POTENTIAL IMPACTS OF DREDGING AND OPERATIONAL CHANGES AT CORALVILLE RESERVOIR ON MITIGATION OF EXTREME FLOOD EVENTS

by

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ABSTRACT

Flooding downstream from the Coralville Reservoir in 1993 and 2008 has motivated stakeholders to explore ways of managing the reservoir sedimentation and operations. The City of Coralville, Iowa contracted IIHR – Hydroscience & Engineering (IIHR) to assess the feasibility of dredging and/or operational changes to mitigate damages resulting from extreme flood events. Using a HEC-ResSim model provided by the United States Army Corps of Engineers (USACE) Rock Island District, several scenarios relevant to reservoir sedimentation and releases were simulated to evaluate their potential to attenuate major flooding events. The different scenarios explored the effects of dredging, conservation pool elevations, operation plans, major flood procedures, relaxation of downstream constraints, and potential future reservoir sedimentation.

Analyses revealed additional storage provided by dredging would be consumed early in the spring, before the largest rainfall events of 1993 and 2008. Dredging had no effect on the peak discharges observed in 1993 and 2008. Increased storage allowed downstream constraints at Lone Tree, Wapello, and Burlington to be observed for longer periods. However, Dredging may have a greater impact on smaller, more frequent flood events.

More aggressive operation of the reservoir may slightly decrease peak discharges for large magnitude floods, but at the cost of increasing frequency of annual flood damages from smaller events. Additional analyses would be necessary to quantify benefits and determine whether such measures would be economically justified.

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I. INTRODUCTION

The devastating floods of 1993 and 2008 were used to assess the potential impacts of dredging the Coralville Reservoir and any changes to the current Coralville Dam operations plan. Analyses of these alterations were completed using a HEC-ResSim model of the Coralville Reservoir developed by the United States Army Corps of Engineers (USACE) Rock Island District. The model utilizes a set of operational constraints, shown in Appendices A, D, and E, reservoir stage-storage curves, shown in Appendix B, and inflow hydrographs. Operational constraints are evaluated at each time step in order to make a release decision. The release hydrograph is then routed downstream using the Muskingum routing method. Adherence to downstream constraint requirements is determined using travel times and reservoir pool elevation. A detailed description of the HEC-ResSim model is presented in section IV.

Simulated operations were not intended to replicate the observed operations of 1993 or 2008, but were used to evaluate changes in reservoir storage and the current operations plan. Initial simulations were used to demonstrate the differences in observed releases and simulated releases for the floods of 1993 and 2008. Several scenarios were implemented in an attempt to isolate reservoir dredging and operational changes and evaluate their benefits. Model scenarios evaluate impacts of increased storage, changes in the conservation pool, the downstream constraints, changes to the major flood pool elevations, and future sedimentation on attenuation of major flood events.

II. BACKGROUND

A. The 2008 Flood. To consider how dredging or operational changes at Coralville Reservoir may affect flood mitigation, it is first beneficial to examine the release decisions made by the United States Army Corps of Engineers (USACE) during the spring of 2008. A plot showing the observed pool elevation, reservoir inflow, and releases can be seen in Figure 1. The current Coralville Reservoir operations plan is included in Appendix A.

Preceding the major flood event of June 2008, several spring rainfall events began to fill the reservoir. As a result, use of flood control storage above the conservation pool began in mid-March. Operations from March to late April utilized the reservoir as it was intended: to lower the peak discharges of the unregulated inflow. By using the storage to reduce the discharges to a maximum of 10,000 cfs during the spring, flooding was prevented in downstream communities. However, there was less storage available for protection against the most significant rainfall event of 2008.

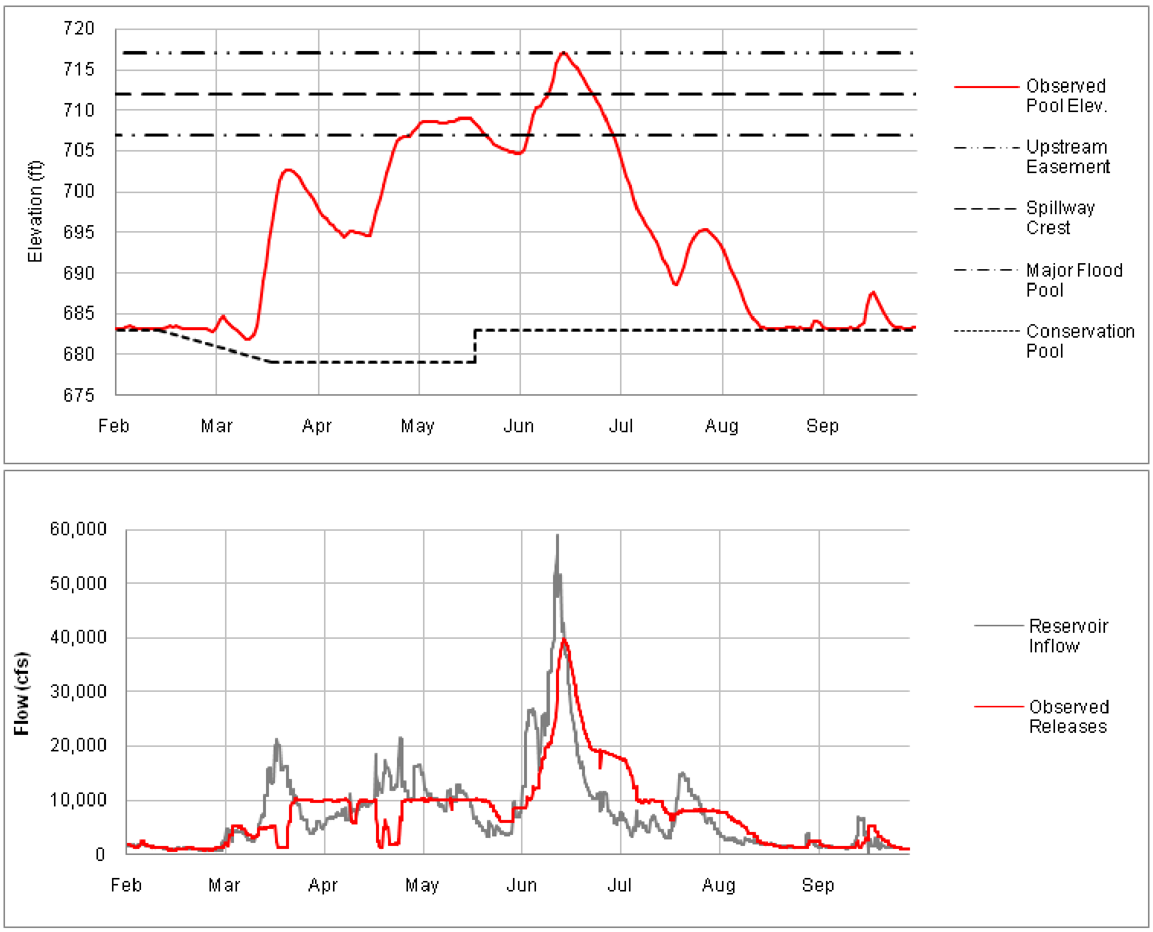


Figure 1. Observed 2008 Flood: pool elevation, inflow, and releases.

Releases from Coralville Reservoir are constrained by river stages occurring downstream on the Iowa and Mississippi Rivers. During spring 2008, the downstream constraints at Lone Tree, Wapello and Burlington were active several times, as shown in Figure 2. The releases were limited to a maximum of 1,000 cfs and flood storage capacity was consumed during these periods to prevent flooding at these locations.

During late April, the pool elevation was forecast to exceed the major flood pool elevation of 707 feet. The downstream constraints were then disregarded and the releases were increased to 10,000 cfs. This continued through May until the pool fell below el. 707. The releases were then incrementally decreased to the summer maximum release of 6,000 cfs.

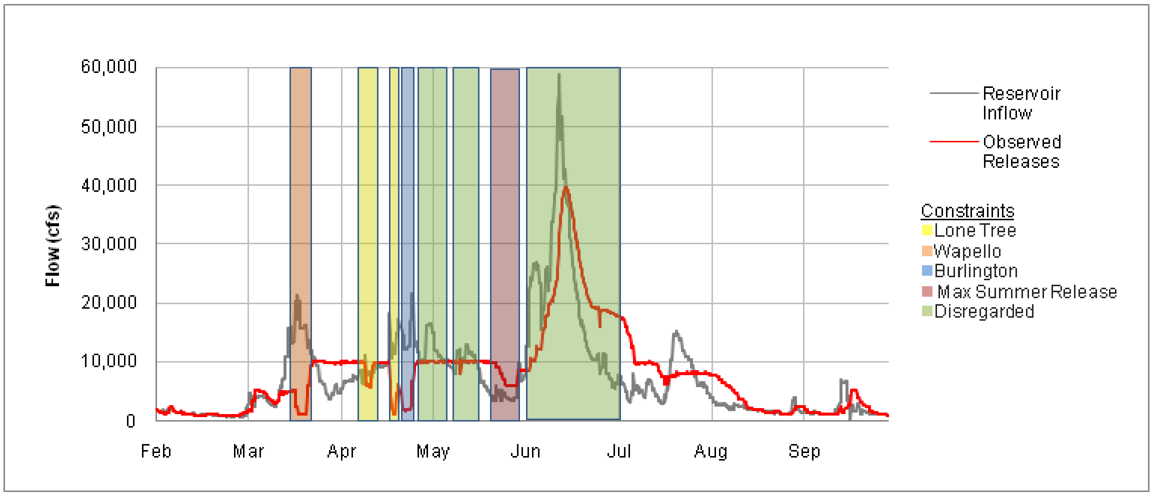


Figure 2. Active constraints during the 2008 flood. Some were disregarded due to the pool elevation being within the major flood pool.

The reservoir inflow volume from March 1st to May 31st totaled approximately 1,600,000 ac-ft. The volume stored in the reservoir at the beginning of June was approximately 260,000 ac-ft., with 160,000 ac-ft. remaining below the spillway crest for flood control. The June event had an inflow volume of 1,300,000 ac-ft, roughly eight times greater than the remaining storage volume. The remaining storage was quickly consumed and the emergency spillway went into operation on June 9th. The unregulated flow into the reservoir had a peak discharge of approximately 57,000 cfs. The peak outflow during the flood was 40,000 cfs, indicating the reservoir did have a significant attenuating effect on the flood hydrograph. The pool elevation peaked at el. 717 ft. This elevation is significant because it corresponds to the upstream flood easements currently held by the USACE. After the pool elevation fell from el. 717 to below the spillway crest, el. 712, the gates regulating the discharge were left fully open to regain flood storage.

B. Sedimentation in Coralville Reservoir. Over its lifetime, the Coralville Reservoir has lost storage capacity to sedimentation. Using historical storage curves, found in Appendix B, it is possible to quantify the vertical distribution of storage lost since implementation of the reservoir in 1958. Figure 3 illustrates the changes in storage for different elevation ranges through time. This plot indicates that the total reservoir storage lost from 1958 to the most current survey in 1999 has occurred primarily in the lower elevations of the reservoir. The cumulative storage lost below the spillway amounts to approximately 71,000 ac-ft. This is approximately 14% of the original 492,000 ac-ft of storage available below the spillway in 1958. The current sediment volume is likely somewhat larger than 71,000 ac-ft, given consideration of additional sedimentation following 1999.

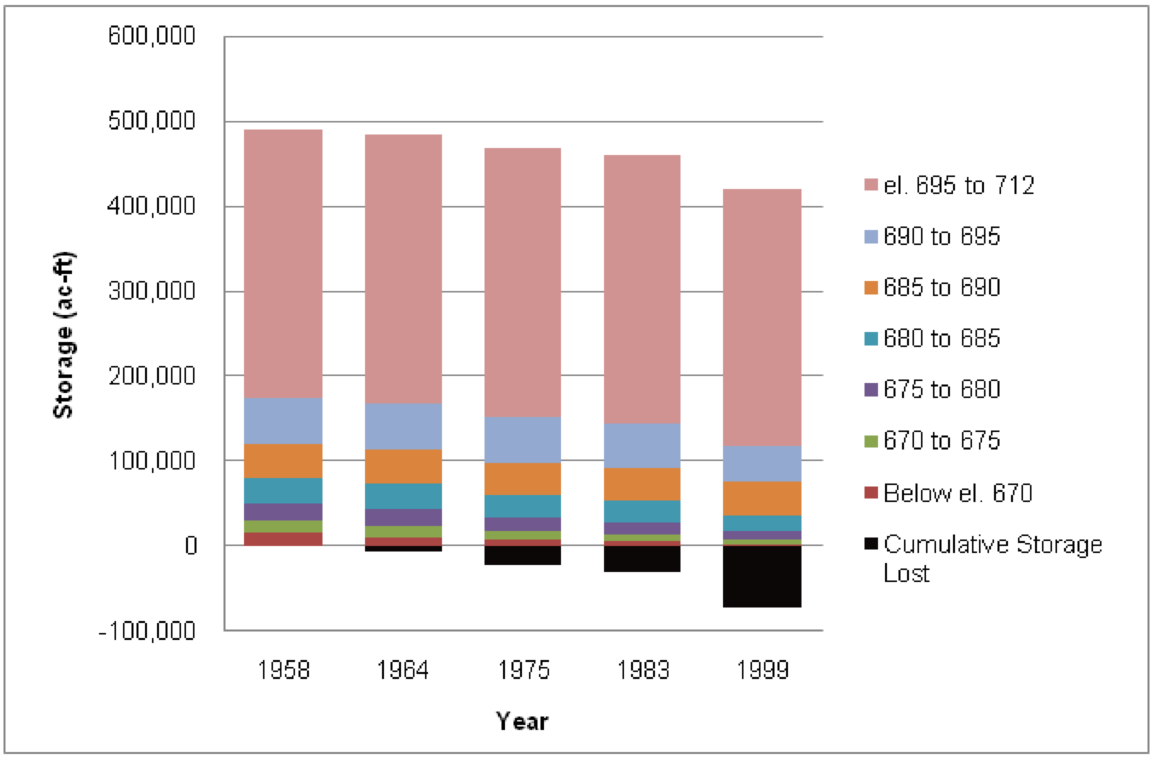


Figure 3. Changes in storage (ac-ft) for different elevation ranges below the spillway through time.

Had an additional 71,000 ac-ft of storage been available during 2008 it would have been quickly consumed. For example, if all of this storage was available in the flood control zone, and the difference in inflow and outflow were 10,000 cfs, the storage would be used in 3.6 days. Figure 4 provides perspective on the relative volumes of water and sediment associated with the 2008 flood.

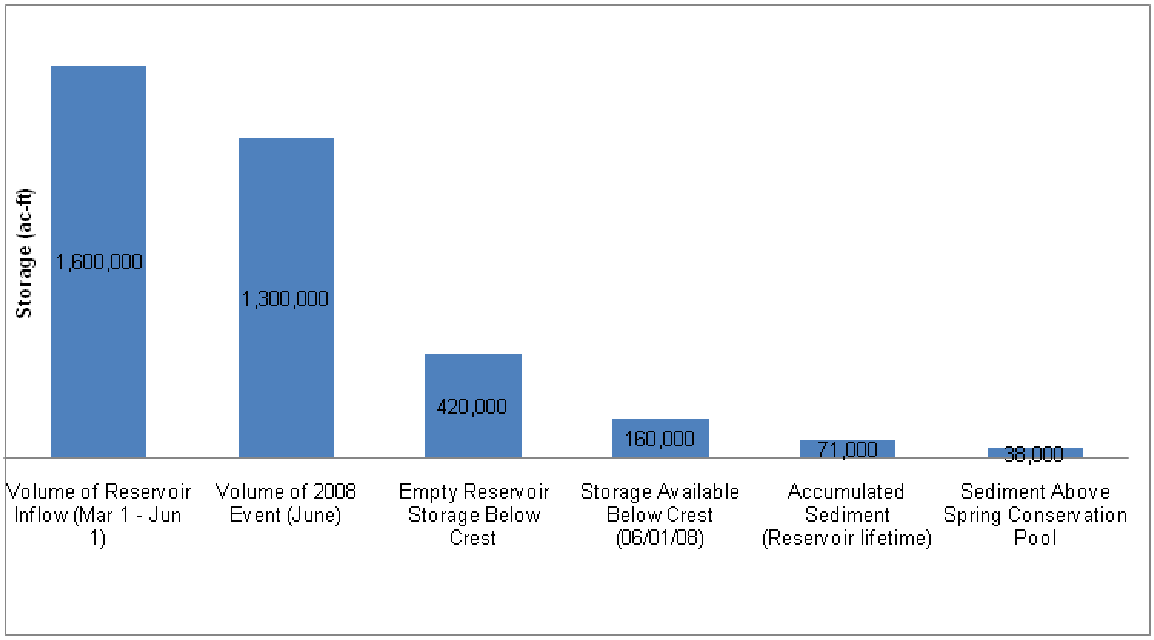


Figure 4. Volumes (ac-ft) associated with the 2008 Flood.

