stream flow requirements and/or reservoir outflows used in this study is shown in *Table 2-3*. Under provisions of Public Law 92-500, the Corps of Engineers cooperates with all state and Federal agencies to achieve the goals set forth by Congress in 1972 of improving the Nation's water quality.

Table 2-3
WATER QUALITY DEMAND POINTS AND DEMAND IN CFS

DEMAND POINT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ALTOONA	3	3	3	3	5	5	5	5	5	3	3	3
FREDONIA	5	5	5	5	5	5	5	5	5	5	5	5
INDEPENDENCE	20	20	20	20	20	20	20	20	20	20	20	20
HULAH	2	2	2	2	2	4	4	4	2	2	2	2
COPAN	5	5	5	5	5	8	8	8	5	5	5	5
BARTLESVILLE	10	10	14	22	35	49	74	74	48	22	14	10
BIRCH	1	1	1	6	6	8	8	8	8	8	1	1
SKIATOOK	5	5	5	5	5	5	5	5	5	5	5	5
SPERRY	49	49	49	122	122	134	134	134	134	98	49	49
INOLA	239	239	239	239	239	239	239	239	239	239	239	239
KAW	113	113	113	113	113	123	156	156	113	113	113	113
KEYSTONE	200	200	200	200	200	200	200	200	200	200	200	200
MUSKOGEE	315	315	315	315	315	315	315	315	315	315	315	315
TENKILLER	25	25	25	25	25	25	25	25	25	25	25	25
SALLISAW	526	526	526	526	526	526	526	526	526	526	526	526

2.3.8 Recreation. — The development, operation and maintenance of recreation areas and facilities around the lakes are usually done by the owning and operating agency; however, some recreational areas are developed and maintained by other Federal agencies or agencies of the various states in which the projects are located. Some cities also maintain small recreational areas on nearby lakes. No special system operations are made for recreation; however, impacts to recreation were evaluated in the development of the system regulation plan and those impacts serve as a guide in the day-to-day decision making of the system operation. When possible, special operations are made to enhance the recreational benefits to be derived from the system. These special operations are considered on a case by case basis such as raft races and canoe float trips, and usually involve only a single lake rather than the whole system.

2.3.9 Fish and wildlife. — The Corps cooperates with state and Federal fish and wildlife agencies in developing plans for, and providing regular seasonal pool fluctuations at, some lakes. The seasonal pool variations help to improve the fish spawn during the spring months, the water recreation during the summer months, and the wildfowl food and hunting during the fall months. Individual water level management plans have been developed and initiated at six Arkansas River Basin lakes in Kansas, Wister Lake in eastern Oklahoma, and at Nimrod and Blue Mountain Lakes in Arkansas. The Kansas lake water level management plans are evaluated annually and adjusted as needed to meet fish and wildlife management objectives without serious impact upon other project purposes. Regular surveillance of the stilling basins below the dams are made to detect poor water quality and prevent fish kills. Special releases to maintain fish life are made as

necessary. Since most of the fish and wildlife benefits are derived for the individual projects, no special operations are designed in the system regulation plan for fish and wildlife.

2.4 DESCRIPTION OF SYSTEM OPERATION

2.4.1 General: Reservoirs are operated for their individual authorized purposes; which means that decisions concerning system operations require evaluation of the impacts on all of the authorized purposes. In the case of flood control each reservoir has limitations immediately below their outlet works which can limit the releases. Current limitations are found in *Table 2-2* :

Since each reservoir is linked by their discharge to the same river system (Arkansas River main stem) they are not only operated for local conditions but also must be operated as a part of a larger system in conjunction with other reservoirs. In many cases a reservoir may be operated with one or more reservoirs as a system and also as a part of a larger system. Example: Hulah and Copan are operated as a system for Bartlesville and Ramona and are also operated in conjunction with 9 other projects for control of the lower Arkansas basin. There are limitations along all reaches of the Arkansas River System; however, the most notable in the overall system is the Fort Smith and Van Buren area. About 128,000 square miles of the 138,000 square miles in the Arkansas River lay above Van Buren, Arkansas. It was recognized during the design stage that control of the main stem of the Arkansas would depended on control of the flow past Van Buren, Arkansas. It was also recognized that 11 projects in the southeastern part of Oklahoma were the key to this flood control. These reservoirs are: Pensacola, Markham Ferry and Fort Gibson on the Grand (Neosho) River, Oologah on the Verdigris River, Hulah and Copan on the Caney River, Kaw and Keystone on the Arkansas River, Tenkiller Ferry on the Illinois River, Eufaula on the Canadian River, and Wister on the Poteau River. Their proximity to main stem and the fact that each is the primary control for the their respected river, make the operation of each reservoir critical to the flood control of the Arkansas River System.

2.4.2 EVOLUTION OF THE SYSTEM OPERATION PLAN

2.4.2.1 TAPER OPERATION

Since the completion of the McClellan-Kerr Arkansas River Navigation System in 1970, the Corps of Engineers has modified the system operating plans several times to improve the flow regime and to enhance benefits to users of the system. Shortly after the completion of the Navigation System it was noted that following a flood event, shoaling would occur in the river channel and restrict navigation until maintenance dredging could be performed. To maintain navigation depths during dredging activities, a "taper" operation was implemented to gradually reduce flows following such floods events. This navigation taper operation required an increase in the time water was held in the lower few feet of the flood control pools in the Oklahoma lakes. Note: The taper operation does not increase the level in the flood control pools but it does delayed the timing for complete evacuation of the flood pool. The first such navigation taper plan was utilized from 1979 to 1986.

2.4.2.2 EXISTING PLAN (1986 FINE TUNING PLAN)

In 1985, the volume of water flowing down the Arkansas River past Van Buren was the second largest of record (at that time) and was the fourth year in succession of above normal flows. Because of the high flows, navigation interests experienced increased costs and delays; and, farmers, who had been accustomed to farming land near the river, found it impossible to produce crops during this period.

To address these problems, the Corps of Engineers restudied the system operating plan and in June 1986, following a public comment period, implemented a new operating plan. The objective of the new plan (Fine Tuning Plan) was to increase the number of days of flow below 80,000 cubic feet per second (cfs) for the benefit of the navigation system and low-lying farmland, while causing minimal impacts on hydropower, recreation and flood control in Arkansas and Oklahoma.

The 'Fine Tuning Plan' has been used since June 1986 and is the current or existing operating plan. Key features of this plan are:

1. **A taper operation of 40,000 cfs to 20,000 cfs . When the flood storage remaining in the 11 controlling reservoirs reaches from 3% in the spring to 11% in the summer, the target flow at Van Buren is gradually reduced from 40,000 cfs to 20,000 cfs. This allows navigation to continue until dredging operation can remove the sediment deposited in the channel during high flow.**

2. **A 75,000 cfs bench (a range where the flow is held at or below 75,000 cfs). This feature is also adjusted seasonally to maximize benefit to farming and minimize flood impacts during that portion of the year more susceptible to floods.**

3. SYSTEM STUDY METHODS AND ANALYSIS

The purpose of this section of the report is to present; the procedures used in the development and screening of alternative operating plans for the Arkansas River Basin system, the logic used in the selection of each plan, the methodologies used to analyze the impacts of those plans, and the findings resulting from those efforts. The report identifies and compares the impacts of each alternative reservoir system operating plan on the system's purposes, including navigation, flood control, hydropower generation, and recreation. This screening did not evaluate the impact on environmental and cultural resources.

