Appraisal Report

Lower Republican River Basin

Nebraska and Kansas

January 2005

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Acronyms and Abbreviations

ac-ft	acre-feet
the Basin	Lower Republican River Basin
BCU	Beneficial Consumptive Use
BOC	Bottom of conservation pool
CFR	Comprehensive Facility Review
cfs	cubic feet per second
the Compact	Republican River Compact
Corps	U.S. Army Corp of Engineers
the Court	U.S. Supreme Court
DPR	Definite Plan Report
EOM	end of month
ERS	Economic Research Service
fps	feet per second
FSS	Final Settlement Stipulation
FWCA	Fish and Wildlife Coordination Act of 1958
HP	horsepower
Irr.	Irrigation
LRNRD	Lower Republican Natural Resource District
KAR	Kansas Administrative Regulation
KBID	Kansas Bostwick Irrigation District No. 2
KAF	1,000 ac-ft
kV	kilovolts
KSA	Kansas Storage Act
KWO	Kansas Water Office
MDS	Minimum Desirable Streamflow
MP	mile post

msl	mean sea level
NA	not appropriate
NED	National Economic Development
NEPA	National Environmental Policy Act
NAGPRA	Native American Graves Protection and Repatriation Act
NPDES	National Pollutant Discharge Elimination System
NRD	Natural Resources District
O&M	Operation and Maintenance
OM&R	Operation, Maintenance and Replacement
P.L.	Public Law
PMF	Probable Maximum Flood
POS	plan of study
P-SMBP	Pick-Sloan Missouri Basin Program
Reclamation	Bureau of Reclamation
RMA	Resource Management Assessment
ROW	Right-of-Way
RRCA	Republican River Compact Administration
RTU	Remote Terminal Unit
Service	U.S. Fish and Wildlife Service
SHPO	State Historic Preservation Office
the States	Colorado, Kansas, and Nebraska
TATS	Technical Assistance to States
Affiliated Tribes	Pawnee, Wichita, and Arikara
TOC	Top of conservation pool
USDA, ERS	U.S. Department of Agriculture Economic Research Service
USGS	U.S. Geological Survey

Executive Summary

General

The objectives of this Appraisal Study (Study) of the Lower Republican River Basin (Basin) are to review existing data and information, qualitatively identify some system improvement needs of the area, identify possible constraints and opportunities to make more efficient use of the water that is available, and identify potential solutions to determine the advisability of proceeding to a feasibility study.

This Study meets the States (Colorado, Kansas, and Nebraska) responsibilities of the 1942 Republican River Compact (Compact) "… to provide for the most efficient use of the water of the Republican River Basin for multiple purposes…" This Study and future study efforts indicate a willingness to continue to work with the States to achieve the efficient use of the waters in the Basin.

This Study is based on available data and information with no additional field investigations.

The appraisal study area lies in the Basin below Harlan County Dam in south-central Nebraska to Clay Center, Kansas, just upstream of Milford Lake in north-central Kansas (Figure 1). Included in this area is the Bostwick Division of the Pick-Sloan Missouri River Program (P-SMBP), a Reclamation project.

There are two irrigation districts that operate and maintain the irrigation system: the Bostwick Irrigation District in Nebraska and the Kansas Bostwick Irrigation District No. 2 (KBID). Project water is supplied to 22,935 acres in Nebraska and 42,500 acres in Kansas from the Corp of Engineer's (Corps) Harlan County Lake and Bureau of Reclamation's (Reclamation) Lovewell Reservoir.

Kansas versus Nebraska and Colorado – Lawsuit and Settlement Negotiations

In May, 1998, the State of Kansas filed a Motion for Leave to file a Bill of Complaint before the U.S. Supreme Court (Court) alleging the States of Nebraska and Colorado were violating the Compact. The Court referred the matter to a Special Master in November 1999 and the States entered into negotiations for settlement. On May 19, 2003, the Court approved the Final Settlement Stipulation (FSS) entered into by the States. On October 20, 2003, the Court, based on the final report of the Special Master, took notice of this action, bringing to a formal end to the litigation between the States.

On August 22, 2003, the Republican River Compact Administration (RRCA) formally adopted the Settlement's accounting procedures, including the groundwater model. The purpose of this Study, supported by Kansas and Nebraska, is to meet the requirements as stated in the Final Settlement Stipulation (FSS), December 15, 2002:

> IV. Compact Accounting E. *"The States agree to pursue in good faith, and in collaboration with the United States, system improvements in the Basin, including measures to improve the ability to utilize the water supply below Hardy, Nebraska on the main stem."*
>
> V.A.4. *"Kansas and Nebraska, in collaboration with the United States agree to take actions to minimize by the bypass flows at Superior-Courtland Diversion Dam."*

Needs

There are many competing needs for the limited available water supplies in the study area. The two project irrigation districts usually receive less than the amount of water needed for a full irrigation water supply. Kansas has established Minimum Desirable Streamflow (MDS) requirements at two locations on the Republican River. The instream flow requirements for these two locations have a priority date of April 12, 1984, established by the Kansas Legislature. Water users that have a priority date after April 12, 1984 are closed when the flows are less than the established MDS levels.

Development of Alternatives

During the settlement negotiations, Reclamation published a Value Study Report, "Proposals for More Efficient Management of Lower Republican River Water Supplies," concerning management of the Lower Republican River water supplies. The report recommended that priorities be given to individual proposals, or proposal combinations, when conducting further study and analysis.