Because a large portion of this sedimentation has occurred below the current conservation pool levels, much of the 71,000 ac-ft cannot be recovered for flood storage. Only 38,000 ac-ft of this sediment is currently above the lowest conservation pool elevation. Figure 5 depicts the flood storage remaining below the spillway according to pool elevation. From this figure, it is apparent that sedimentation has affected storage up to el. 695, but has had the most effect below el. 685. Full utilization of any dredged storage would require drastically lowering the conservation pool, which may negatively affect wildlife habitat and recreation.

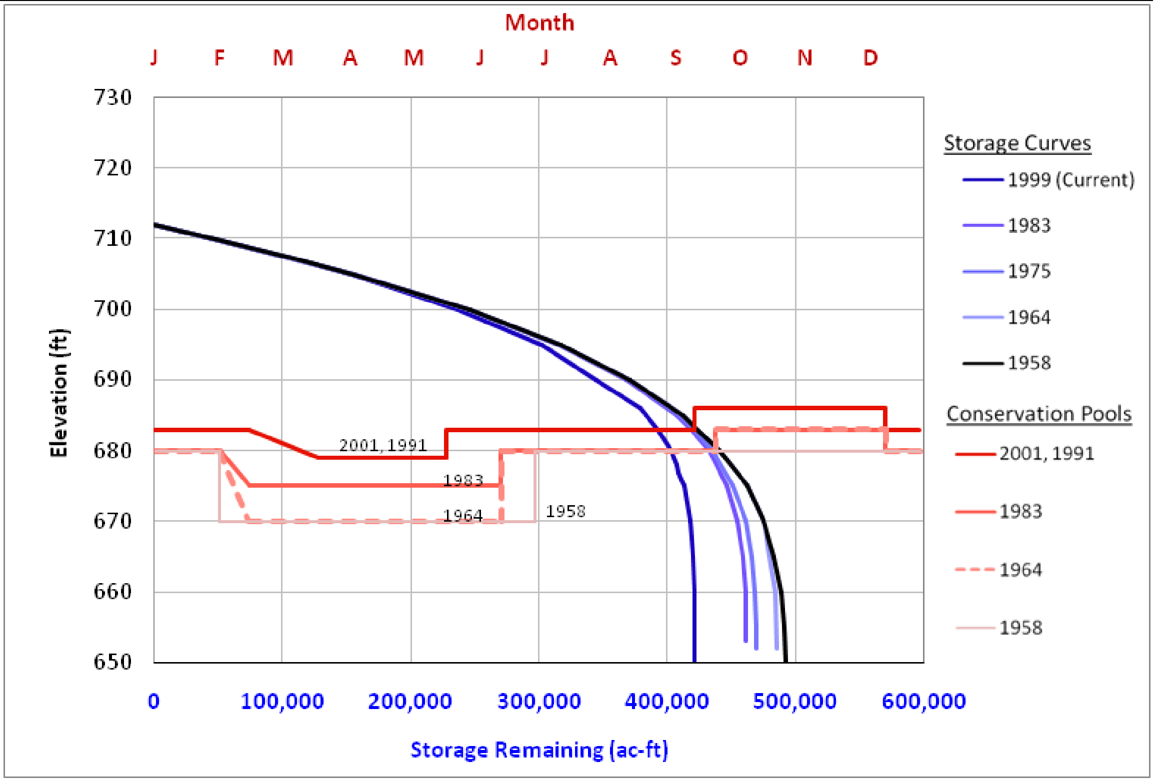


Figure 5. Flood storage remaining below the spillway according to pool elevation. The extent of the sedimentation is demonstrated by the deviation of storage curves from the original capacity in 1958. The storage in the upper elevations of the reservoir has remained relatively unchanged.

III. OBJECTIVES

The goal of this study is to quantify the impact of dredging and changes to the current Coralville Reservoir operations schedule on attenuation of major flood events. Model scenarios constructed from combinations of historic storage curves, historic operations plans, and the significant hydrologic events that occurred in 1993 and 2008 are used to perform the evaluation. While this study seeks to characterize these impacts, ultimately, feasibility will depend upon social, ecological, and financial factors identified by stakeholders in the lower Iowa River corridor. These may include time constraints, permitting, waste disposal, adverse wildlife or habitat effects, and cost.

IV. METHODS

To evaluate changes in operations and storage capacity curves, a HEC-ResSim model of the Coralville Reservoir and associated downstream reaches was developed using an existing model provided by USACE Rock Island District. HEC-ResSim software utilizes reservoir elevation-storage curves, inflow hydrographs and user-defined operation rules. The historic reservoir elevation-storage curves and operations were also obtained from USACE Rock Island District. The historic reservoir elevation-storage curves, shown in Appendix B, were developed from surveys conducted in 1958, 1964, 1975, 1983, and 1999. The historic operational rules from 2001, 1983 and 1964 are shown in Appendices A, D and E, respectively. The 1993 and 2008 hydrographs used in the model were constructed from gaged time-series flow data obtained from the United States Geological Survey (USGS). The model included flow data for the Iowa River (downstream of Coralville Dam, at Iowa City, IA, at Lone Tree, IA, and at Wapello, IA), Clear Creek (at Coralville, IA), Rapid Creek (near Iowa City, IA) , English River (at Kalona, IA), Old Man's Creek (near Iowa City, IA), the Cedar River (near Conesville, IA), and the Mississippi River (at Muscatine, IA and at Burlington, IA).

An important model consideration was reservoir inflow. A stream gage is located upstream of Coralville Reservoir at Marengo. However, it does not account for local drainage from the 320-mi2 ungaged area between Marengo and the reservoir outlet. The reservoir inflow was therefore computed by summing the measured discharge at the stream gage immediately below Coralville Dam and the change in reservoir storage for each model time step.

The local inflows from ungaged areas downstream of Coralville Reservoir are not considered in the model. Ungaged flows may influence hydrographs downstream of Coralville Reservoir. However complete and fully accurate reconstruction of historic flood events is not the goal of the present effort. Exclusion of local drainage downstream of the reservoir does not prevent assessment of reservoir sedimentation and operations on flood mitigation.

An important element of reservoir operation is the ability to forecast river discharges and stages when making release decisions. The operations model described herein does not possess any forecasting capability. Modeled release decisions are based primarily upon observed reservoir and river stages. Therefore, simulated operations do not accurately replicate the observed events of 1993 or 2008. Observed hydrologic data associated with these significant events were used as model inputs to evaluate the benefits of dredging and operational changes on major flood events; but, in many cases reservoir releases deviate from decisions made in 1993 and 2008.

V. RESULTS AND DISCUSSION

A. Comparison of Simulated and Observed Data.

1. 2008 Flood. This scenario was intended to demonstrate how the modeled operations deviate from 2008 observed data. The simulation utilized the 2008 event, the most recent elevation-storage curve, and the 2001 operation plan. A comparison between the simulated and the observed hydrographs, shown in Figure 6, shows there are differences in releases several times during the simulation period. These occurred during mid-March, late April, and following the largest event in late June. During mid-March and late April the downstream constraints were active and the observed releases were approximately 1,000 cfs. The model responded to the downstream constraints also, but released at higher discharges. This is likely a result of the model's use of observed rather than forecasted hydrologic data. In spite of these operational differences, the model was able to replicate the observed peak discharge.

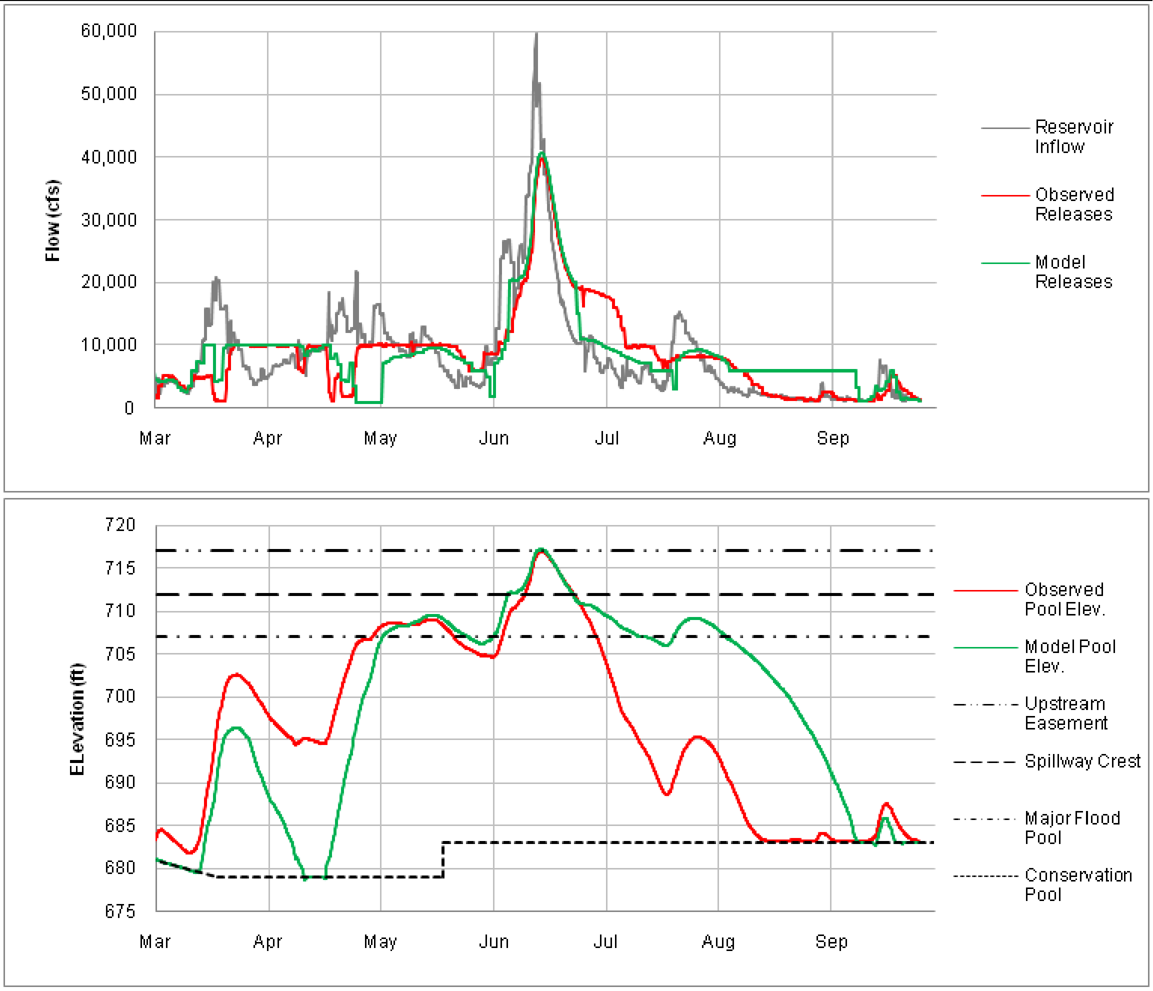


Figure 6. Comparison of model simulation using 2008 event, 1999 elevation-storage curve and 2001 operations with observed data. Differences in releases can be attributed to the inability to replicate decisions made using forecasted river stages and discharges.

The operations plan used for the simulation shown in Figure 6 was modified to replicate the observed release decisions in an effort to demonstrate model validity. The operations were altered only at points where the observed data differed from the operational rules. An example deviation occurred when the primary outlet gates were left fully open after the 2008 flood peak in late June to recover flood storage. Model operations were altered during this period to reproduce this operation decision. The results from this simulation are shown in Figure 7. These modifications are only applicable to the 2008 event and are not valuable when comparing dredging and operational alternatives. Therefore, the modified operational rules depicted in Figure 7 were not used in further analyses. The simulated releases shown in Figure 6 were used as a baseline condition to evaluate any changes in storage and operation rules.

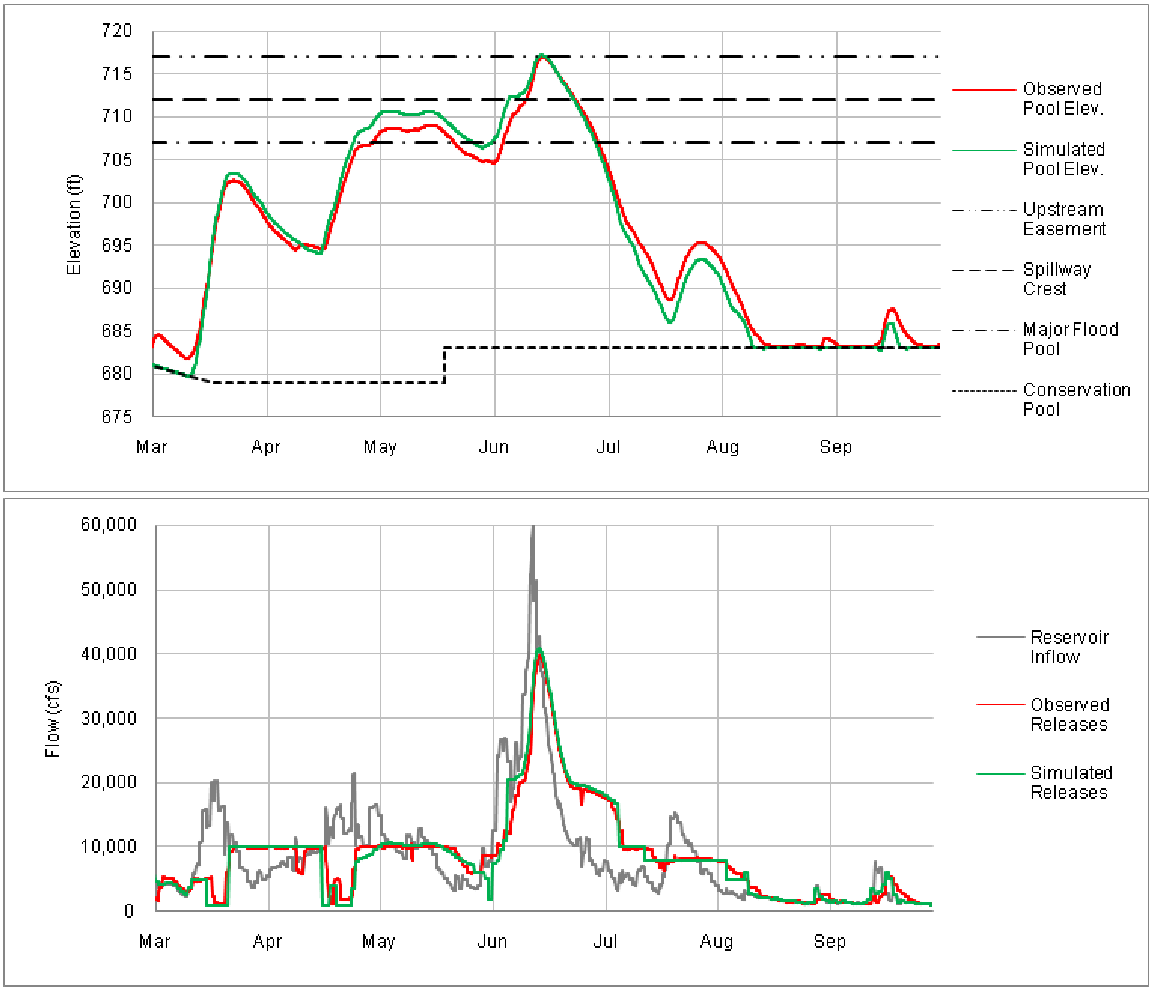


Figure 7. Simulation utilizing a modified form of the 2001 operations plan to replicate the observed release decisions. This modified operations plan is only applicable to 2008, and was not used to evaluate the impacts of dredging.

2. 1993 Flood. This scenario was intended to demonstrate how the modeled operations deviate from the 1993 observed data. This simulation utilized the 1993 event, the most recent elevation-storage curve and the 2001 operations plan. Comparison between the simulated and the observed values, shown in Figure 8, indicates several discrepancies. The major discrepancies occur in late April, mid-July, early August, and early September. The discrepancy in late April is a result of the simulation's pool

elevation being below the major flood pool, and a downstream constraint remaining active. The discrepancy in mid-July occurs at the peak discharge. USACE partially closed the release gates to induce a surcharge, which ultimately lowered the peak discharge. As a result, the reservoir reached el. 717, which was higher that the peak elevation of el.715 produced by the simulation. The observed peak discharge was 25,000 cfs, while the simulated peak discharge was 27,500 cfs. The other discrepancies occurred when the gates were left open to regain flood storage after the large peak discharges. The simulated releases shown in Figure 8 were used as a baseline condition to evaluate changes in storage and operation rules.