3.1 STUDY TOOLS

The hydrologic portion of the study was performed using the "Southwestern Division Modeling System for the Simulation of the regulation of a Multipurpose Reservoir System" more affectionately know as SUPER. SUPER was written by Ron Hula of the Corps of Engineers and evolved around the needs to model reservoir systems in the Southwest Division. SUPER is a linked system of programs that have been designed to perform and analyze a "period of record" simulation for a specific system of multipurpose reservoirs using various plans of regulation. The hydrologic routing interval used for the simulation is a one day period. The flow used to represent that period is the average flow for the particular 24 hour day. For a more complete description of SUPER see the write-up "Southwestern Division Modeling System for the Simulation of the Regulation of a Multipurpose Reservoir System", dated January 2000, written by Ronald L. Hula. Attachment 24, Volume II.

3.1.1 ARKANSAS RIVER SYSTEM MODEL

The Arkansas River System model is made up of 23 multipurpose storage reservoirs and 50 control points. The hydrologic period of simulation for this study is January 1940 through December 2000 or 61 years of daily records (22,282 days). This period is believed to be a good representation of what may be expected in the Arkansas River Basin since it contains floods with large volumes and high peak flow periods (1943, 1957, 1986, 1990, 1994, and 1995) as well as drought periods (1950's and 1970's).

Reservoirs are defined by their project features. There are several physical relationships used as input to describe each reservoir.

1. **The elevation-area-capacity relationship.**
2. **The free flow discharge rating curve (maximum release rate physically possibly).**
3. **The induced surcharge envelope curve (minimum release rate allowed).**
4. **Leakage from the reservoir (gate and other).**
5. **A description of the hydropower plant facilities including: power plant capacity, power plant efficiency, head loss in the approach to the turbine, and tail water rating curve.**

The relationship between reservoirs is defined in terms of hydraulics, priorities, and purposes. The reservoirs are defined hydraulically by describing travel time between

projects and their location within the system. Releases from upstream projects will add to the inflow of a downstream project. Releases from other projects in the system will add to the flows in the main stem and may further restrict releases. Damage reaches are also defined along the system by describing their flow/damage relationship.

A reservoir's priority in the system is described by establishing a relationship to other projects using elevation and storage. Since the projects are operated as a system, an elevation/storage balance level is defined for each reservoir that will be used to establish priority of operations within the reservoir system.

3.2 ANALYSIS OF EFFECTS OF SIMULATIONS

Each operating plan was analyzed to compare it's effectiveness in controlling the water in the basin for the authorized purposes and quantifying the benefit or damage to each purpose. This was accomplished by simulating the same hydrologic period of record through the reservoir system using the different operating plans. The period of record for this study is January 1, 1940 through December 31, 2000.

Each operating plan was evaluated using the following methods:

3.2.1 NUMBER OF DAYS EQUALED OR EXCEEDED

Since most of the challenges could be related to the control of flow in the Van Buren reach, a table for each simulation was developed to compare the number of days that selected flows were reached or exceeded on average per year. This was used to quantify the effectiveness of each plan in accomplishing the stated goals. The flows and their reason for selection follow:

60,000 cfs - Farming and navigation both benefit with flows below this level
75,000 cfs - Benched flow in the current operating plan
100,000 cfs - Above this flow navigation is restricted
137,000 cfs - Approximate channel capacity at Van Buren
150,000 cfs - Considered to be the design flow for the system
175,000 cfs - The flow that historically is reached or exceeded at least once per year

NOTE: FOR THIS STUDY FRACTIONS OF DAYS WERE ROUNDED TO THE NEAREST WHOLE DAY.

3.2.2 DAMAGE CENTER EVALUATION

Damages that occurred with each operating plan were tabulated and compared. (Note: These values were used for screening purposes only. The final evaluation was accomplished by a more traditional economic evaluation.) The following damages were tabulated and evaluated:

- **Total system damages**
  - **Crop losses**
  - **Pasture losses**
- **Structural damages**
  - **Urban**
  - **Rural**
- **Navigation Damages**
  - **Daily fuel cost**
  - **Daily time cost**
- **Navigation pool damages**
  - **Dredging cost**
  - **Blocked navigation cost**
- **Reservoir Pool Damage**
- **Recreation Losses**
- **Hydropower**
  - **Power produced by the storage reservoirs**
  - **Power produced on load**
  - **Power produced at lock and dams**
  - **Dump energy**
  - **Thermal purchase**

3.2.3 EFFECT ON TAPER OPERATION

Various floods were analyzed to see if the operation plan had a significant effect on taper operation

3.2.4 RESERVOIR FLOOD CONTROL IMPACTS

Evaluation of impacts to the flood control pools at the storage reservoirs was accomplished by comparing each simulation with the existing operation plan. These evaluations involved the following:

- **Pool duration curves**
- **Pool frequency curves**
- **Pool duration tables**

3. STUDY RESULTS

The screening study resulted in the identification of three possible plans of operation. Two of the plans (A02X11 and A02X12) require increasing channel capacity in the lower Arkansas basin. This could require easements, flood proofing or some other method of mitigation.

The third possible plan of operation (A02X13) is a modification of the existing plan and does not increase the need for channel capacity and should require no additional easements.

Each of these simulations were compared to the existing plan of operation (A01X16.)

4.1 A01X16 EXISTING OPERATING PLAN

A simulation using the existing operating plan was run with the updated period of record hydrology (January 1940 – December 2000) and updated power loads furnished by SWPA. The run established a base condition to which all other simulations were compared.

The following data can be found in appendix 1 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

4.2 A02X11 VAN BUREN AT 175,000 CFS AND SALLISAW AT 175,000 CFS WITH 60,000 CFS BENCH REPLACING 75,000 CFS BENCH LOWERED 3% EXCEPT JUNE15-OCTOBER 1

This run was made to evaluate a combination of 175,000 cfs increase in the target flow at Van Buren and Sallisaw (A01X23) and a modified 60,000 cfs bench replacing the 75,000 cfs bench (A02X10).

The run decreased the number of days above 60,000 cfs by 9 days per year (a 13 % improvement.) It decreased the number of days above 100,000 cfs by 15 day (a 46% improvement.) It decreased by 4 days the flow above 137,000 cfs (a 20% improvement.) Agricultural and structural damages were found to increase approximately 3% (a similar result to A01X23.) Navigation damages decreased less than 1%. Pool damages and recreation damages increased by 3% and 8% respectively. Hydropower production was slightly lower at the storage projects (less than 1%) and increased by 3% at the hydropower lock and dams.

NUMBER OF DAYS OF DURATION ABOVE EXISTING PLAN
COLUMNS REPRESENT FEET ABOVE CONSERVATION POOL

STORAGE	0 feet	2 feet	4 feet	6 feet	8 feet	10 feet	12 feet
GIBSON	1	2	6	6	2	-1	-2
OOLOGAH	5	11	14	9	0	-1	-2
HULAH	0	0	0	0	0	0	0
COPAN	1	1	1	0	0	0	0
KEYSTONE	3	10	12	13	11	2	-1
TENKILLER	4	9	13	11	7	-1e	-2e
EUFAULA	4	9	0	0	-1	0	0
WISTER	3	3	2	1	0	0	-1

Note: "e" for Tenkiller indicates estimated values.