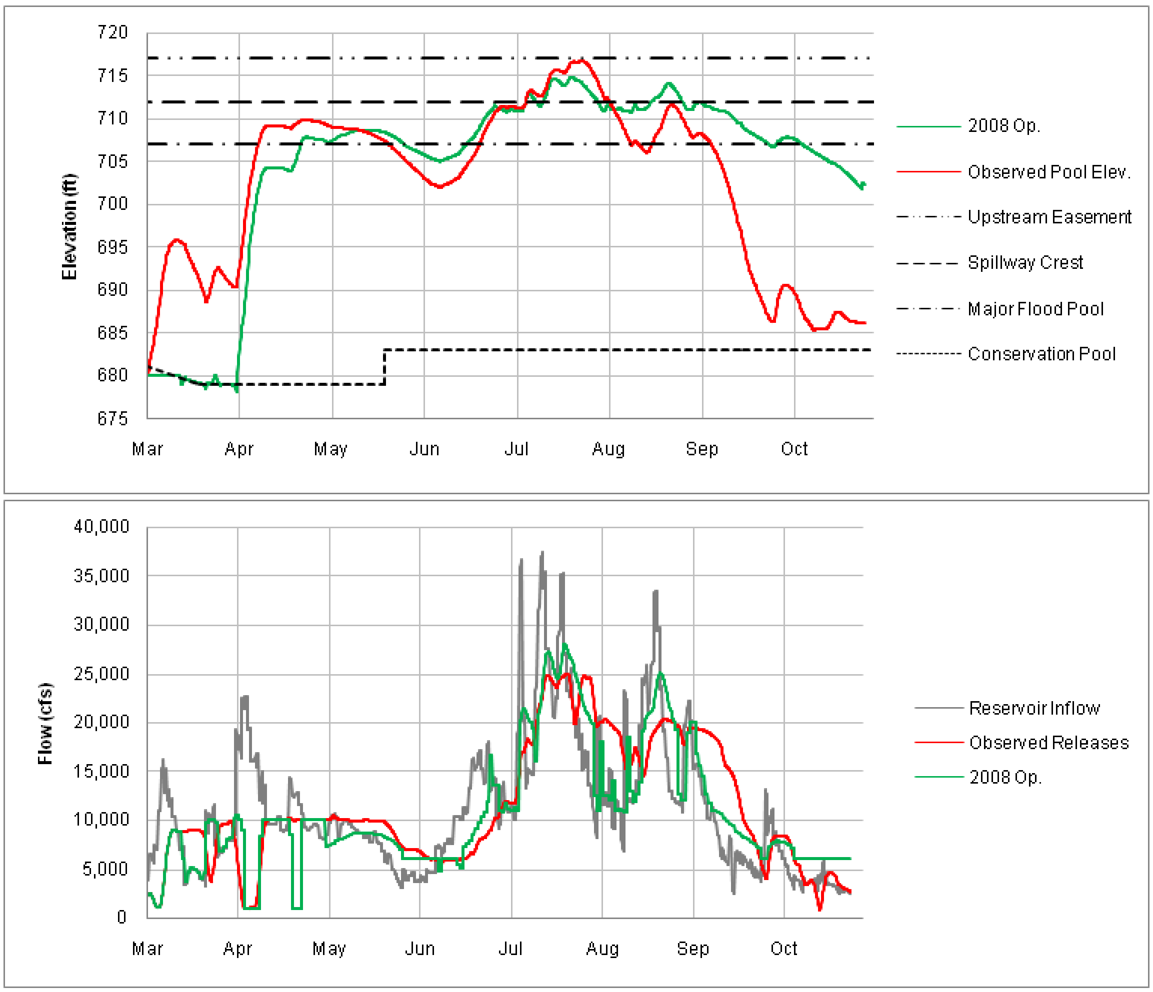


Figure 8. Comparison of Simulation of 2008 operations to 1993 observed data.

B. Impact of Dredging.

1. Current operations and conservation pool, 2008 Flood. This scenario is intended to demonstrate the impact of dredging alone. This scenario used the 2008 event, current operational rules and conservation pool elevation, while varying the reservoir's stage-storage curve. Stage-storage relationships were modeled according to the historical curves shown in Appendix B. The 1999 storage curve was used as the base 2008 configuration. The simulation begins three months prior to the June 2008, the last time prior to the 2008 event that the pool elevation equaled the conservation pool. This is an ideal initial condition for the model because once the pool elevation reaches the conservation pool, any previous operations do not contribute to future pool elevation changes or releases. The results of this simulation are shown in Figure 9.

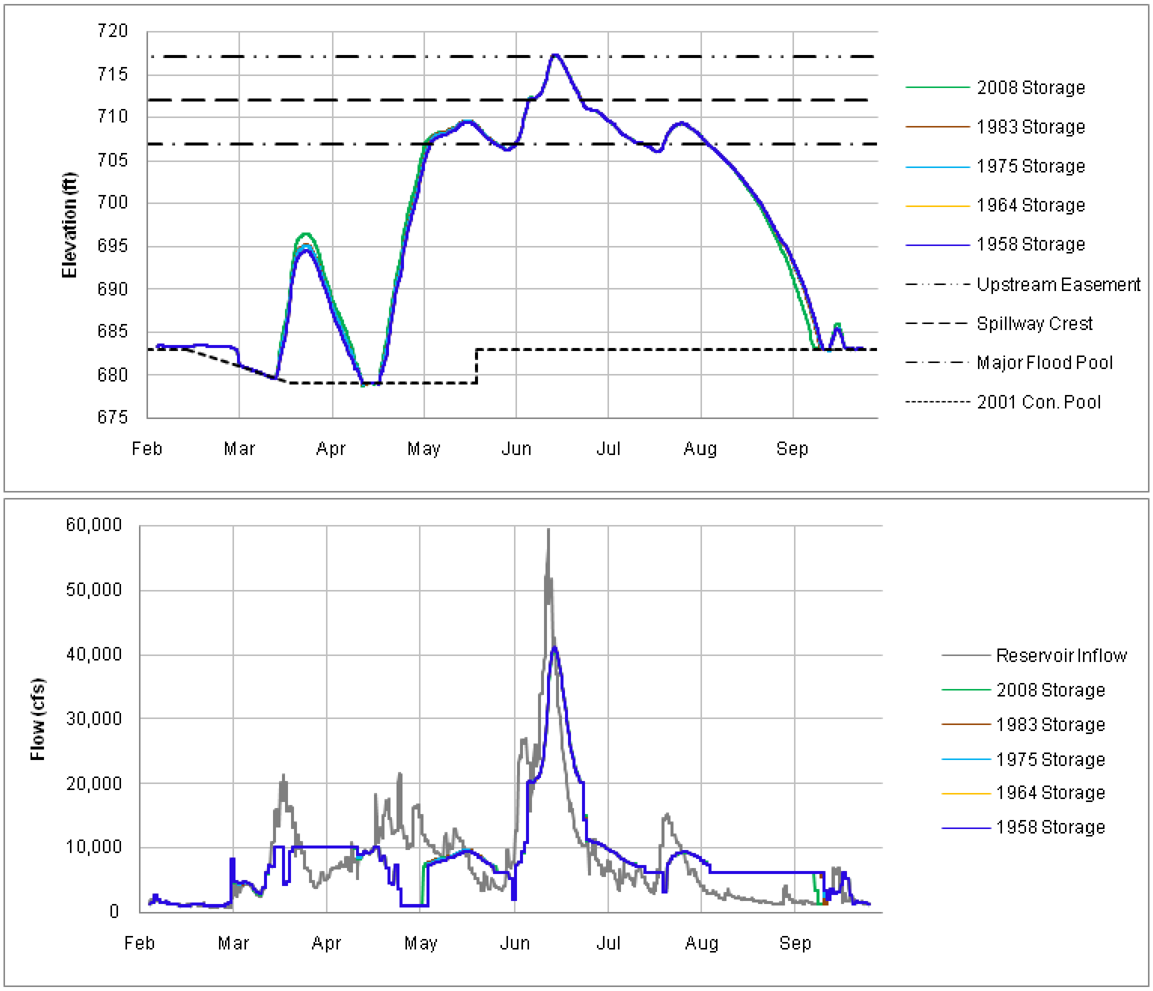


Figure 9. Simulation using 2008 flood event, 2001 operations, 2001 conservation pool, and varied storage curves.

Additional storage from dredging was consumed in early May. Flow was limited to 1,000 cfs by an active downstream constraint from late April until early May when the pool elevations reached the major flood pool. Downstream constraints were then disregarded and releases were regulated by height above the major flood pool. Pool elevations reached the major flood pool level in the order of storage from least to greatest. All the trials in this scenario behaved similarly after reaching the major flood pool. The peak discharge for all trials was approximately 41,000 cfs, slightly larger than the observed discharge of 40,000 cfs.

2. Current operations, 2008 Flood. This scenario is intended to demonstrate the impact of dredging and conservation pool alterations with no changes to the current

operations plan. This scenario used the 2008 event and the current operational rules, while varying the reservoir's stage-storage relationship and conservation pool elevation. Each storage curve has a corresponding historical conservation pool that must be utilized to take advantage of additional storage capacity. The historic changes in conservation pool are documented in Appendix C. The results of this simulation are shown in Figure 10.

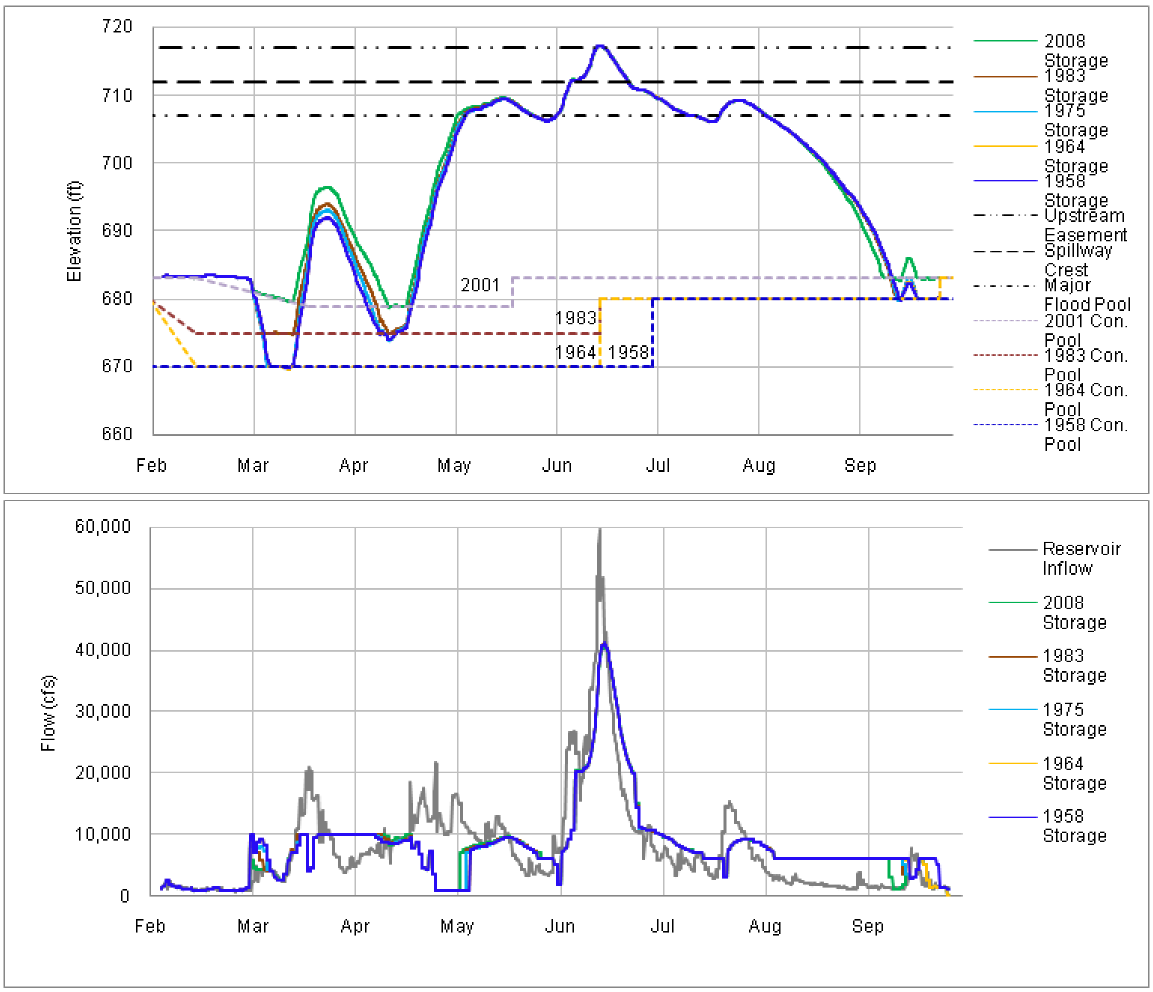


Figure 10. Simulation using 2008 flood event, 2001 operations, and varied storage curves and conservation pools.

Dredging would allow the downstream constraints to be observed for longer periods of time before the pool elevation would enter the major flood pool. This could possibly prevent some flooding in these communities from minor rainfall events. However, for extreme flooding events dredging has no significant impact on the peak discharge.

3. Current operations, 1993 Flood. This scenario is intended to demonstrate the impact of dredging and conservation pool alterations with no changes to the current operations plan. This scenario used the 1993 event and the current operational rules, while varying the reservoir’s stage-storage relationship and conservation pool elevation. The results of this simulation are shown in Figure 11. The results were similar to those associated with the 2008 flood. Any additional storage was used in the early spring before the major event. This is a result of downstream constraints remaining active until additional storage is used. The behavior is nearly identical for all storage curves once simulated pool elevations reach the major flood pool.

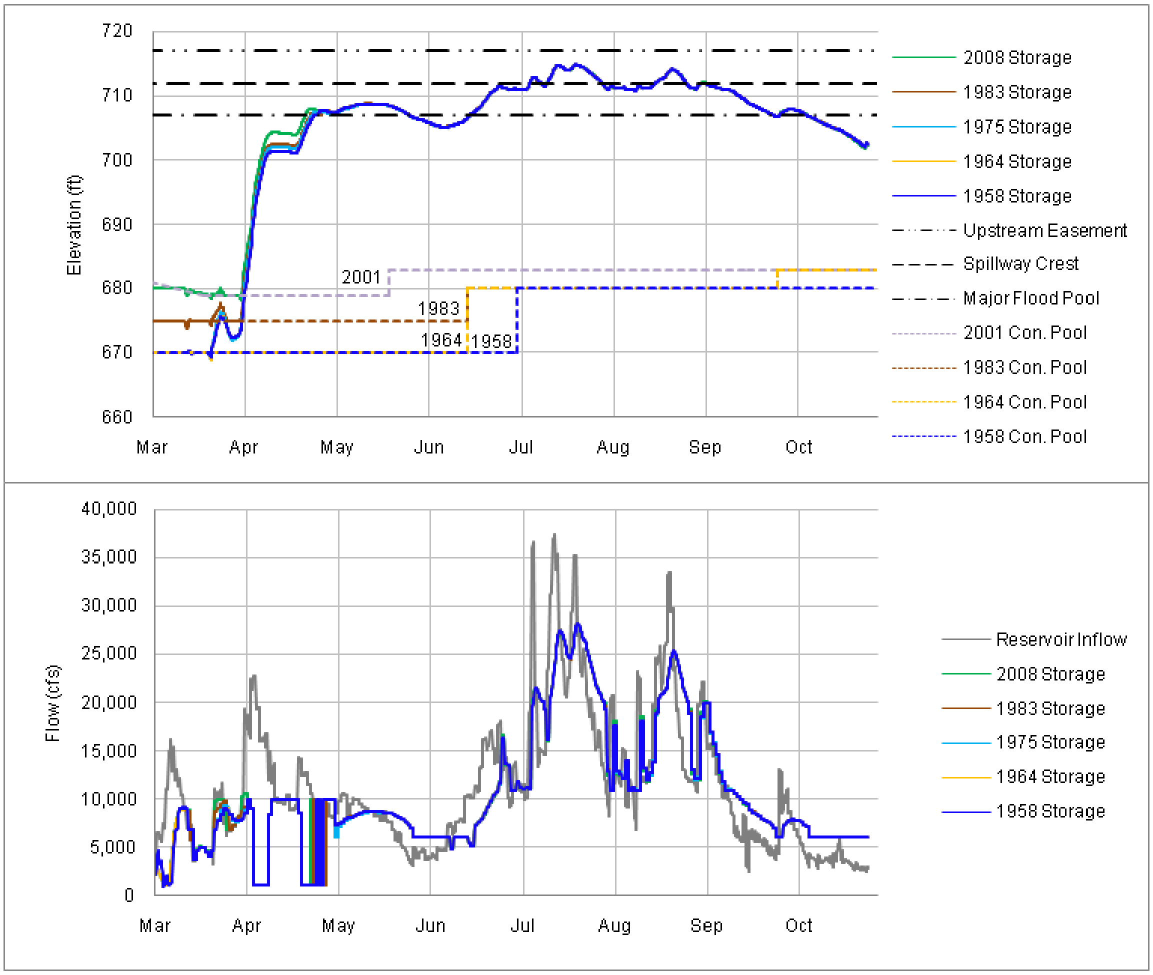


Figure 11. Simulation using 1993 flood event, 2001 operations, and varied storage curves and conservation pools.