The following data can be found in appendix 2 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Produce data for external economic evaluation.

4.3 A02X12 VAN BUREN AT 200,000 CFS AND SALLISAW AT 200,000 CFS WITH 60,000 CFS BENCH REPLACING 75,000 CFS BENCH LOWERED 3% EXCEPT JUNE15-OCTOBER 1

This run was made to evaluate a combination of 200,000 cfs increase in target at Van Buren and Sallisaw (A01X18) and a modified 60,000 cfs bench replacing the 75,000 cfs bench (A02X10).

The run decreased the number of days above 60,000 cfs by 9 days per year (a 13 % improvement.) It decreased the number of days above 100,000 cfs by 17 day (a 48% improvement.) It decreased by 5 days the flow above 137,000 cfs (a 26% improvement.) Agricultural and structural damages were found to increase approximately 7% (a similar result to A01X18.) Navigation damages decreased slightly. Pool damages and recreation damages increased by 1% and 6% respectively. Hydropower production was 1% lower at the storage projects and increased by 3% at the hydropower lock and dams.

NUMBER OF DAYS OF DURATION ABOVE EXISTING PLAN
COLUMNS REPRESENT FEET ABOVE CONSERVATION POOL

STORAGE	0 feet	2 feet	4 feet	6 feet	8 feet	10 feet	12 feet
GIBSON	1	2	5	4	1	-2	-3
OOLOGAH	5	11	12	7	-1	-2	-2
HULAH	1	1	1	1	1	1	1
COPAN	1	1	0	0	0	0	0
KEYSTONE	3	10	11	11	8	0	-2
TENKILLER	4	8	8	3	-1	-5e	-4e
EUFAULA	4	6	-1	-1	-1	-1	0
WISTER	2	3	1	-1	-1	-1	-1

Note: e for Tenkiller indicates estimated values.

The following data can be found in appendix 3 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Produce data for external economic evaluation.

4.4 A02X13 Existing plan with a modified 60,000 cfs bench in place of the 75,000 cfs bench and filling behind the flood when the flow reaches 150,000-250,000 cfs and the system storage exceeds 75%

This run titled A02X13 was made to determine the impacts of a 60,000 cfs bench replacing the 75,000 cfs bench combined with filling in behind the flood hydrograph when the flow reach 150,000 – 250,000 cfs and the system percent storage exceeds 75 percent. NOTE: This is similar to a plan identified in the 1989 report but never implemented.

Analysis indicated approximately 15 days reduction in flows above 60,000 cfs. It also produced less than 1 day increase in flows above 100,000 cfs at Van Buren compared to A01X16 (existing operation plan). It also showed an increase above 175,000 cfs of less than 1 day and essentially no change at 137,000 cfs (channel capacity). There was a decrease in duration in the upper limits of the flood pools from run A01X16. There was an increase in duration of storage in the lower 2-6 feet of the pools at the storage projects.

The analysis indicated less than 1% increase in overall damages to crops and structures and less than 1% decrease in power production from A01X16. Navigation and in pool damages had negligible changes.

The following data can be found in appendix 4 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Note: This run had minor negative affects on the project purposes. The run had three positive changes: (1) the reduction of 15 days below 60,000 cfs (a key level for farming interest in Arkansas), (2) an increase in days between 40,000 cfs and 60,000 cfs (key to scouring flows in the navigation system) and accelerated evacuation of the storage projects when the system percent full exceeds 75%.

5. SYSTEM OPERATION SCREENING STUDY

The study was broken into phases corresponding to the stated objectives. It was determined early in the study that each change to the operating system should be evaluated separately. This separation of changes is necessary to evaluate the affects of each. Note: It is not possible to tell which change had an impact on the authorized purposes if more than one change is made in a simulation.

The objective, a description of each simulations used to evaluate the operating system changes to accomplish that objective and conclusions are described in the following paragraphs.

5.1 OBJECTIVE: MINIMIZE DAYS FLOW AT VAN BUREN EXCEED 100,000 CFS

Navigation interest have stated that flows above 100,000 cfs at Van Buren cause the Arkansas system to be un-navigable. Therefore, the system would become more reliable for every additional day flows in the main stem of the Arkansas River could be held below 100,000 cfs. A summary of simulations used to accomplish this objective and analysis of each are described in the following paragraphs.

The maximum target at Van Buren was increased when the 11 reservoir system filled to various levels of flood storage in an attempt to lessen the impact on the flood control pools. After various levels of filling and various maximum flow targets were evaluated it was determined that a target flow at or below 99,000 cfs could be realized until the system of 11 reservoirs reached 30% full at which time the target would be increased to 200,000 cfs. Note: the operation of the rest of the system and the Van Buren guide curve below the 75,000 cfs bench were not changed from the existing operating plan. This combination was the beginning simulation to be evaluated for objective I.

5.1.1 *A01X16 EXISTING OPERATING PLAN*

A simulation using the existing operating plan was run with the updated period of record hydrology and updated power loads furnished by SWPA. The run established a base condition by which all other simulations were compared.

The following data can be found in appendix 1 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

5.1.2 VAN BUREN AT 99,000 CFS ABOVE 75,000 BENCH

An initial series of screenings were performed in which a 99,000 cfs target replaced the portion of the Van Buren guide curve above the taper and 75,000 cfs bench. (A target of 99,000 cfs was chosen to keep the flow below 100,000 cfs a much as possible.) The initial runs showed an unacceptable level of impact on the flood control pools. Subsequent simulations indicated that the target at Van Buren should be increased above the current channel capacity when the system storage exceeded 30%.

Action: Increase the Van Buren target flow when system storage exceeds 30%.

5.1.3 A01X17 200,000 CFS AT VAN BUREN ABOVE 30%

The purpose of run A01X17 was to evaluate the effects of the combination of a 99,000 cfs target above the 75,000 cfs bench to 30% system full capacity. The simulation showed a significant reduction in the average number of days per year the flow at Van Buren exceeded 100,000 cfs when compared to the existing conditions run A01X16. The simulation indicated a reduction of 13 days/year (from 34 days to 21 days). It is believed this reduction would make the navigation system more dependable. The change also reduced the flow above 137,000 cfs (channel capacity) by 2.5 days. Hydropower did not show a significant impact (less than 1%) at the storage projects but did increase generation at the lock and dams by 37.4 gwh (2%). (Note: this increase was probably due to the 99,000 cfs bench in place of the 137,000 cfs -150,000 cfs upper target and resulted in less spill). Using SUPER economics as a screening tool, it was determined that damages exceeded benefits by a significant amount (this was expected since the non-damaging flow at Van Buren is approximately 137,000 cfs.) The increase in damages was primarily along the main stem of the Arkansas river from Haskell, Oklahoma to the Little Rock, Arkansas area.