C. Impact of Dredging and Operational Changes.

1. 2008 Flood. This scenario was intended to examine the impact of both dredging and operational changes at Coralville Reservoir. Historic stage-storage curves and their corresponding operational plans were used to characterize potential benefits. The results are shown in Figure 12.

All of the simulations in this scenario produced an identical peak discharge slightly larger than the observed peak. The release procedure in Schedule C of the operations for 1983, 1975 and 1964 are such that the pool levels oscillate around the major flood pool elevation. This is a result of prescribed releases in Schedule C of the 1964 and 1983 operations, which decrease the reservoir elevation slightly below the flood control pool when the Lone Tree constraint of 5,000 cfs becomes active. The flow is then limited by active downstream constraints, therefore, pool elevation rises above the major flood major flood pool once again, and so on.

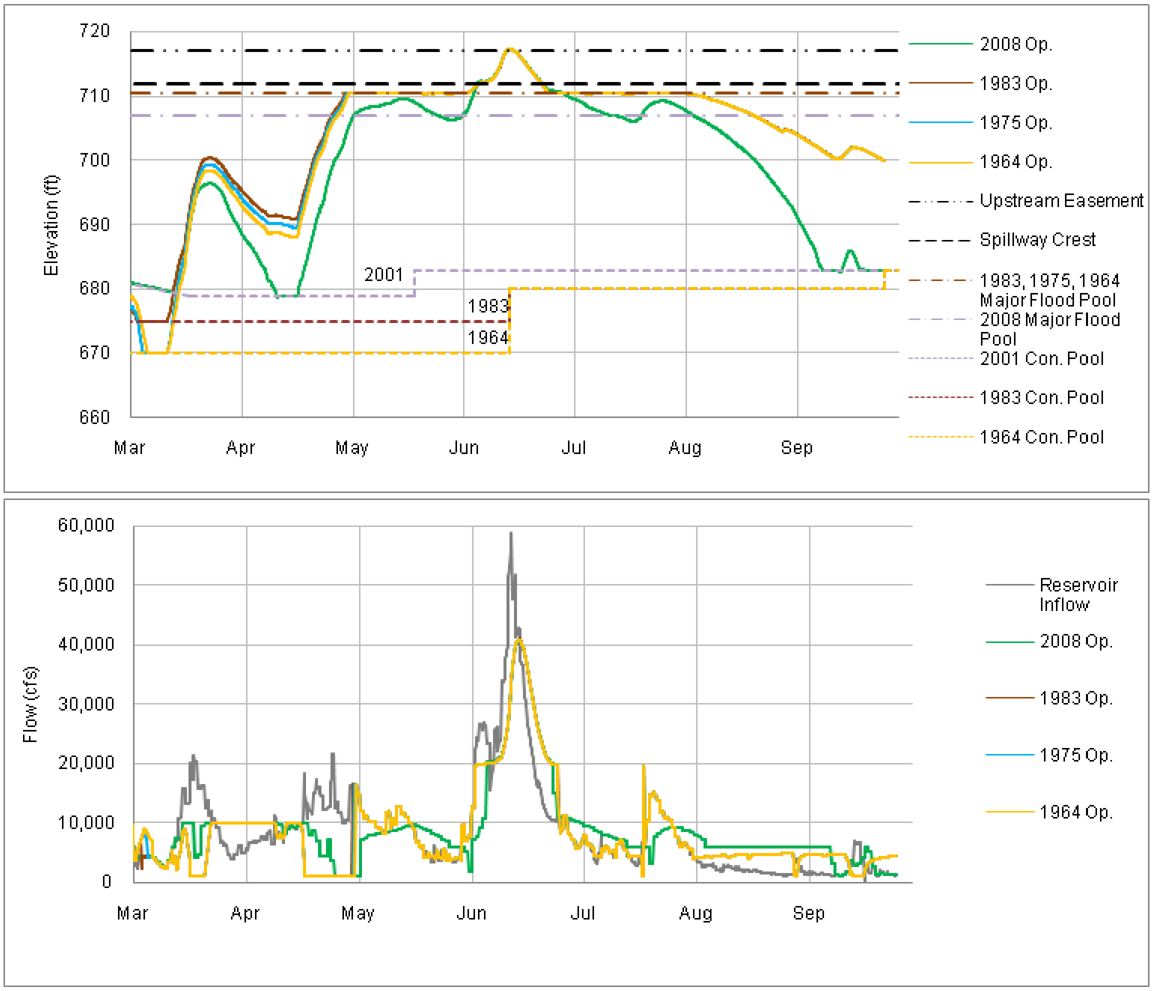


Figure 12. Simulation using 2008 flood event, varied historical operations, storage curves, and conservation pools.

2. 1993 Flood. This scenario was intended to examine the impact of both dredging and operational changes at Coralville Reservoir on the 1993 flood event. Historic stage-storage curves and their corresponding operational plans were used to characterize potential benefits. The results for this scenario, shown in Figure 13, also show the pool elevations oscillating at the major flood pool for the historic operations. There was no significant change in the peak discharge.

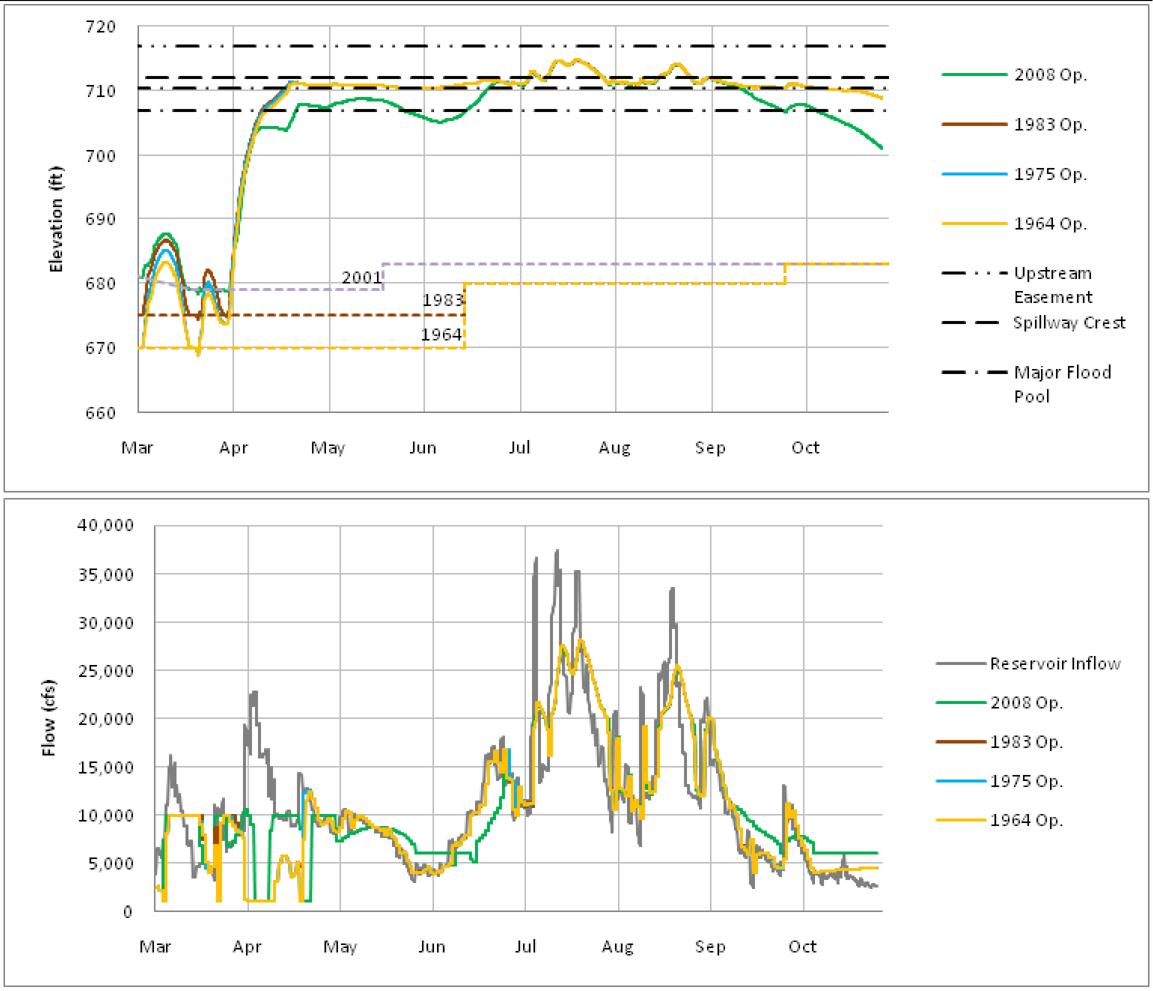


Figure 13. Simulation using 1993 flood event, varied historical operations, storage curves, and conservation pools.

D. Impact of Downstream Operational Constraints. A series of simulations were performed to evaluate the impact adherence to downstream constraints on reservoir releases had on the 2008 flood, and assess the potential benefits of modifying such constraints to improve major flood mitigation. Active downstream constraints during 2008 are shown in Figure 2. The constraints include the maximum summer release, and stage limitations at Lone Tree, Wapello, and Burlington. The river stage constraints for Lone Tree, Wapello, and Burlington can be seen in the current operations plan located in Appendix A.

1. Maximum summer releases. A proposal to increase the maximum summer release from 6,000 cfs to 8,000 cfs was rejected by the downstream communities in 2001, as documented in Appendix C. Simulation results in Figure 14 characterize changes in 2008 flood discharges associated with an increased maximum summer release of 8,000 cfs. There was no significant change in peak discharge.

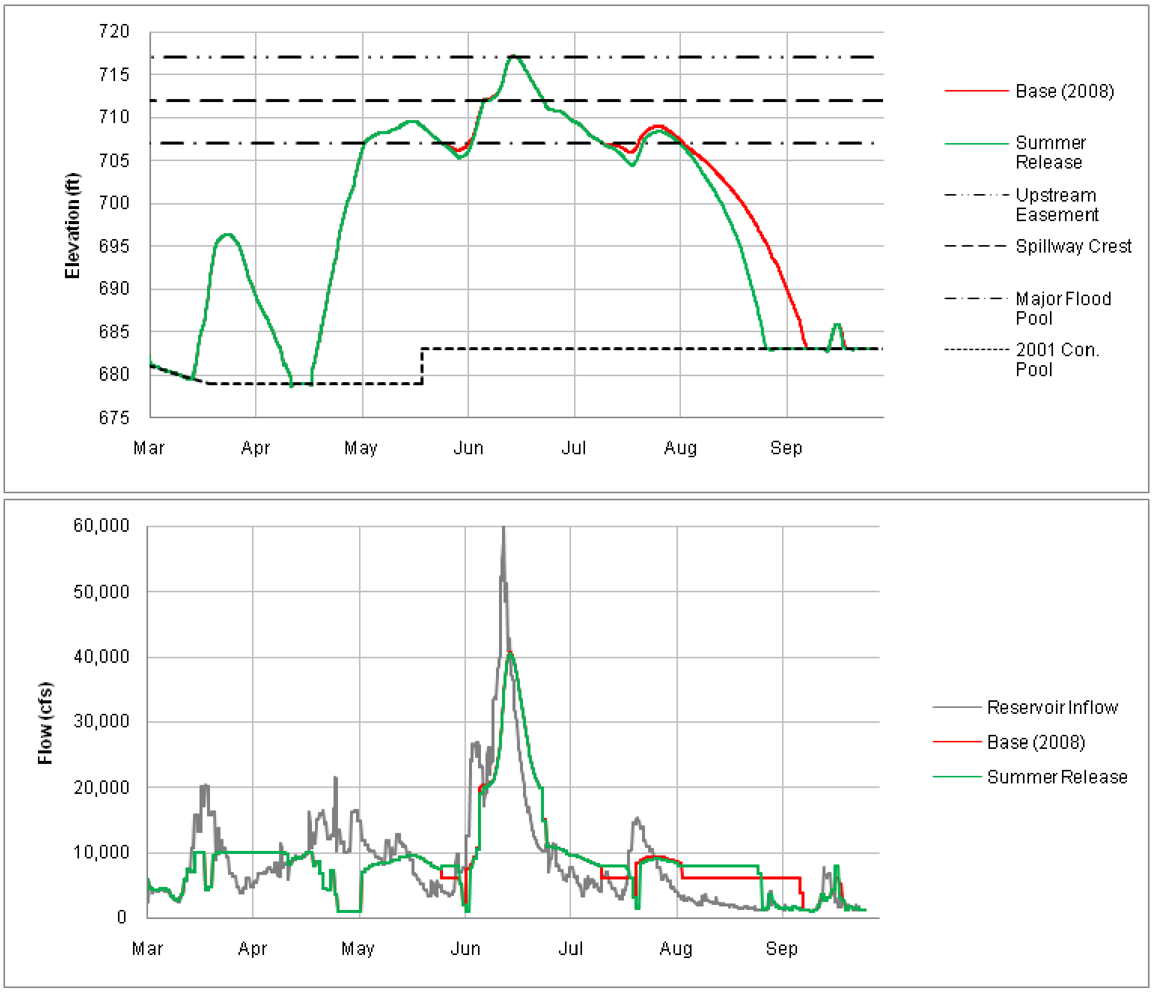


Figure 14. Simulation changing the maximum summer release from 6,000 cfs to 8,000 cfs.

2. Burlington, Iowa Mississippi river stage constraint. Simulation results in Figure 15 characterize changes in 2008 flood discharges associated with disregarding the Burlington Mississippi River stage constraint in the current operations plan. There was no significant change in peak discharge.

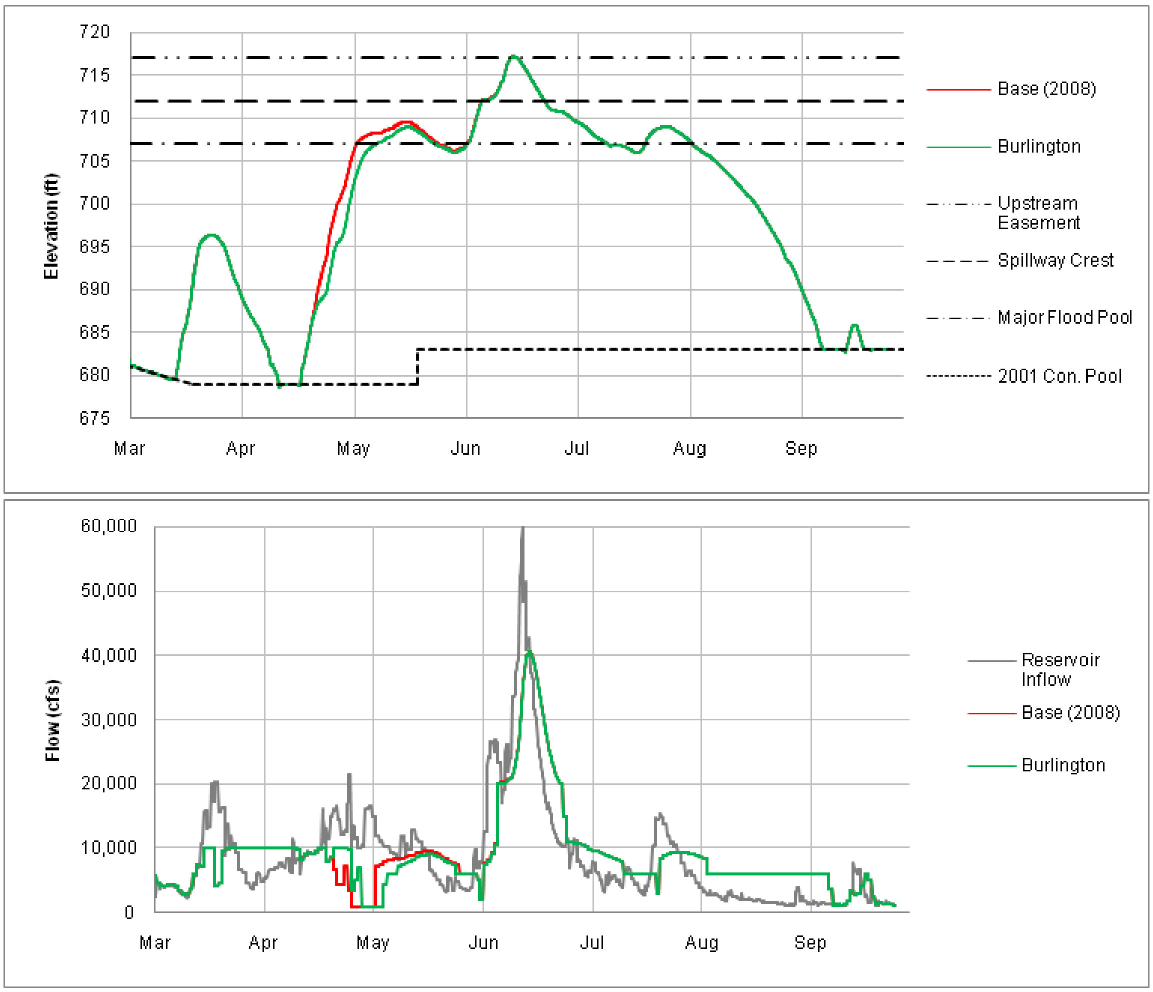


Figure 15. Simulation demonstrating disregarding of the Burlington river stage constraint.

3. Lone Tree, Iowa river stage constraint. Simulation results in Figure 16 characterize changes in 2008 flood discharges associated with disregarding the Lone Tree Iowa River stage constraint in the current operations plan. There was no significant change in peak discharge.

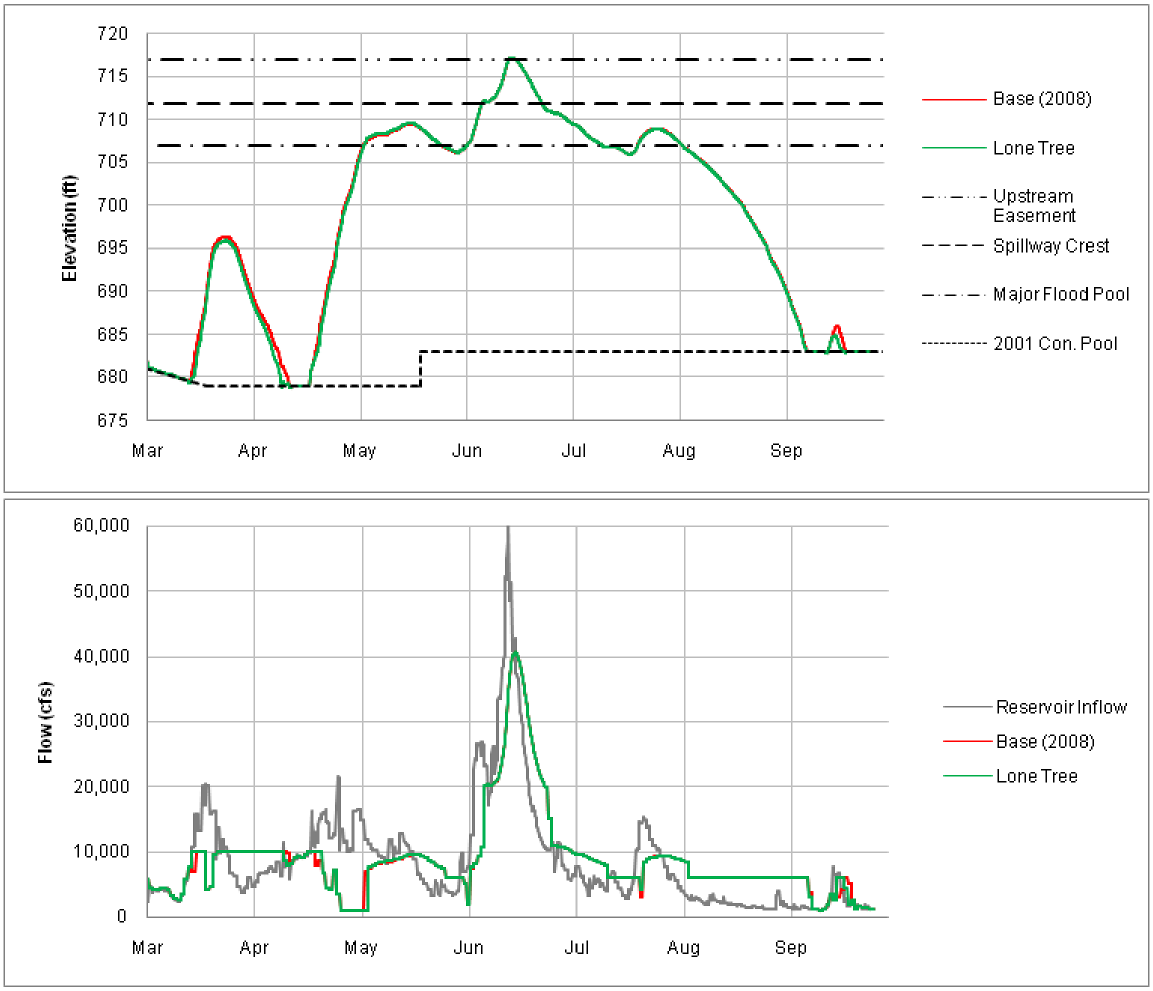


Figure 16. Simulation disregarding of the Lone Tree river stage constraint.

4. Wapello, Iowa river stage constraint. Simulation results in Figure 17 characterize changes in 2008 flood discharges associated with disregarding the Wapello Iowa River stage constraint in the current operations plan. There was no significant change in peak discharge.

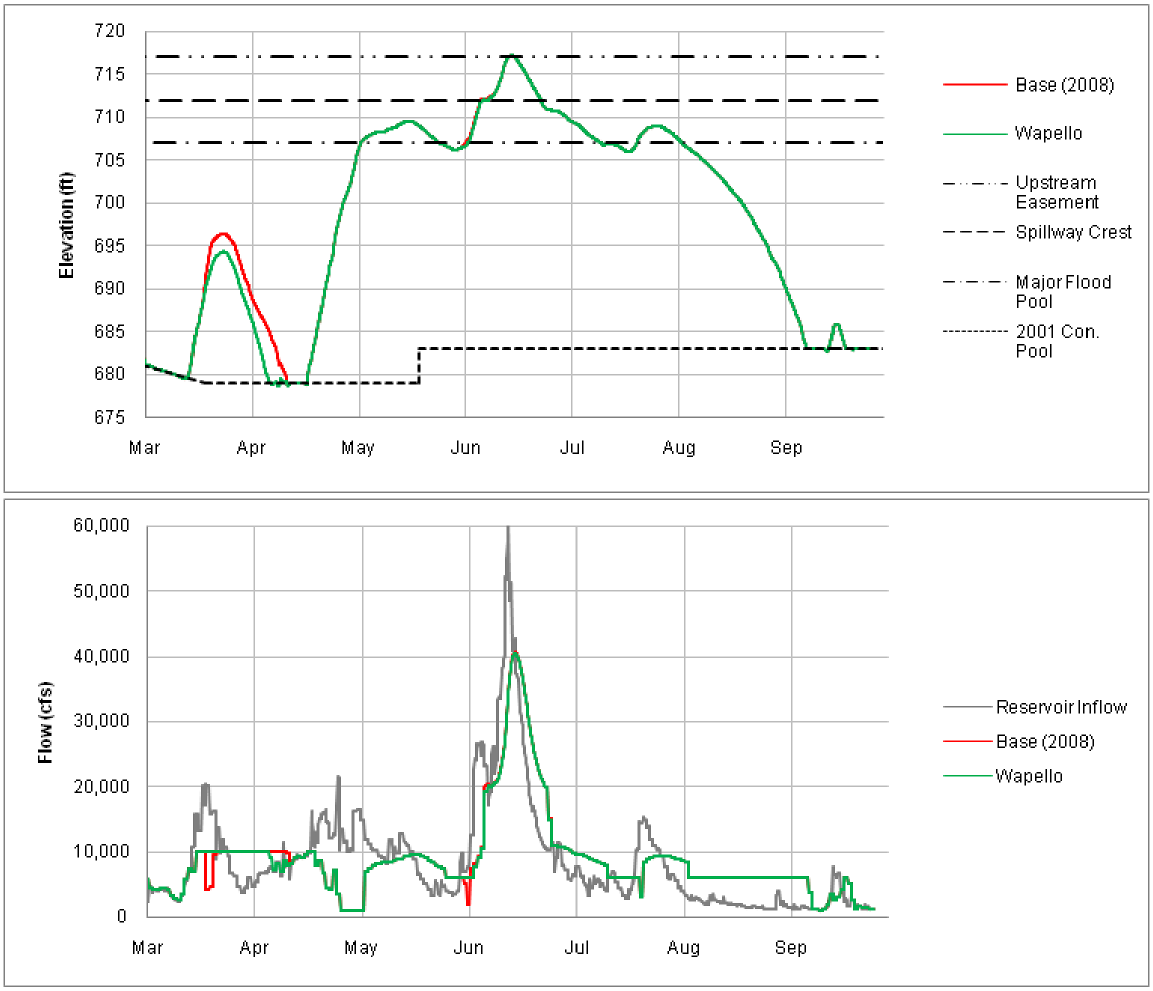


Figure 17. Simulation disregarding of the Wapello river stage constraint.

5. Cumulative impact of all downstream constraints. Simulation results shown in Figure 18 disregard all downstream constraints to preserve reservoir storage. Results indicate a decrease of 2,000 cfs in the 2008 peak discharge.. Relaxation of downstream constraints has potential to augment the reservoir's impact on major flood events, but at the cost of increasing the frequency of annual flood damages from smaller events.

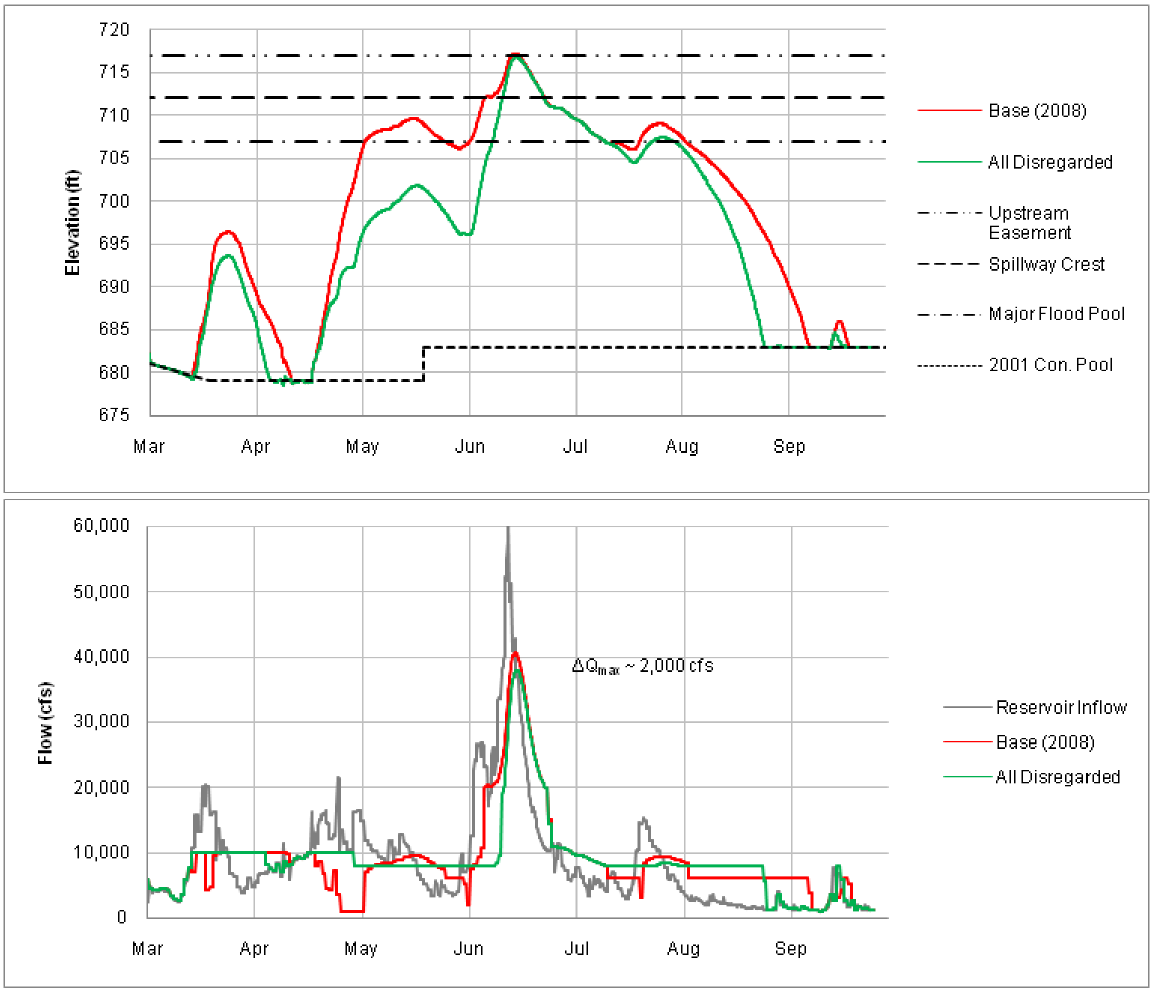
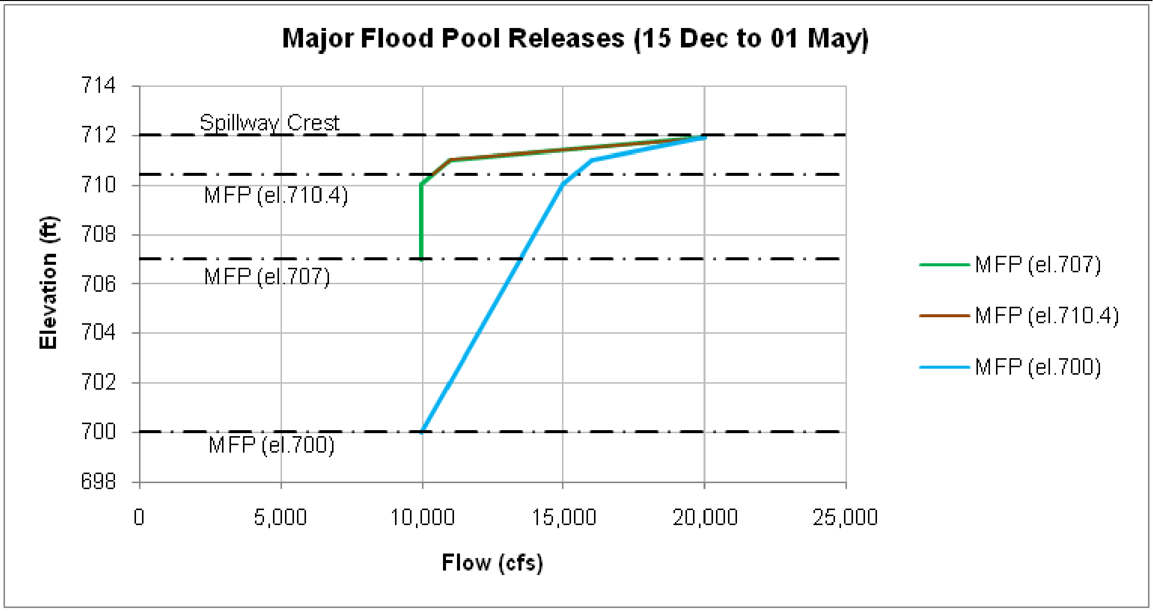


Figure 18. Simulation disregarding all downstream river stage constraints and increasing the maximum summer release from 6,000 cfs to 8,000 cfs.

E. Impact of Major Flood Pool Elevation.

1. 2008 Flood. This scenario investigated how the 2008 peak discharge is affected by changing the major flood pool elevation. Downstream constraints are currently disregarded when the reservoir pool reaches the major flood pool elevation of 707 ft. Alternate major flood pool elevations associated with both more aggressive and less aggressive reservoir operations were considered. The more aggressive trial used the major flood pool at el.700 ft; while the less aggressive trial used the major flood pool prior to 1991, el.710.4 ft. Changing the major flood pool elevation also required changing graduated releases in Schedule B of the current operations in Appendix A. These changes are shown in Figure 19.



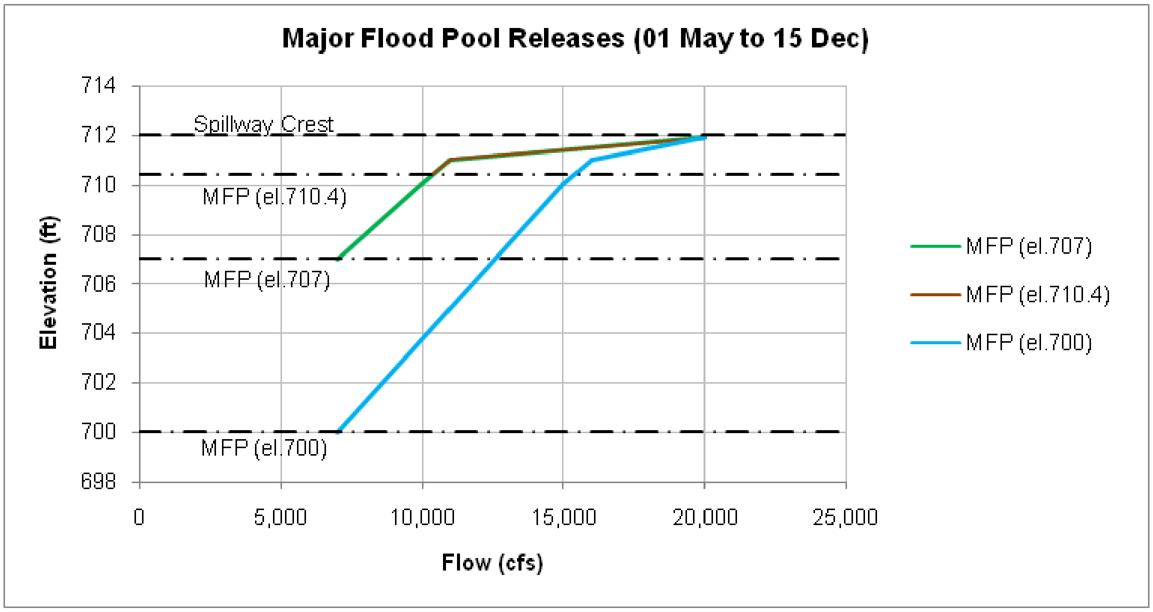


Figure 19. Prescribed releases for current and alternate Major Flood Pool elevations.