The increase in channel capacity at Van Buren from 150,000 cfs to 200,000 cfs above 30% system storage did reduce the amount of time (duration) flood waters were stored in the upper flood pools. However, the duration of the storage below the 30% level was increased significantly resulting in a loss of recreation and increased pool damages (primarily recreation areas.) Fort Gibson, Oologah, Keystone and Tenkiller increased duration of storage in the lower 10 feet of the pool while Eufaula showed an increase in the lower 6 feet. Hulah, Copan and Wister showed little change in operation. Note: Hulah and Copan are regulated more by the channel capacity at Bartlesville and Ramona than by the restrictions on the main stem.

Evaluation of flow data passing the Van Buren gage indicated that 175,000 cfs was exceeded only 2 days per year as compared to 1 day in the existing conditions run. This led to the conclusion that some other control was restricting the releases. The target of 150,000 cfs at Sallisaw was identified as the probably restriction to the releases when the target at Van Buren was increase from 150,000 cfs to 200,000 cfs.

The following data can be found in appendix 5 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Increase the Sallisaw target to 200,000 cfs to match the Van Buren target.

5.1.4 A01X18 VAN BUREN AT 200,000 CFS AND SALLISAW AT 200,000 CFS

This run titled A01X18 was made to allow the 200,000 cfs increase in target flow at Van Buren to realize it's full benefit by removing the restriction of 150,000 cfs at Sallisaw, OK. Analysis indicated an additional 3 days reduction in flows above 100,000 cfs at Van Buren compared to A01X17. It also showed an increase above 175,000 cfs from a 2 day average/ year to 8 days average/year and 2.4 more days below the 137,000 cfs (channel capacity). There was a decrease duration in the upper limits of the flood pools between runs A01X17 and A01X18. There were fewer days duration of storage in the lower pools at Eufaula and Fort Gibson with only slight changes in Tenkiller, Keystone and Oologah.. Note: The increased duration in the lower portion of the flood pools is due to the change is target below 30% full from 137,000 cfs to 99,000 cfs .

The analysis also indicated 3 times the increase in overall damages to crops and structures and a 1% decrease in power production from A01X17. On the positive side pool damages, and recreation losses both decreased.

Since the number of days increased by only 2 days and the damages significantly increased , there may be a combination of Van Buren at 200,000 cfs and Sallisaw between 150,000 cfs and 200,000 cfs that would maximize days gained and minimize damages.

The following data can be found in appendix 6 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Make run with Van Buren at 200,000 cfs and Sallisaw at 175,000.

5.1.5 A01X19 VAN BUREN AT 200,000 CFS AND SALLISAW AT 175,000 CFS

This run was made in an attempt to retain the extra days below 100,000 cfs at Van Buren gained in A01X18 without the dramatic increase in agricultural and structural damages.

This run did retain most of the 3 extra days below 100,000 cfs gained in A01X18 with approximately half the increase in agricultural and structural damages. It also retained 2 of the days below the 137,000 cfs (channel capacity.) Power production gained back a small amount of that lost in A01X18. Recreation losses and pool damages gave back half of the gain between the results of runs A01X17 and A01X18. The duration of the upper flood pools was similar to A01X18.

Analysis of this run brought the question; "Would an upper target of 175,000 cfs at Van Buren rather than 200,000 cfs gain days below 100,000 cfs with less economic losses?"

The following data can be found in appendix 7 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Make two runs. One with Van Buren upper target at 175,000 cfs and Sallisaw back to 150,000 cfs . The second run with Van Buren upper target at 175,000 cfs and Sallisaw at 175,000 cfs. Note: Two runs are needed to evaluate the effects of the change. If only the second were made, it would be impossible to know whither the effects were from the Van Buren change or the Sallisaw change or both.

5.1.6 A01X20 VAN BUREN AT 175,000 CFS AND SALLISAW AT 150,000 CFS

This run was made to see if the days equaling or exceeding 100,000 cfs vs. damages could be improved by lowering the regulated flows at Van Buren to 175,000 cfs.

The run gave approximately the same 13 days below 100,000 cfs that were achieved in the 200,000 cfs run (A01X17). It also produced the same 2 days below the 137,000 cfs (channel capacity.) The agricultural and structural damages were slightly less than A01X17 as were the navigation damages. Pool damages, recreation and hydropower losses were slightly larger. The use of the upper flood pools was similar to A01X18.

It is believed that by opening Sallisaw to 175,000 cfs to match the Van Buren target the number of days below 100,000 cfs can be improved without a significant impact to other purposes.

The following data can be found in appendix 8 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Increase Sallisaw target to 175,000 cfs to match Van Buren target.

5.1.7 A01X21 VAN BUREN AT 225,000 CFS AND SALLISAW AT 150,000 CFS

The study team wanted to evaluate the impacts of an increase of 25,000 cfs from A01X17. The days equaling or exceeding 100,000 cfs vs. damages were evaluated after increasing the regulated flows at Van Buren to 225,000 cfs.

The run gave very similar results to A01X17 which was restricted because of Sallisaw. The value of increasing the target at Van Buren cannot be realized without increasing Sallisaw.

The following data can be found in appendix 9 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: 1. Increase Sallisaw target to 225,000 cfs to match Van Buren target.

5.1.8 A01X22 VAN BUREN AT 225,000 CFS AND SALLISAW AT 225,000 CFS

This run was made to allow the 225,000 cfs increase in target at Van Buren to realize it's full benefit by increasing the flow target at Sallisaw, OK. from 150,000 cfs to 225,000 cfs.

This run did increase the number of days below 100,000 cfs by one more day over the 16 days gained in run A01X18. The total damages increase to agriculture and structures was even more dramatic, increasing by 8.68% in total damages compared to 6.68% increase in run A01X18. Navigation cost, recreation losses, and hydropower are approximately the same. Duration of flood waters in the upper flood pools was similar to A01X18 with

somewhat less impact on the lower pools. Pool damages were slightly less than existing conditions A01X16.

Note: The United States National Weather Service indicates that flows of 225,000 – 250,000 cfs can be expected to have the following results:

1. **Extensive agricultural lowland flooding.**
2. **Marine terminals and similar businesses in the flood plain along the river will begin to flood.**
3. **Flooding of sand and gravel companies**
4. **Residential subdivisions in the flood plain along the river will begin to flood.**
5. **Expect backwater flooding of roads and trailer parks next to Lee Creek.**

It appears that 175,000 cfs or 200,000 cfs upper target at Van Buren are going to have the most benefit to navigation with the least impact on other purposes.

The following data can be found in appendix 10 of Volume II:

Graph of the Van Buren guide curve
Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock
Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.
Screening level economics comparing this run with the Existing Plan

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: The team wants to see the upper limit target of 300,000 cfs to see if any other increases would have a positive effect.

5.1.9 A01X23 VAN BUREN AT 175,000 CFS AND SALLISAW AT 175,000 CFS

This run was made to allow the 175,000 cfs increase in target at Van Buren in A02X20 to realize it's full benefit by increasing the flow target at Sallisaw, OK from 150,000 cfs to 175,000 cfs.

The run retained most of the 16 day increase realized in A01X18. It increased by one day the flow above the 137,000 cfs (channel capacity.) Agricultural and structural damages were found to increase 3.12% where as A01X18 increased by 6.68%. Pool damages and recreation damages were larger than A01X18. Hydropower production was slightly improved from A01X18.

It appears that the upper limit of channel capacity should be 175,000 cfs or 200,000 cfs depending on the cost of flood proofing and/or real estate requirements.