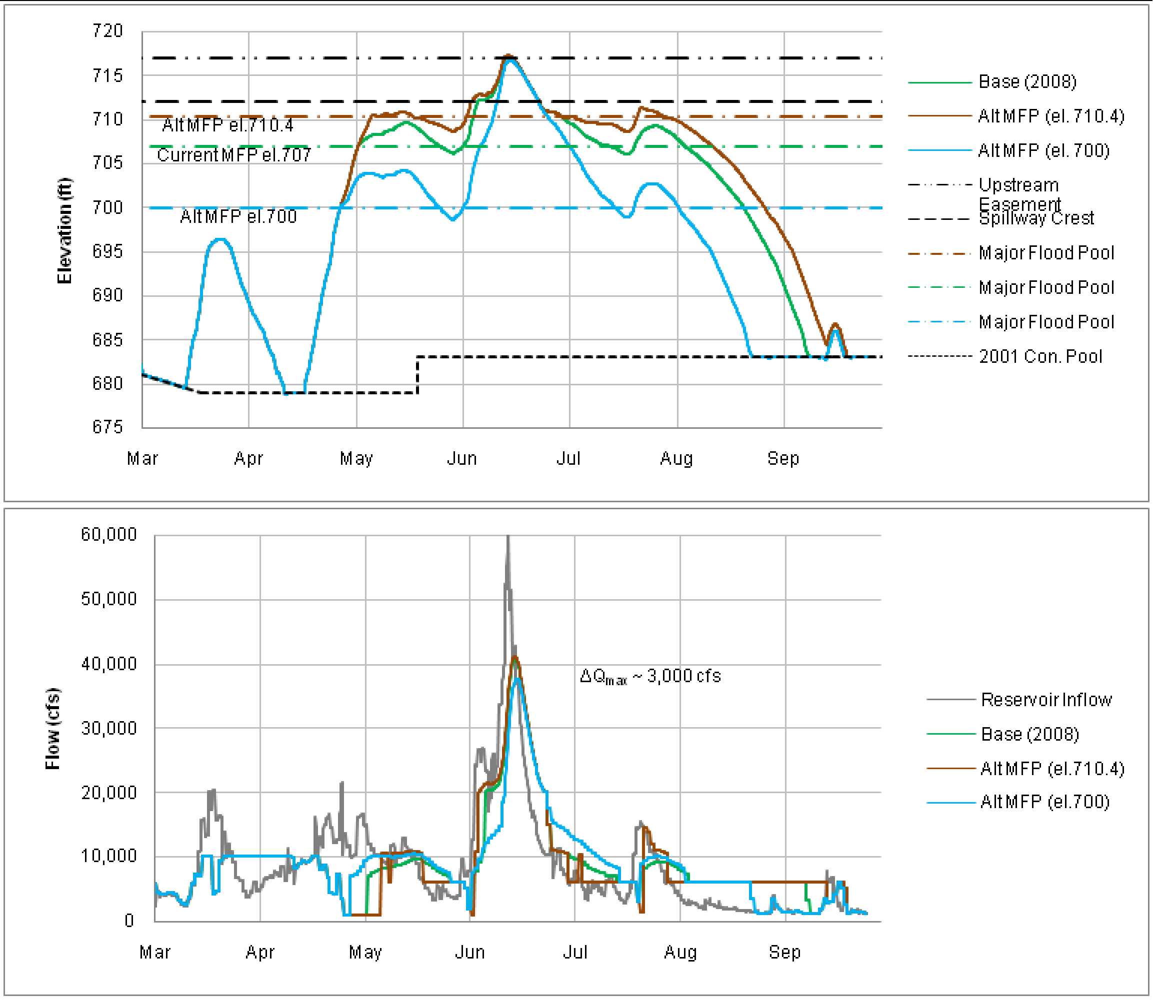


Figure 20. Simulation evaluating the effect of changing the Major Flood Pool elevation using the 2008 event.

Simulation results are shown in Figure 20. Raising the major flood pool elevation had no effect on the peak discharge. The change resulted in additional flooding from a 15,000 cfs release following the small hydrologic event in late July. Lowering the major flood pool elevation from el.707 to el.700 and using the prescribed releases in Figure 20, decreased the peak discharge by approximately 3,000 cfs

2. 1993 Flood. This scenario used the 1993 event, the prescribed releases in Figure 19, and the current operations. The results in Figure 21 show there was decrease in the minor peaks as a result of changing the major flood pool from el. 707 to el. 700. With a lower major flood pool, active constraints were ignored in late April and more storage was available in July. However, there was no significant decrease in peak discharge in late July.

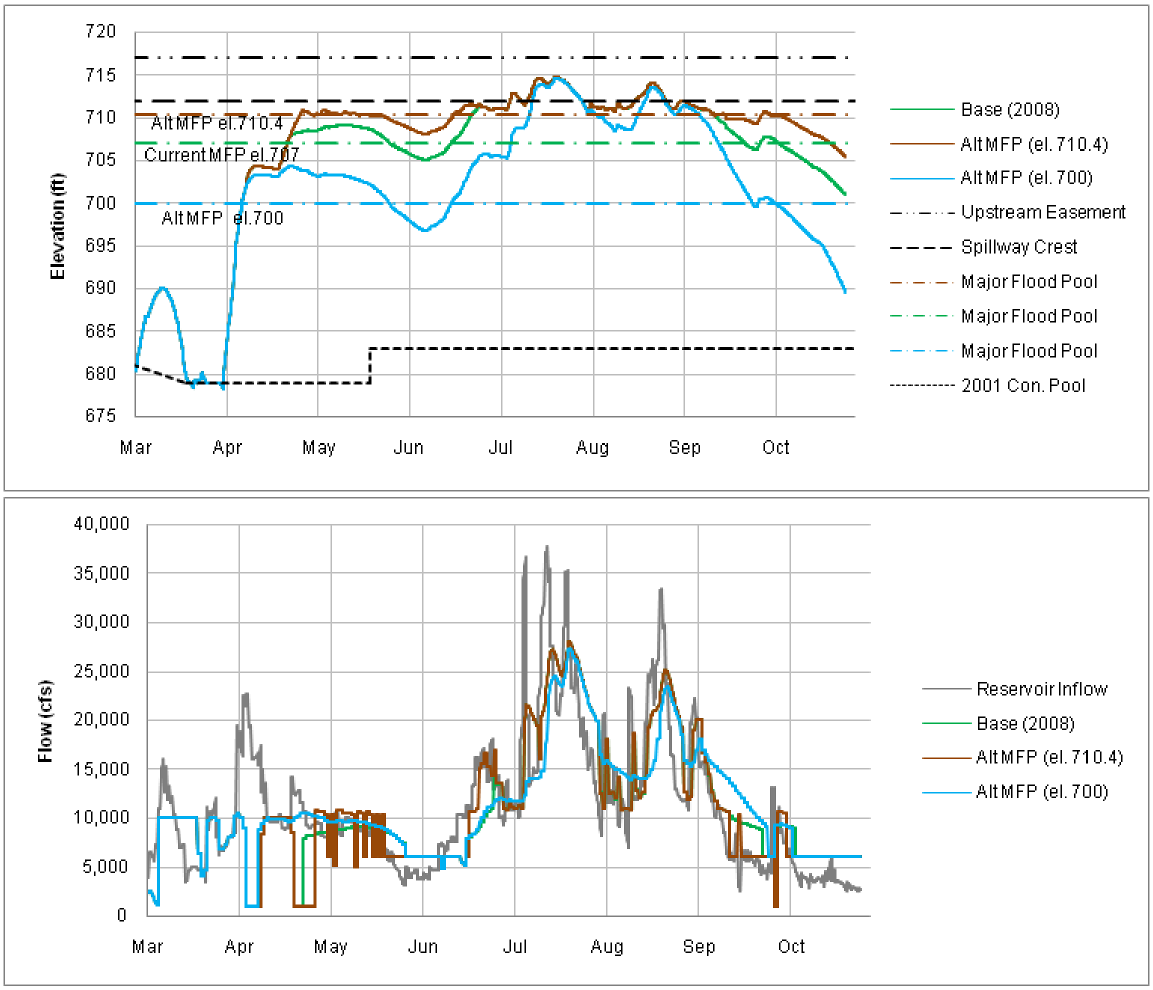


Figure 21. Simulation evaluating the effect of changing the Major Flood Pool elevation using the 1993 event.

F. Predicted Impact of Future Sedimentation.

1. Predicted sedimentation. A series of simulations were performed to evaluate possible future reservoir geometries resulting from continued sedimentation. Predicting future sedimentation is challenging due to its event-driven nature. This is evident in comparing USACE surveys from 1983 and 1999, shown in Figure 22. Approximately 40,000 ac-ft of sediment accumulated in the reservoir from 1983 to 1999. Approximately half of this sedimentation occurred below el. 685 ft, while the other half occurred above el. 690 ft. The distribution of sediment that was deposited above el. 690 ft did not follow the trend from the previous surveys. Historically, the majority of sedimentation occurred in the lowest elevations of the reservoir. The 1993 Flood was likely a major contributor to the quantity and distribution of sedimentation that occurred during this period.

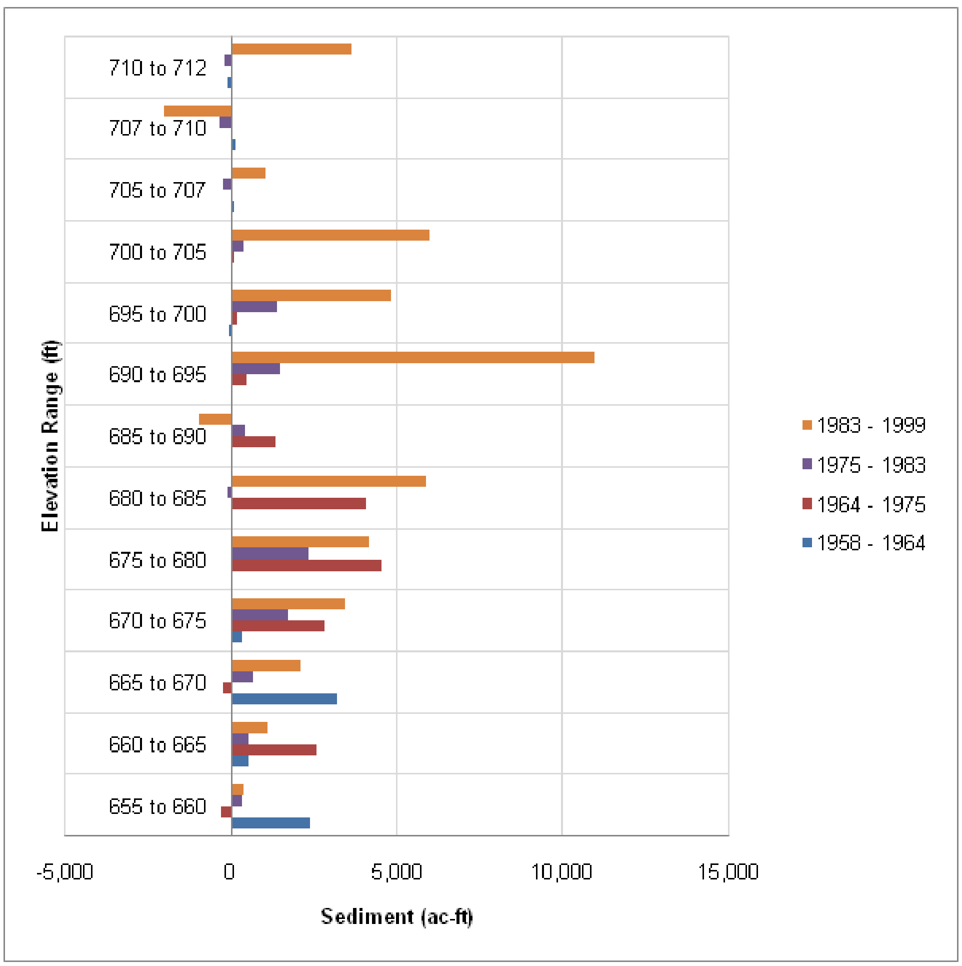


Figure 22. Depiction of the sedimentation in different elevation ranges during periods between reservoir surveys.

Future sedimentation was estimated using the historic elevation-storage curves. High levels of uncertainty associated with sedimentation estimates must be considered when interpreting simulation results. The most significant source of uncertainty is the lack of available survey data following the 2008 Flood. As with the 1993 event, the 2008 Flood likely deposited a large volume of sediment over broad range of elevations.

Linear extrapolation of trends from historic elevation-storage curves was used to estimate future sedimentation. Figure 23 shows the data points used to establish a linear regression based on total sediment below el. 720. The 1999 elevation storage curve was translated to match the total volume of sediment predicted by the regression analysis. The results are shown in Figure 24.

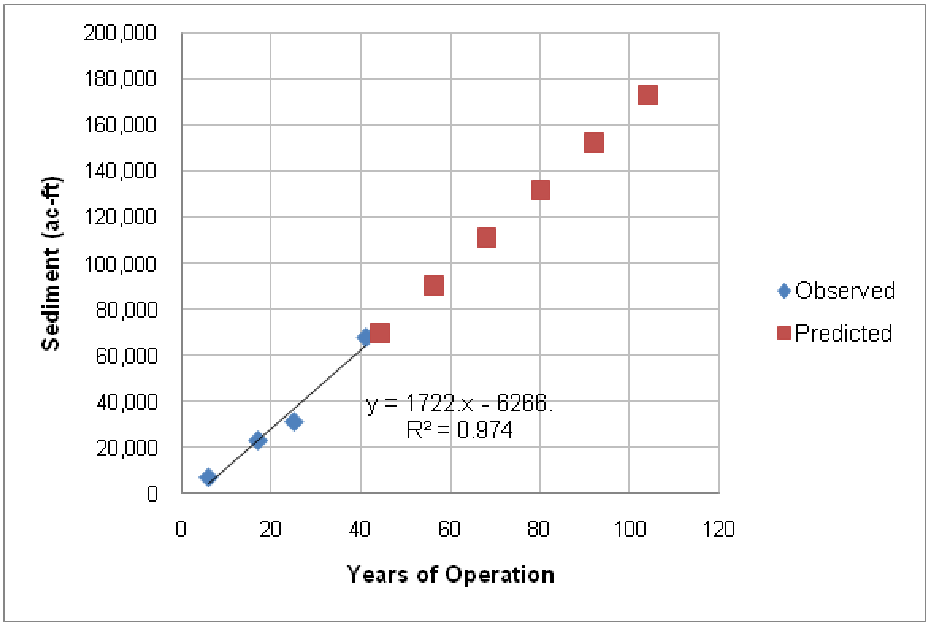


Figure 23. Linear Regression of total sediment below el.720 through years of operation.

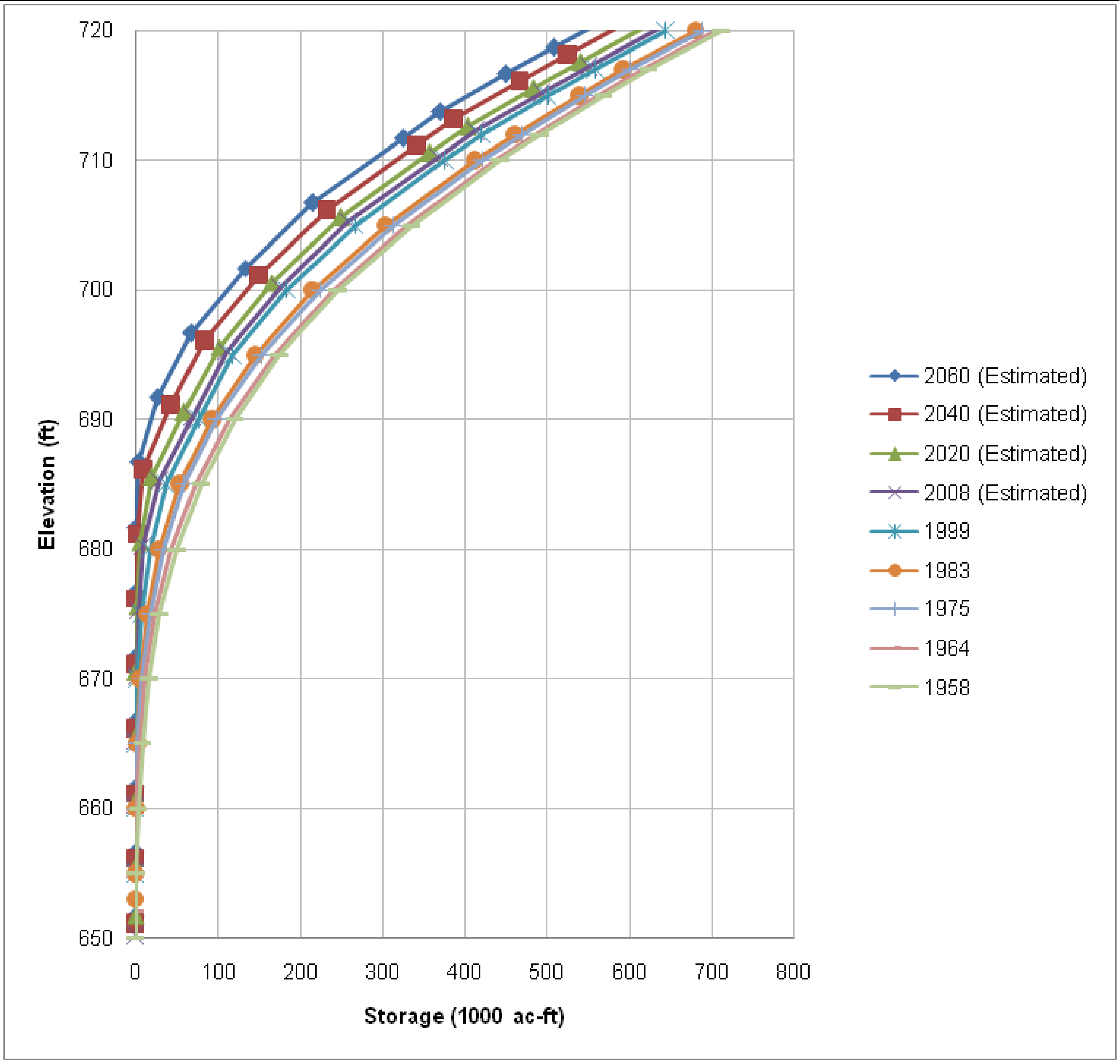


Figure 24. Forecasted elevation storage relationships obtained by using a linear regression of total storage lost below el. 720, and shifting the 1999 storage curve.

2. 2008 Flood. This scenario is intended to evaluate impact of possible future reservoir geometries on flood events similar to the 2008 Flood. The simulation used the predicted elevation-storage curves from Figure 24 and the 1999 survey. The operations were assumed to remain unchanged, while the conservation pools were raised to el. 685 for 2020, el. 687.5 for 2040, and el. 690 for 2060 to accommodate wildlife habitat and recreation. The results for this scenario are shown in Figure 25. There is essentially no change in the peak discharge. For all scenarios considered, the reservoir enters the major flood pool in late April and early May, and the downstream constraints are then disregarded. The additional sedimentation is shown to have some effect on how long downstream constraints can be observed.

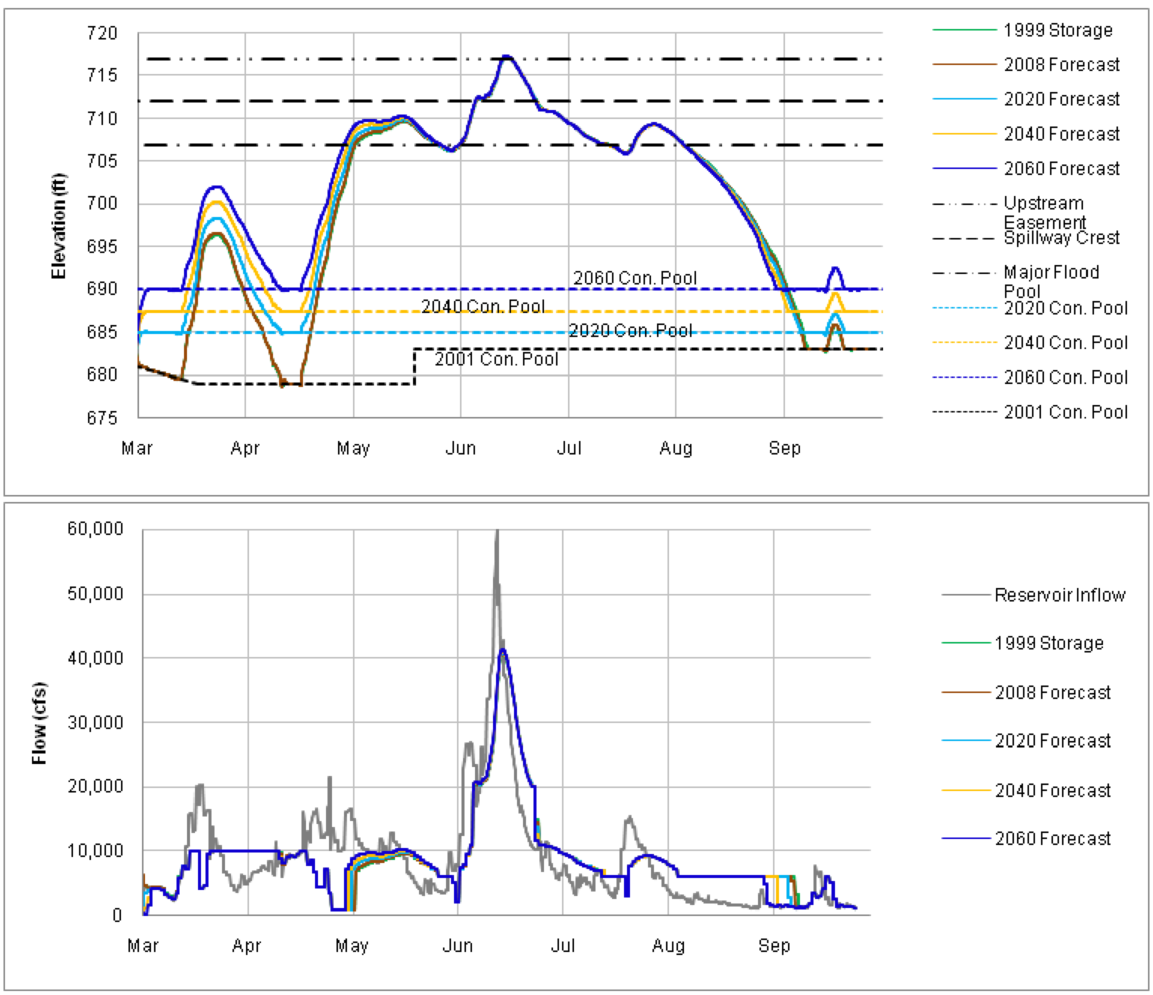


Figure 25. Simulation evaluating the effect of predicted sedimentation using the 2008 event.

3. 1993 Flood. This scenario evaluated the impact of sedimentation on events similar the 1993 Flood. The operations were assumed to remain unchanged, while the conservation pool was raised to el. 685 for 2020, el. 687.5 for 2040, and el. 690 for 2060 to accommodate wildlife habitat and recreation. The results for this scenario are shown in Figure 26. There is essentially no change in the peak discharge. The different pool elevation curves begin entering the major flood pool throughout April. Similar to 2008 event results, sedimentation affects how long downstream constraints are observed.

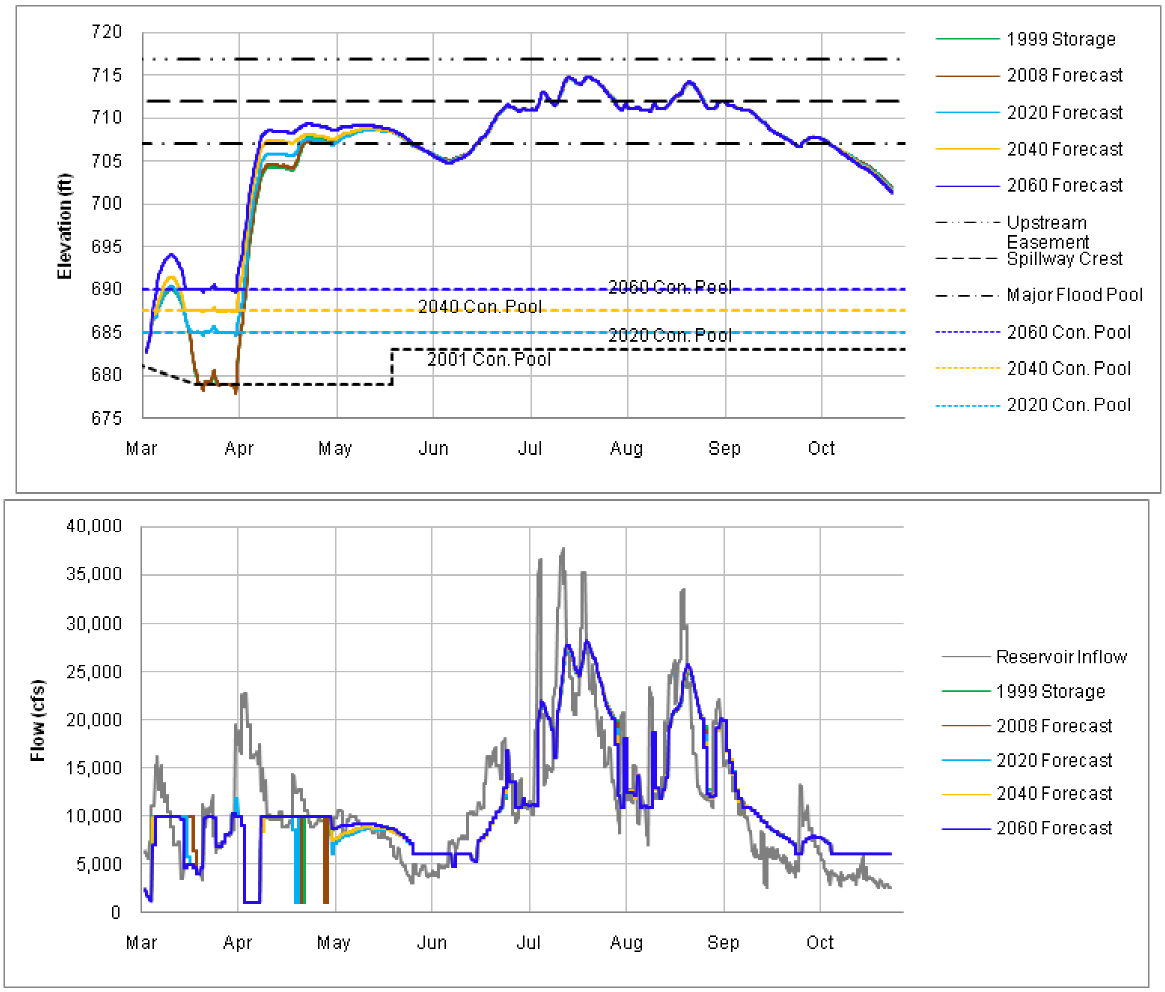


Figure 26. Simulation evaluating the effect of predicted sedimentation using the 1993 event.

VI. CONCLUSIONS

The volume of storage lost to sedimentation in Coralville Reservoir is small compared to the storage available. Additionally, the majority of the sedimentation has occurred below the current conservation pool, having little effect on the capacity of the reservoir to attenuate floods. Utilization of any storage recovered by dredging would require lowering of the current conservation pool, which may negatively impact recreation and wildlife habitat.

Dredging would provide limited additional flood protection against major floods similar to 2008. The large volume of water associated with such events rapidly consumes additional storage gained from dredging. Both of the 1993 and 2008 events had exceptionally wet springs that used storage prior to the most severe events. Dredging may have a greater impact on smaller, more frequent flood events, however additional analyses would be necessary to quantify such benefits and determine whether such measures would be economically justified.

Future sedimentation will have no effect on peak discharges of events like 1993 and 2008 based on the predicted sedimentation. The additional sediment will affect the duration that downstream constraints are observed in order to prevent minor floods. Future sedimentation will also adversely affect the ability to augment flow during dry periods. A more recent survey would provide further information to predict sedimentation and evaluate impacts on low flow augmentation.

The most effective method for managing a large flooding event is to maximize available storage preceding its occurrence. Using a more aggressive operations plan would increase available storage should a large event occur. However, benefits demonstrated in the analyses described above are not substantial. Furthermore, aggressive operations would frequently flood downstream communities, in most cases unnecessarily. A flood frequency and economic assessment would provide information necessary to determine whether aggressive operational practices may have an overall benefit to stakeholders downstream of Coralville Reservoir.

APPENDIX A:
Current Coralville Reservoir Operations Plan

TABLE C-2
Coralville Lake
Regulation Schedule

Schedule A **Normal Flood Control Operation** **Pool elevation at or forecast between 683 and 707**	Conservation pool Schedule Date / Operation 15 Feb - 20 Mar: 683 to 679^ 20 Mar - 20 May: Hold 679^ 20 May - 15 Sep: Hold 683 15 Sep - 15 Dec: Hold 683-686* 15 Dec - 15 Feb: Hold 683 Notes: ^ *Variable draw down based on snow cover, ice, and 30 day climatic conditions coordinated with IDNR* ** Dates and elevation of fall pool raise coordinated with the IDNR*

Condition	Operation
A-1 All Dates	Regulated pool level as nearly as possible without adversely affecting downstream conditions. Do not release less than minimum outflow of 150 cfs
A – 2 15 December through 1 May	Maintain conservation pool according to schedule without exceeding release of 10,000 cfs except as limited by conditions A-3, A-6 or A7
A-3 15 December through 1 May Stage at above or forecast to exceed…. Lone Tree 16.0 feet Wapello 22.0 feet	Reduce release to not less than 1,000 cfs to control flow to those discharges as near as possible during three days of crest at the respected station with due allowance to travel times.
A-4 1 May through 15 December	Maintain conservation pool according to schedule without exceeding release of 6,000 cfs except as limited by conditions A-5, A-6 or A7
A-5 1 May through 15 December Stage at above or forecast to exceed…. Lone Tree 14.0 feet Wapello 21.0 feet	Reduce release to not less than 1,000 cfs to control flow to those discharges as near as possible during three days of crest at the respected station with due allowance to travel times.
A-6 All Dates Stage at above or forecast to exceed… Mississippi River at Burlington - 18.0	Reduce release to not less than 1,000 cfs during seven days corresponding to the crest flow on the Mississippi River with due allowance for travel time.
A-7 Flash Flood: Any date flow at above or forecast to exceed 16,000 cfs at Iowa City	Reduce release to not less than 1,000 cfs to keep flow at or below 16,000 cfs at Iowa City

Schedule B **Major Flood** **Pool Elevation at above or forecast to exceed 707 feet NGVD**	

Condition	Operation
B-1 Inflow has not Peaked	Determine the pool elevation that would occur at the peak of the inflow hydrograph. Release not more than allowed on table below:

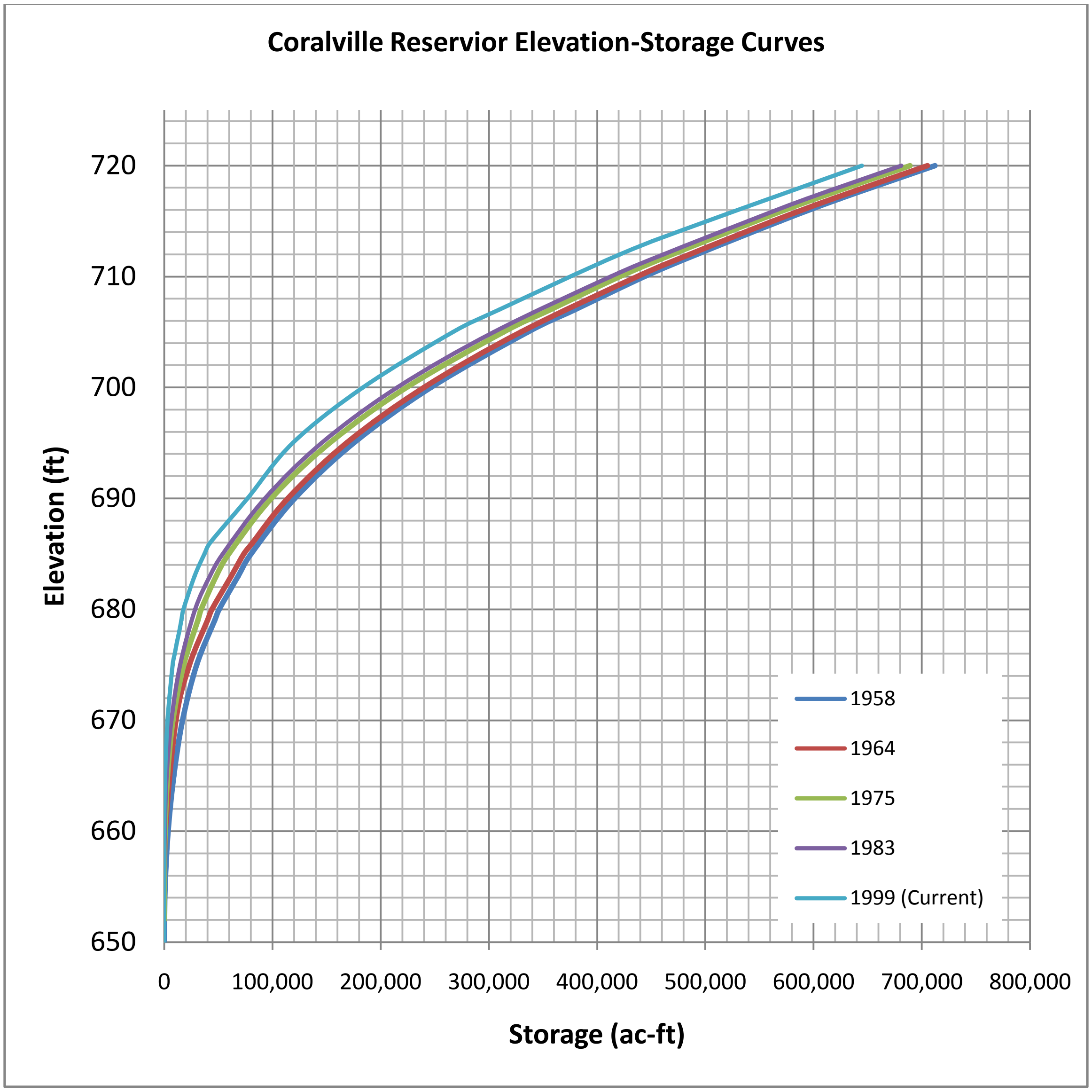
15 Dec – 1 May Elev.	15 Dec – 1 May Outflow	1 May – 15 Dec Elev.	1 May – 15 Dec Outflow
707	10000	707	7000
708	10000	708	8000
709	10000	709	9000
710	10000	710	10000
711	11000	711	11000
711.1	12000	711.1	12000
711.2	13000	711.2	13000
711.3	14000	711.3	14000
711.4	15000	711.4	15000
711.5	16000	711.5	16000
711.6	17000	711.6	17000
711.7	18000	711.7	18000
711.8	19000	711.8	19000
711.9	20000	711.9	20000

712.0 and above - Gates Fully open

Condition	Operation
B-2 Inflow has Peaked	Determine the minimum outflow required to utilize the remaining storage below 712.0. Release that flow or the present outflow – whichever is higher.
B-3 Reservoir Pool Falling	Release outflow established by B-2 until elevation 707 is reached then gradually reduce flows to Schedule A
B-4 Emergency: flow forecast to exceed the control flow established by the U.S. Army Corps of Engineers for public exigency downstream	Reduce release to keep flow at or below the control flow established by the "Corps".

Schedule C **Drought -- All Dates** **Any time pool below conservation according to Schedule A and inflow not sufficient to get to conservation pool.**	
C-1 Pool between Conservation and 678.0	Release 150 cfs
C-2 Pool between 677.0 and 678.0	Reduce release to 100 cfs
C-3 Pool below 677.0	Reduce release to 75 cfs

APPENDIX B:
Historic Coralville Reservoir Elevation-Storage Curves


Coralville Reservior Elevation-Storage Curves
Elevation (ft)
720
710
700
690
680
670
660
650
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
800,000
Storage (ac-ft)
1958
1964
1975
1983
1999 (Current)

APPENDIX C:
Coralville Reservoir Regulation History

Coralville Regulation History

December 1939: Project Submitted to Chief of Engineers
Top of Flood Pool 708 feet (400,000 acre-feet storage)

January 1940: State of Iowa objected to plan based on conservation practices

September 1948: Revised Corps' Plan
Top of Flood Pool 712 feet (492,000 acre-feet storage)
Conservation pool 670 feet

September 1958: Plan at implementation
Conservation pool - normal 680 feet
Spring 670 feet
Winter release 10,000 cfs
Summer release 8,500 cfs

Farmers complain about high summer time releases

1961 Interim Plan
Summer releases varied between 5,000 cfs and 6,500 cfs

1963 new plan
Summer releases varied between 4,000 cfs and 6,000 cfs
Major flood release at pool elevation 710.4 feet
Conservation pools: Spring 670 feet, Normal 680 feet, Fall 683 feet

1983 Spring Conservation pool raised to 675 feet
From complaints about mudflats and fish habitat

New Regulation plan 1991
Conservation pool: Spring 679 feet, Normal 683 feet, Fall 686 feet
Summer release 6,000 cfs, Winter release 10,000 cfs
Major Flood Pool at 707 feet

January 2001: New Regulation Manual
Proposed summer release rate to 8,000 cfs -
Coralville, Iowa City, and UofI objected
Down-stream farmers objected
Only regulation change - spring draw down variable

APPENDIX D:
1983 Coralville Reservoir Operations

1982

PLAN 8

CORALVILLE RESERVOIR REGULATION SCHEDULE

Approved by Office, Chief of Engineers 21 January 1964

Regulation Schedule	Condition	Operation
A. Conservation Storage	I. Normal	Regulate pool level in accordance with Fig (c) of Plate 2 as nearly as possible without adversely affecting downstream conditions as follows:

DATE	OPERATION
1 Feb-15 Feb	Lower from 680 to [illegible] 675
15 Feb-15 Jun	Hold elev [illegible] 675
15 Jun-25 Sep	Hold 680
25 Sep-15 Dec	Hold 683
15 Dec- 1 Feb	Hold 680

Do not release less than a minimum outflow of 150 cfs, nor exceed releases specified in Schedules B and C.

Regulation Schedule	Condition	Operation
B. Flood Control	I. 15 December to 21 April	Maintain pool levels specified under Schedule A as nearly as possible without exceeding release of 10,000 cfs except as limited by Conditions B.IV, B.VII, and Schedule C.
	II. 21 April to 1 May Reservoir at or Above Conservation Elevation	Release 6,000 cfs to 10,000 cfs as indicated by Fig (a) of Plate 2 depending on amount of flood control storage occupied on 21 April except as limited by Conditions A.I, B.V, B.VII, and Schedule C.
	III. 1 May to 15 December Reservoir Above Conservation Elevation	Release 4,000 cfs to 6,000 cfs as indicated by Fig (b) of Plate 2 depending on amount of flood storage occupied on 1 May until reservoir recedes to conservation level, after which it shall be held at that level insofar as possible without exceeding release determined on basis of 1 May reservoir elevation or 5,000 cfs whichever is smaller, except as limited by Conditions B.VI, B.VII, and Schedule C.
	IV. 15 December thru 21 April Discharge at Lone Tree or Wapello are above, or forecast to exceed 15,000 cfs or 35,000, respectively	Reduce release to not less than 1,000 cfs to control flow to those discharges at respective stations insofar as possible during 3 days of crest at respective station, except as limited by Schedule C.
	V. 21 April to 1 May discharge at Lone Tree or Wapello above or forecast to exceed 5,000 cfs or 26,000 cfs respectively plus release in Condition B.II.	Same as Operation for Condition B.IV.
	VI. 1 May to 15 December discharge at Lone Tree or Wapello above or forecast to exceed 5,000 cfs or 26,000 cfs respectively plus release in Condition B.III	Same as Operation for Condition B.IV.
	VII. Any date, stage at, above or forecast to exceed 17.5 feet on Mississippi River gage at Muscatine, Iowa	Reduce release to 1,000 cfs during several days corresponding to crest flow in the Mississippi River with due allowance for time of travel, except as limited by Schedule C.
C. Major Flood Emergency	I. Any date reservoir elevation is rising and above or forecast to exceed elevation 710.4 feet	When predictions indicate that anticipated runoff from a storm will appreciably exceed the storage capacity remaining in the reservoir when operated under Schedule B, increase in outflow rates will be made as necessary to prevent reservoir from exceeding elevation 712.0 on basis of those predictions, but not less than given in the following schedule:

Pool Elev	Outflow cfs	Pool Elev	Outflow cfs
710.4	4,000	711.3	13,000
710.5	5,000	711.4	14,000
710.6	6,000	711.5	15,000
710.7	7,000	711.6	16,000
710.8	8,000	711.7	17,000
710.9	9,000	711.8	18,000
711.0	10,000	711.9	19,000
711.1	11,000	712.0	20,000
711.2	12,000		

Plate 1

APPENDIX E:
1964 Coralville Reservoir Operations

BASE PLAN 1
CORALVILLE RESERVOIR REGULATION SCHEDULE

PLAN 8 : Approved by OCE 21 January 1964

Regulation Schedule	Condition	Operation
A. Conservation Storage	I. Normal	Regulate pool level in accordance with Fig (c) of Plate 2 as nearly as possible without adversely affecting downstream conditions as follows: DATE — OPERATION 1 Feb-15 Feb — Lower from 680 to 670 15 Feb-15 Jun — Hold elev 670 15 Jun-25 Sep — Hold 680 25 Sep-15 Dec — Hold 683 15 Dec-1 Feb — Hold 680 Do not release less than a minimum outflow of 150 cfs nor exceed releases specified in Schedules B and C.
B. Flood Control	I. 15 December to 21 April	Maintain pool levels specified under Schedule A as nearly as possible without exceeding release of 10,000 cfs except as limited by Conditions B.IV, B.VII, and Schedule C.
	II. 21 April to 1 May Reservoir at or Above Conservation Elevation	Release 6,000 cfs to 10,000 cfs as indicated by Fig (a) of Plate 2 depending on amount of flood control storage occupied on 21 April except as limited by Conditions A.I, B.V, B.VII, and Schedule C.
	III. 1 May to 15 December Reservoir Above Conservation Elevation	Release 4,000 cfs to 6,000 cfs as indicated by Fig (b) of Plate 2 depending on amount of flood storage occupied on 1 May until reservoir recedes to conservation level, after which it shall be held at that level insofar as possible without exceeding release determined on basis of 1 May reservoir elevation or 5,000 cfs whichever is smaller, except as limited by Conditions B.VI, B.VII, and Schedule C.
	IV. 15 December thru 21 April Discharge at Lone Tree or Wapello are above, or forecast to exceed 15,000 cfs or 35,000, respectively	Reduce release to not less than 1,000 cfs to control flow to those discharges at respective stations insofar as possible during 3 days of crest at respective station, except as limited by Schedule C.
	V. 21 April to 1 May discharge at Lone Tree or Wapello above or forecast to exceed 5,000 cfs or 26,000 cfs respectively plus release in Condition B.II	Same as Operation for Condition B.IV.
	VI. 1 May to 15 December discharge at Lone Tree or Wapello above or forecast to exceed 5,000 cfs or 26,000 cfs respectively plus release in Condition B.III	Same as Operation for Condition B.IV.

	VII. Any date, stage at above or forecast to exceed 17.5 feet on Mississippi River gage at Muscatine, Iowa	Reduce release to 1,000 cfs during several days corresponding to crest flow in the Mississippi River with due allowance for time of travel, except as limited by Schedule C.
C. Major Flood Emergency	I. Any date reservoir elevation is rising and above or forecast to exceed elevation 710.4 feet	When predictions indicate that anticipated runoff from a storm will appreciably exceed the storage capacity remaining in the reservoir when operated under Schedule B, increase in outflow rates will be made as necessary to prevent reservoir from exceeding elevation 712.0 on basis of those predictions, but not less than given in the following schedule.

Pool Elev	Outflow cfs	Pool Elev	Outflow cfs
710.4	4,000	711.3	13,000
710.5	5,000	711.4	14,000
710.6	6,000	711.5	15,000
710.7	7,000	711.6	16,000
710.8	8,000	711.7	17,000
710.9	9,000	711.8	18,000
711.0	10,000	711.9	19,000
711.1	11,000	712.0	20,000
711.2	12,000		

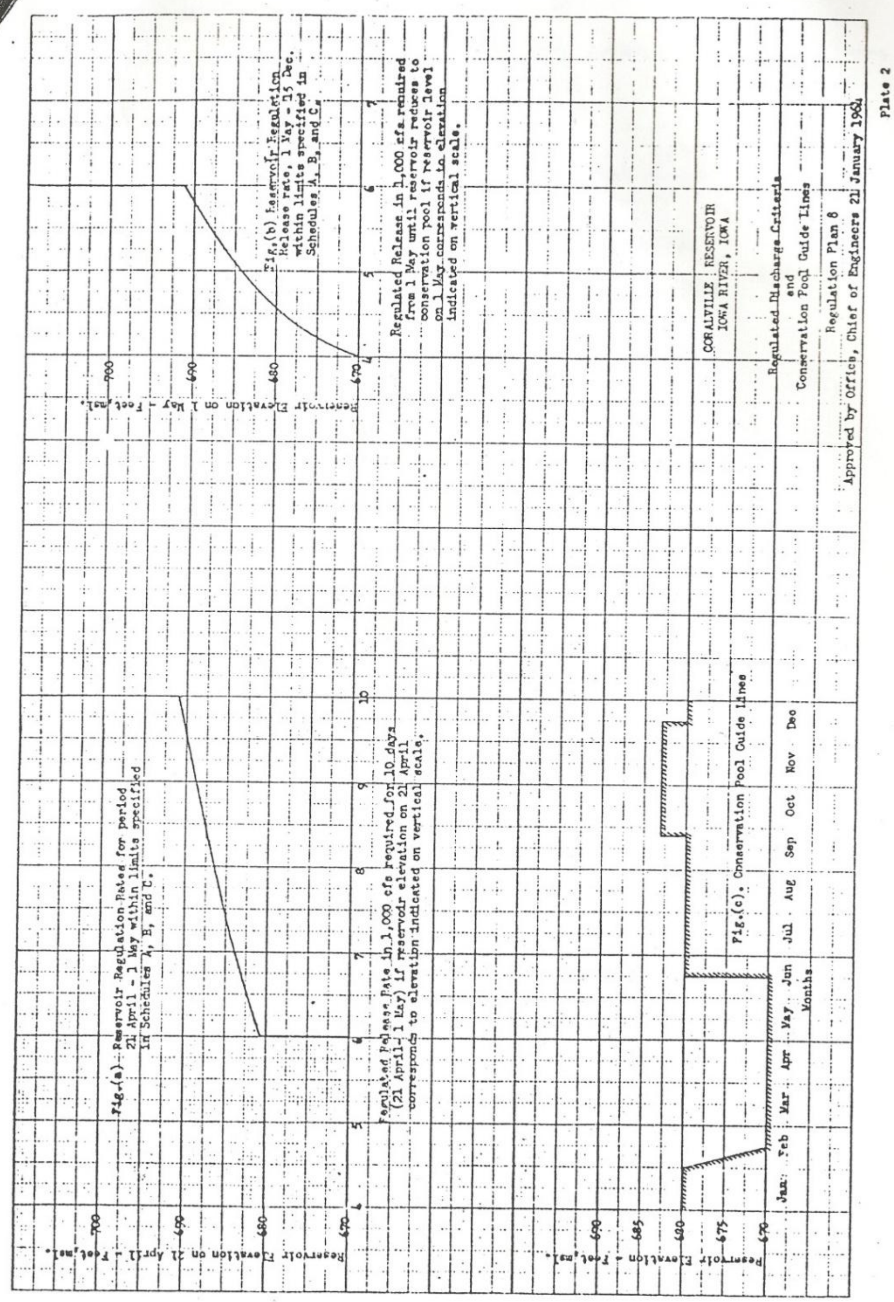


Fig.(a). Reservoir Regulation Rates for period 21 April - 1 May within limits specified in Schedules A, B, and C.
Reservoir Elevation on 21 April - Feet, msl.
700
690
680
670
4
5
6
7
8
9
10
Regulated Release Rate in 1,000 cfs required for 10 days (21 April - 1 May) if reservoir elevation on 21 April corresponds to elevation indicated on vertical scale.
Fig.(b) Reservoir Regulation Release rate, 1 May - 15 Dec. within limits specified in Schedules A, B, and C.
Reservoir Elevation on 1 May - Feet, msl.
Regulated Release in 1,000 cfs required from 1 May until reservoir reduces to conservation pool if reservoir level on 1 May corresponds to elevation indicated on vertical scale.
Reservoir Elevation - Feet, msl.
690
685
680
675
670
Fig.(c). Conservation Pool Guide Lines
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months
CORALVILLE RESERVOIR
IOWA RIVER, IOWA
Regulated Discharge Criteria
and
Conservation Pool Guide Lines
Regulation Plan 8
Approved by Office, Chief of Engineers 21 January 1964
Plate 2