The following data can be found in appendix 11 of Volume II:

Graph of the Van Buren guide curve

Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock
Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.
Screening level economics comparing this run with the Existing Plan

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the cost of a target to 175,000 cfs and 200,000 cfs flows at Sallisaw and Van Buren.

5.1.10 A01X24 VAN BUREN AT 300,000 CFS, SALLISAW AT 300,000 CFS AND MUSKOGEE AT 250,000 CFS

This run was made to see the effects of opening the lower Arkansas to match the maximum discharges allowed from all projects without exceeding channel capacity immediately below each reservoir. It was desired to see what maximum number of days could be attained without modifying the storage reservoirs or the channel below each reservoir.

This run did increase the number of days below 100,000 cfs by 19 days as compared to 16 days in run A01X18 (200,000 cfs target). There was a dramatic 300% increase in agricultural and structural damages over the A01X18 increase. There was also an increase of 7 days below the 137,000 cfs (channel capacity.) Power production was impacted more in this simulation than any other run with a loss of generation in all categories except the lock and dams with only minor gains there. Recreation losses and pool damages were improved over any of the previous run.

Note: The United States National Weather Service indicates that with flows of 300,000 cfs the expectations are:

(1) Extensive agricultural lowland flooding.
(2) Marine terminals and similar businesses in the flood plain along the river will begin to flood.
(3) Flooding of sand and gravel companies
(4) Flooding of marine terminals and similar businesses along with residential subdivisions in the flood plain along the river.
(5) Expect backwater flooding of roads and trailer parks next to Lee Creek.
(6) Expect flooding in the town of Moffett, Oklahoma. Expect extensive flooding of businesses around Fort Smith and residential subdivisions in the flood plain the Arkansas River.. .the Poteau River and Lee Creek.
(7) Very damaging flooding will occur along the Arkansas River flood plain from Moffett, Oklahoma downstream to Lock and Dam 12. The port of Fort Smith and nearby businesses along the Poteau River will be flooded. Backwater flooding will cover roads and trailer parks next to Lee Creek. Residential subdivisions in the flood plain of the Arkansas River will be flooded.
(8) Above 335,000 cfs near catastrophic flooding will occur along the Arkansas River.

This run was the most favorable for recreation and in-pool damages and added another 3 days per year to flow below 100,000 cfs. However, with the added damages and negative impacts on hydropower, flow of this magnitude or larger will probably not be considered further.

The following data can be found in appendix 12 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the cost of a target to 175,000 cfs and 200,000 cfs flows at Sallisaw and Van Buren.

5.2 OBJECTIVE: MINIMIZE DAYS FLOWS AT VAN BUREN EXCEED 60,000 CFS

Farming interest in western Arkansas requested the Corps investigate the possibility of reducing the flooding of agricultural land along the lower Arkansas River. It has been determined that flows above 60,000 cfs cause flooding of some fields along the main stem in western Arkansas.

It has also been noted that the existing 75,000 cfs (bench) flow hinders channel recovery operations (dredging) in the lower reaches of the Arkansas River where intervening runoff increase the flows to 85,000 or 90,000 cfs. It is difficult to perform dredging when flows exceed 70,000 cfs.

It is believed that lowering the bench from 75,000 cfs to 60,000 cfs would accomplish both objectives

5.2.1 A01X25 VAN BUREN AT 60,000 CFS TARGET ABOVE THE TAPER

This run was used to determine the amount of additional storage that would be required in the 11 multipurpose projects to maintain a maximum target flow of 60,000 cfs at Van Buren. This was accomplished by simulating unlimited storage in the 11 controlling reservoirs and observing the maximum storage reached.

The goals were:

a. Establish the maximum number of days that flows could be controlled below 60,000 cfs. Note. Even with unlimited storage in the reservoirs, flows above 60,000 cfs will occur at Van Buren when rain falls on the 7500 square miles of drainage area below the controlling reservoir.

b. Answer the question "how much storage would have to be added to the storage projects to achieve maximum control on the lower Arkansas?"

Analysis: Unlimited storage in the controlling projects would reduce the flows above 61,000 cfs to an average of approximately 10 days per year (61,000 cfs was selected rather than 60,000 cfs to evaluate the flows "exceeding" rather than "equaling or exceeding" 60,000 cfs.) Flows above 75,000 cfs would be reduced to approximately 4 days per year. Flows above 100,000 cfs would be reduced to approximately 2.5 days per year. Flows above 137,000 cfs or bank full would be reduced to less than once per year on the average. Agricultural and structural damages would be much less in the lower Arkansas. Navigation costs would be significantly reduced. Recreation losses would be dramatically increased since the recreation areas would be flooded much of the year. Hydropower would be increased since any releases would be made through the hydropower units.

A 200% increase in storage would be required to accomplish maximum control below 60,000 cfs. Storage for each project and the year required may be found in Table 2-1. (Note. The 1991 Arkansas River Basin report indicated a 150% increase in storage needed.

The 1991 study used 75,000 cfs in the place of 60,000 cfs. The 1991 report was also based on a period of record of 1940-1986. It should also noted in table 2-1 that most of the peak storage years occurred after 1986.)

TABLE 2-1

FLOOD STORAGE REQUIRED FOR 60,000 CFS AT VAN BUREN (IN ACRE-FEET)

RESERVOIR	CURRENT TOTAL STORAGE	2002 STUDY MAXIMUM STORAGE	YEAR MAXIMUM OCCURRED
FORT GIBSON	1,284,400	5,479,500	JUN 1993
OOLOGAH	1,519,000	4,896,200	OCT 1993
HULAH	288,088	473,400	JUL 1995
COPAN	227,730	409,900	OCT 1986
KEYSTONE	1,737,631	6,959,600	JUN 1993
TENKILLER	1,230,800	2,945,500	NOV 1993
EUFAULA	3,825,362	8,524,700	MAY 1990
WISTER	427,900	1,648,700	JUN 1975
	10,281,631	31,337,500	

The following data can be found in appendix 13 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

5.2.2 A02X01 EXISTING OPERATING PLAN WITH A 60,000 CFS BENCH REPLACING THE 75,000 CFS BENCH

This run was made to determine the impact of changing the 75,000 cfs bench at Van Buren to a 60,000 cfs bench. Additional changes can be analyzed by comparing the impacts to the results of this simulation.

Analysis: The 60,000 cfs bench decreases the number of days above 60,000 cfs by 18 days over the existing run; it decreases the number of days above 75,000 cfs by 4 days; increases the number of days above 100,000 cfs by 1 day and has no effect on the number of days above channel capacity of 137,000 cfs.

Comparing the other impacts of this run to the existing regulation plan, indicated a slight (.5%) decrease in overall damages to crops and structures. There was also a decrease in navigation damages. Pool damages and recreation losses were increased. Power production at the storage projects was negatively impacted while generation at locks and dams increased.

Changing the 75,000 cfs bench to a 60,000 cfs bench with all other parameters remaining equal increased the duration of flood water in the pools by as much as 9 days. The amount of pool affected ranged from 5 feet in Eufaula to 16 feet in Fort Gibson. The lower part of the pools was used more frequently thus resulting in a loss of recreation and more damages to in-pool facilities (primarily recreation facilities.)

The change from 75,000 cfs bench to 60,000 cfs bench with all other parameters equal appears to cause more damage than benefit. There may be ways to mitigate the increased duration in the pools by modifying the percent full parameters, a higher release target and/or the taper operation.

The following data can be found in appendix 14 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the effect of moving the percent full at which the 60,000 cfs bench begins.

5.2.3 A02X02 MODIFICATION OF A01X23 OPERATING PLAN WITH A 60,000 CFS BENCH REPLACING THE 75,000 CFS BENCH

Previous screening analysis indicated that A01X23 or A01X18 were the best candidates for further investigation. This run was made to determine the impact of keeping the 175,000 cfs maximum target and changing the 75,000 cfs bench to a 60,000 cfs bench. This would indicate if the two objectives should be combined.

Analysis: The 60,000 cfs bench decreases the number of days above 60,000 cfs by 16 days over run A01X23; it decreases the number of days above 75,000 cfs by 4 days; it had no significant impact on the number of days above 100,000 cfs or the number of days above channel capacity of 137,000 cfs.

Comparing the other impacts of this run to A01X23, indicated no significant change in overall damages to crops and structures. There was a slight decrease in navigation damages. Pool damages and recreation losses were increased. Power production at the storage projects was negatively impacted while generation at locks and dams increased.

The change of the 75,000 cfs bench to a 60,000 cfs bench with all other parameters equal causes the lower 30% of the pools to be used more frequently thus resulting in a loss of recreation and more damages to in-pool facilities (primarily recreation facilities.)

It should also be noted that opening the channel capacity to 175,000 cfs would require some type of mitigation for crops that are being damaged in this run.

The following data can be found in appendix 15 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

5.2.4 A02X03 MODIFICATION OF A02X01 WITH THE UPPER LIMIT OF THE 60,000 CFS BENCH BEGINNING AT A 3% LOWER SYSTEM STORAGE

This run was made to determine if the negative impact of changing the 75,000 cfs bench at Van Buren to a 60,000 cfs bench could be mitigated by lowering the point at which the 60,000 cfs bench begins.

Analysis: Lowering the 60,000 cfs bench by 3% decreases the number of days above 60,000 cfs by 13 days over the existing plan but increased 5 days from A02X01; it increases the number of days above 75,000 cfs by 3 day; increases the number of days above 100,000 cfs by 1 day and has no effect on the number of days above channel capacity of 137,000 cfs.

Comparing the other impacts of this run to the existing regulation plan, indicated a .25% decrease in overall damages to crops and structures. There was a slight increase in navigation damages. There was a slight decrease in pool damages, recreation losses and power production.

Lowering the 60,000 cfs bench by 3% with all other parameters remaining equal eliminated most of the impact on the duration of flood water being held in the pools experienced by lowering the bench from 75,000 cfs. There was only a few days increase in the lower 2-6 feet.

Note: Lowering the 60,000 cfs bench by 3% does have some positive impact on the flows below 60,000 cfs with little impact on other purposes. It will have to be determined if 11 days out of 67 is significant for the crops in Arkansas.

The following data can be found in appendix 16 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the impacts of raising the 60,000 cfs bench by 3%.

5.2.5 A02X04 MODIFICATION OF A02X01 WITH THE UPPER LIMIT OF THE 60,000 CFS BENCH BEGINNING AT A 3% HIGHER SYSTEM STORAGE

This run was made to determine the effect of raising the 60,000 cfs bench by 3%.

Analysis: Raising the 60,000 cfs bench by 3% decreases the number of days above 60,000 cfs by 22 days over the existing plan; it decreases the number of days above 75,000 cfs by 8 days; decreases the number of days above 100,000 cfs by 1 day and has no effect on the number of days above channel capacity of 137,000 cfs.

The duration of flood water in the lower 30% of the pools were increased by 5-15 days over the existing plan A01X16 and 2-9 days over A02X01. The amount of pool affected ranged from 5 feet in Eufaula to 16 feet in Fort Gibson. Similar to A02X01 the lower part of the pools was used more frequently thus resulting in a loss of recreation and more damages to in-pool facilities (primarily recreation facilities.) The loss of hydropower at the storage projects is the result of restricting the releases to discharges below generation capacity.

Comparing the other impacts of this run to the existing regulation plan, indicated a slight increase in overall damages to crops and structures in the Haskell area and Sallisaw area.

Navigation damages decreased slightly while pool damages, recreation losses and power production at storage projects were negatively impacted.

Note: Raising the 60,000 cfs bench by 3% has a positive impact on navigation and a negative impact on most other purposes. This change does not appear to be an option since it actually causes more damage to crops than the existing conditions run.

The following data can be found in appendix 17 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the effect of not reducing the flood storage during the spring months.

5.2.6 A02X05 EXISTING PLAN WITH A 75,000 CFS BENCH UPPER LIMIT AT 18%

This run was executed to determine the impact of changing the 75,000 cfs bench upper limit to 18%. This would evaluate the benefit of the reduction during the spring months.

Analysis: Eliminating the spring dip in the 75,000 cfs bench increases the number of days above 60,000 cfs by 4 days over the existing run; it decreases the number of days above 75,000 cfs by 1 day; decreases the number of days above 100,000 cfs by 3 day and has no effect on the number of days above channel capacity of 137,000 cfs.

Comparing the other impacts of this run to the existing regulation plan, indicated a slight (.5%) increase in overall damages to crops and structures, primarily in the Haskell and Sallisaw areas. There was a slight decrease in navigation damages. Pool damages and recreation losses were increased. Power production at the storage projects was negatively impacted while generation at locks and dams increased.

The amount of pool affected ranged from 4 feet in Eufaula to 12 feet in Fort Gibson. The lower part of the pools was used more frequently thus resulting in a loss of recreation and more damages to in-pool facilities (primarily recreation facilities.) Also the loss of hydropower at the storage projects is the result of restricting the releases to discharges below generation capacity. The decrease in damages was relatively small.

The change appears to cause more damage than benefit. The lower 30% of the pools were used more frequently on the average and the upper pool was impacted only in the a few major floods (1975,1993,1995). There is probably not a reason to pursue this further until the taper operation is investigated.

The following data can be found in appendix 18 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the affect of removing Hulah and Copan from the 11 controlling projects. Most of the runs to date indicate that Hulah and Copan are not affected by changes at Van Buren.

5.2.7 A02X06 EXISTING OPERATING PLAN WITH HULAH AND COPAN REMOVED FROM 11 CONTROLLING PROJECTS

This run was made to determine if Hulah and Copan were making a significant contribution to the control of flooding in the lower Arkansas. It was suspected that the restrictions at Bartlesville and Ramona were the primary control on these reservoirs.

Analysis: The removal of Hulah and Copan had little if any effect on the Van Buren flows.

Comparing the other impacts of this run to the existing regulation plan, indicated little or no change in overall damages to crops and structures. There was a slight increase in navigation damages. Pool damages and recreation losses were increased only slightly. Power production was not impacted.

There was little impact on the duration of the storage projects including Hulah and Copan.

Removal of Hulah and Copan from the 11 controlling projects does not appear to have a significant impact on the system.

The following data can be found in appendix 19 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Consider removal of Hulah and Copan from the system full calculation for Van Buren.

5.2.8 A02X10 MODIFICATION OF A02X01 WITH THE UPPER LIMIT OF THE 60,000 CFS BENCH BEGINNING AT A 3% LOWER SYSTEM STORAGE EXCEPT DURING JUNE 15-OCTOBER 1

This run was made at the request of Operations in Little Rock District to determine if the negative impact of changing the 75,000 cfs bench at Van Buren to a 60,000 cfs bench could be mitigated by lowering the point at which the 60,000 cfs bench begins as demonstrated in A02X03 but keep the 18% storage from June 15 through October 1.

Analysis: Not lowering the 60,000 cfs bench by 3% from June-October has similar affect on the Van Buren flows as A02X03 (lowering the bench by 3% year round.) The run decreases the number of days above 60,000 cfs by 14 days over the existing plan but increased 5 days from A02X01; it decreases the number of days above 75,000 cfs by 2 days; increases the number of days above 100,000 cfs by 2 day and has no effect on the number of days above channel capacity of 137,000 cfs.

Comparing the other impacts of this run to the existing regulation plan, indicated the same <.5% decrease in overall damages to crops and structures. There was little change in navigation damages, pool damages, recreation losses or power production when compared to the existing plan (A01X16).

Lowering the 60,000 cfs bench by 3% except June-October with all other parameters remaining equal eliminated most of the impact on the duration of flood water being held in the pools experienced by lowering the bench from 75,000 cfs. There was only a few days increase in the lower 2-6 feet. Making an exception of June 15-October 1 in lowering the 60,000 cfs bench retains the mitigation to pool damages with little impact on other purposes.

The following data can be found in appendix 20 of Volume II:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Include the reduction of the 60,000 cfs bench by 3% except for June 15-October 1 for the final runs.

5.3 OBJECTIVE: 3 IMPROVE THE TAPER OPERATION

The navigation taper from 40,000 cfs to 20,000 cfs was developed during the early days of the system operation. The operation has undergone very little change during the past 30 years.

The purpose of this objective is to evaluate the present taper operation and determine if it can be improved to facilitate channel recovery operations.

5.3.1 A02X07 EXISTING OPERATING PLAN WITH 60,000 CFS – 20,000 CFS TAPER

This simulation was made to determine if a 60,000 cfs – 20,000 cfs taper could be used in the place of the 40,000 cfs – 20,000 cfs taper, the 75,000 cfs bench and/or the 60,000 cfs bench requested by farming interest in Arkansas.

Analysis: Eliminating the 75,000 cfs bench and tapering the target at Van Buren from 60,000 cfs – to 20,000 cfs increases the number of days above 20,000 cfs by 4 days over the existing run; it increases the number of days above 40,000 cfs by 12 day; decreases the number of days above 60,000 cfs by 18 day; decreases the number of days above 75,000 cfs by 4 days; increases the number of days above 100,000 cfs by 2 days; there was little change in the number of days above 137,000 cfs.

Comparing the other impacts of this run to the existing regulation plan, indicated a slight decrease in overall damages to crops and structures but a 4% increase the Haskell area. There was a slight decrease in navigation damages. A 4% increase in pool damages and a 6% increase in recreation losses (primarily in Fort Gibson, Oologah, Keystone, Eufaula and Tenkiller Ferry.) Power production at the storage projects was negatively impacted (1%) while generation at locks and dams increased 2%.

The amount of pool effected ranged from 5 feet in Eufaula to 12 feet in Fort Gibson. The duration ranged from 1-2 days up to 20 days. The lower part of the pools was used more frequently thus resulting in a loss of recreation and more damages to in-pool facilities (primarily recreation facilities.)

Taper evaluation

This simulation produced more time available in the 60,000 cfs to 20,000 cfs range and indicates more days available for the removal of silt form the channels. This is shown by the increase in the number of days above 20,000 cfs by 4 days over the existing run, the increase in the number of days above 40,000 cfs by 12 day and the decrease in the number of days above 60,000 cfs by 18 day. This simulation also indicates a positive control for the farming industry since it decreases the number of days per year above 60,000 cfs.

The following data can be found in appendix 21 of Volume II:

- **Graph of the Van Buren guide curve**

Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock
Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.
Screening level economics comparing this run with the Existing Plan

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the affect of moving the percent full at which the taper begins.

5.3.2 A02X08 EXISTING OPERATING + 60K – 20K CFS TAPER LOWERED 3%

This simulation was made to determine if lowering the 60,000 cfs – 20,000 cfs taper could lower the impacts to the storage projects experienced in A02X07.

Analysis: Lowering the 60,000 cfs – to 20,000 cfs taper by 3% increases the number of days over 20,000 cfs by 2 days over the existing run; it increases the number of days above 40,000 cfs by 7 day; decreases the number of days above 60,000 cfs by 11 day; decreases the number of days above 75,000 cfs by 1 days; increases the number of days above 100,000 cfs by 2 days; there was little change in the number of days above 137,000 cfs.

Comparing the other impacts of this run to the existing regulation plan, indicated a slight decrease in overall damages to crops and structures with a 1% increase the Haskell area. There was a slight decrease in navigation damages. A 1% increase in pool damages and a 2% increase in recreation losses (primarily in Fort Gibson, Oologah, Keystone, Eufaula and Tenkiller Ferry.) Power production at the storage projects registered a slight negative impact while generation at locks and dams increased 2%.

The amount of pool effected ranged from 3 feet in Eufaula to 8 feet in Fort Gibson. The duration ranged from 1-2 days up to 10 days. The lower part of the pools was used less than in A02X07 resulting in less damage to in-pool facilities.

Taper evaluation

This simulation also produced more time available in the 60,000 cfs to 20,000 cfs range though less than A02X07 but did indicate improved days available for the removal of silt form the channels. This is shown by the increase in the number of days above 20,000 cfs by 2 days over the existing run, the increase in the number of days above 40,000 cfs by 7 day and the decrease in the number of days above 60,000 cfs by 11 day. This simulation also indicates a positive control for the farming industry since it decreases the number of days per year above 60,000 cfs.

The following data can be found in appendix 22 of Volume II:
Graph of the Van Buren guide curve
Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock
Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan,

Keystone, Tenkiller Ferry, Eufaula and Wister.
Screening level economics comparing this run with the Existing Plan

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Investigate the affect of making a 75,000 cfs to 60,000 cfs taper in range of the 3% storage lowered in this run.

5.3.3 A02X09 EXISTING OPERATING + 75K-60K AND 60K – 20K CFS TAPER

This simulation was made to determine if replacing the 3% of 75,000 cfs lost in A02X08 with a 75,000 cfs to 60,000 cfs taper would give benefit without additional damages.

Analysis: Replacing the 137,000 cfs for 3% above the taper with a 75,000 cfs - 60,000 cfs taper increases the number of days over 20,000 cfs by 2 days over the existing run; it increases the number of days above 40,000 cfs by 9 day; decreases the number of days above 60,000 cfs by 10 day; decreases the number of days above 75,000 cfs by 4 days; increases the number of days above 100,000 cfs by 1 days; there was little change in the number of days above 137,000 cfs.

Comparing the other impacts of this run to the existing regulation plan, indicated a slight decrease in overall damages to crops and structures but a 3% increase the Haskell areas. There was a slight decrease in navigation damages. A 3% increase in pool damages and a 3% increase in recreation losses (primarily in Oologah, Keystone, Eufaula and Tenkiller Ferry.) Power production at the storage projects reflected a slight negative impact while generation at locks and dams increased 2%.

The amount of pool effected ranged from 5 feet in Eufaula to 10 feet in Fort Gibson. The duration ranged from 1-2 days up to 13 days. The lower part of the pools was used more frequently than in A02X08 but less frequently than in A02X07 as was expected.

Taper evaluation

This simulation produced similar results as A02X08 in terms of the taper operation.

The following data can be found in appendix 23 of Volume II:
- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Unless the operations team from Tulsa or Little Rock have additional tapers they want investigated this appears to be the best taper to insert in the final runs.

Note March 2002: After meeting with Little Rock Operations representatives it was determined that the 60,000 cfs bench was more important than the added days of taper operation. This bench would produce self-scouring of the channel thus reducing the need for dredging. Therefore, it is recommended that the 60,000 cfs to 20,000 cfs taper be abandoned in the final runs.

5.4 CONSOLIDATED SIMULATIONS

Each of the objectives identified by the study team were evaluated separately to asses the impacts of individual changes on the system operation. The following simulations are a combination of the changes indicated in the screening study as possibilities solutions to existing problems. These runs are submitted as candidates for final analysis.

5.4.1 A02X11 VAN BUREN AT 175,000 CFS AND SALLISAW AT 175,000 CFS WITH 60,000 CFS BENCH REPLACING 75,000 CFS BENCH LOWERED 3% EXCEPT JUNE15-OCTOBER 1

This run was made to evaluate a combination of 175,000 cfs increase in the target flow at Van Buren and Sallisaw (A01X23) and a modified 60,000 cfs bench replacing the 75,000 cfs bench (A02X10).

The run decreased the number of days above 60,000 cfs by 9 days per year (a 13 % improvement.) It decreased the number of days above 100,000 cfs by 15 day (a 46% improvement.) It decreased by 4 days the flow above 137,000 cfs (a 20% improvement.) Agricultural and structural damages were found to increase approximately 3% (a similar result to A01X23.) Navigation damages decreased less than 1%. Pool damages and recreation damages increased by 3% and 8% respectively. Hydropower production was slightly lower at the storage projects (less than 1%) and increased by 3% at the hydropower lock and dams.

NUMBER OF DAYS OF DURATION ABOVE EXISTING PLAN
COLUMNS REPRESENT FEET ABOVE CONSERVATION POOL

STORAGE	0 feet	2 feet	4 feet	6 feet	8 feet	10 feet	12 feet
GIBSON	1	2	6	6	2	-1	-2
OOLOGAH	5	11	14	9	0	-1	-2
HULAH	0	0	0	0	0	0	0
COPAN	1	1	1	0	0	0	0
KEYSTONE	3	10	12	13	11	2	-1
TENKILLER	4	9	13	11	7	-1e	-2e
EUFAULA	4	9	0	0	-1	0	0
WISTER	3	3	2	1	0	0	-1

Note: e for Tenkiller indicates estimated values.

The following data can be found in appendix 2 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**
- **Comparison plots for each reservoir**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Produce data for external economic evaluation.

5.4.2 A02X12 VAN BUREN AT 200,000 CFS AND SALLISAW AT 200,000 CFS WITH 60,000 CFS BENCH REPLACING 75,000 CFS BENCH LOWERED 3% EXCEPT JUNE15-OCTOBER 1

This run was made to evaluate a combination of 200,000 cfs increase in target at Van Buren and Sallisaw (A01X18) and a modified 60,000 cfs bench replacing the 75,000 cfs bench (A02X10).

The run decreased the number of days above 60,000 cfs by 9 days per year (a 13 % improvement.) It decreased the number of days above 100,000 cfs by 17 day (a 48% improvement.) It decreased by 5 days the flow above 137,000 cfs (a 26% improvement.) Agricultural and structural damages were found to increase approximately 7% (a similar result to A01X18.) Navigation damages decreased slightly. Pool damages and recreation damages increased by 1% and 6% respectively. Hydropower production was 1% lower at the storage projects and increased by 3% at the hydropower lock and dams.

NUMBER OF DAYS OF DURATION ABOVE EXISTING PLAN
COLUMNS REPRESENT FEET ABOVE CONSERVATION POOL

STORAGE	0 feet	2 feet	4 feet	6 feet	8 feet	10 feet	12 feet
GIBSON	1	2	5	4	1	-2	-3
OOLOGAH	5	11	12	7	-1	-2	-2
HULAH	1	1	1	1	1	1	1
COPAN	1	1	0	0	0	0	0
KEYSTONE	3	10	11	11	8	0	-2
TENKILLER	4	8	8	3	-1	-5e	-4e
EUFAULA	4	6	-1	-1	-1	-1	0
WISTER	2	3	1	-1	-1	-1	-1

Note: e for Tenkiller indicates estimated values.

The following data can be found in appendix 3 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**
- **Tables of input data**
- **Comparison plots for each reservoir**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Action: Produce data for external economic evaluation.

6. OPERATION ONLY PLAN

A02X13 Existing plan with a modified 60,000 cfs bench in place of the 75,000 cfs bench and filling behind the flood when the flow reaches 150,000-250,000 cfs and the system storage exceeds 75%

This run titled A02X13 was made to determine the impacts of a 60,000 cfs bench replacing the 75,000 cfs bench combined with filling in behind the flood hydrograph when the flow reach 150,000 – 250,000 cfs and the system percent storage exceeds 75 percent. NOTE: This is similar to a plan identified in the 1989 report but never implemented.

Analysis indicated approximately 15 days reduction in flows above 60,000 cfs. It also produced less than 1 day increase in flows above 100,000 cfs at Van Buren compared to A01X16 (existing operation plan). It also showed an increase above 175,000 cfs of less than 1 day and essentially no change at 137,000 cfs (channel capacity). There was a decrease duration in the upper limits of the flood pools from run A01X16. There was an increase in duration of storage in the lower 2-6 feet of the pools at the storage projects.

The analysis indicated less than 1% increase in overall damages to crops and structures and less than 1% decrease in power production from A01X16. Navigation and in pool damages had negligible changes.

The following data can be found in appendix 4 of this Volume:

- **Graph of the Van Buren guide curve**
- **Tables of flows equaled or exceeded for Van Buren, Sallisaw and Little Rock**
- **Tables of elevations equaled or exceeded for Fort Gibson, Oologah, Hulah, Copan, Keystone, Tenkiller Ferry, Eufaula and Wister.**
- **Screening level economics comparing this run with the Existing Plan**
- **Tables of input data**
- **Comparison plots for each reservoir**

A computer disc (CD) containing the complete results of the simulation can be found in a sleeve in the back of this binder.

Note: This run had minor negative affects on the project purposes. The run had three positive changes: (1) the reduction of 15 days below 60,000 cfs (a key level for farming interest in Arkansas), (2) an increase in days between 40,000 cfs and 60,000 cfs (key to scouring flows in the navigation system) and accelerated evacuation of the storage projects when the system percent full exceeds 75%.