Nine alternatives (Alternatives A-I) were formulated using the recommended proposals provided by the Compact Commissioners. These nine alternatives provide irrigation benefits to the Bostwick Division or other needs, such as non-project irrigation or to meet MDS needs. Three other alternatives (Alternatives J, K, and L) were investigated for supplying water for meeting MDS related needs in Kansas, which could include providing water to private irrigators who are junior to the MDS.

Some of the alternatives involve the enhancement and rehabilitation of existing Reclamation owned facilities. It is recognized that the work on these existing

facilities may not require additional authority to implement. These alternatives were included in this Study effort to ensure that all of the possible alternatives would be considered and compared in order to determine the most economical and viable alternative.

The total estimated implementation cost for each alternative ranged from $1,650,000 to $25,000,000. Benefits do not exceed costs for all of the alternatives, but four of the alternatives do have benefits that exceed costs. The benefit-cost ratios for the alternatives range from 0.13 to 4.2.

Results from Study

The Study results indicate additional water can be made available for storage in Lovewell Reservoir. The storage of this additional water could also be considered in other possible downstream facilities such as the Beaver Creek site or Jamestown Wildlife Management Area site. Due to the limitations of the operations model, the hydrology analyses modeled the operation of the system for each alternative with the intent to maximize irrigation benefits of the Bostwick Division. Restrictions of the operations model prevented analyzing the economic impacts related to the MDS and/or the non-project irrigators. Additional hydrological analyses to model system operation which emphasized other potential resource needs, such as MDS, were not performed at this time. As a result, only irrigation benefits of the Bostwick Division have been quantitatively estimated. Allocation of water to provide MDS and/or non-project irrigation benefits would reduce the water available to provide irrigation benefits to the Bostwick Division.

Chapter 1 – Introduction

1.1 Authority

This Appraisal Study (Study) of the Lower Republican River Basin (Basin) was authorized under Federal Reclamation Laws (Act of June 17, 1902, 32 Stat. 388, and acts amendatory thereof and supplementary thereto).

1.2 Purpose and Scope of this Appraisal Study

The purpose of this Study, supported by Kansas and Nebraska, is to meet the requirements as stated in the Final Settlement Stipulation (FSS), December 15, 2002:

> IV. Compact Accounting E. *"The States agree to pursue in good faith, and in collaboration with the United States, system improvements in the Basin, including measures to improve the ability to utilize the water supply below Hardy, Nebraska on the main stem."*
>
> V.A.4. "*Kansas and Nebraska, in collaboration with the United States agree to take actions to minimize the bypass flows at Superior-Courtland Diversion Dam."*

This Study also meets the States (Colorado, Kansas, and Nebraska) responsibilities of the 1942 Republican River Compact (Compact) "… to provide for the most efficient use of the water of the Republican River Basin for multiple purposes…"

This Study is based on available data and information with no field investigations.

1.3 Objectives

There are three main objectives for this Study in accordance with the FSS:

1. Review existing data and information
2. Qualitatively identify system improvement needs of the area
3. Identify possible constraints, opportunities, and potential solutions to determine the advisability of proceeding to a feasibility study.

1.4 Project Area and Description

The appraisal study area lies in the lower portion of the Basin from Harlan County Dam in south-central Nebraska to Clay Center, Kansas just above the upper reaches of Milford Lake in north-central Kansas (Figure 1). Included in this area is the Bostwick Division of the Pick-Sloan Missouri River Program (P-SMBP), a Reclamation project. There are two irrigation districts that operate and maintain the irrigation system: the Bostwick Irrigation District in Nebraska and the Kansas Bostwick Irrigation District No. 2 (KBID). These two districts began delivering water in the early 1950's. Current service is available to 22,935 acres in Nebraska and 42,500 acres in Kansas. Storage water is provided to the Bostwick Division from the Corps of Engineer's (Corps) Harlan County Lake and Reclamation's Lovewell Reservoir. The water supply for Harlan County Lake comes from the Republican River and Lovewell's water supply comes from diversions from the Republican River at the Superior-Courtland Diversion Dam with some inflow from White Rock Creek. Irrigation water for the Bostwick Division is diverted directly from Harlan County Lake and Lovewell Reservoir, from the Republican River at the Superior-Courtland Diversion Dam, and a small amount pumped from the Republican River below Harlan County Dam.

There are about 3,722 square miles of surface drainage area in the Basin between Harlan County Dam and the river gaging station at Clay Center, Kansas. The Republican River is the predominant natural feature. Throughout its length, the river has eroded a valley mantled by alluvial sand and gravel deposits ranging to 60 feet in depth. The valley, averaging less than 2 miles wide, is now entrenched 100 to 200 feet below the adjacent uplands. The bordering loess-mantled prairie plains have been eroded into long tongues of rolling uplands. There are several small, entrenched tributaries, flowing nearly at right angles to the river that drain the upland areas.

This study area is considered subhumid. Precipitation in the area is normally poorly distributed and insufficient for optimum plant growth. The Bostwick Division depends primarily upon the storage water from Harlan County Lake and Lovewell Reservoir. Harlan County Lake inflows have been generally declining with an occasional year or two of excess inflows that help to replenish some of the storage water. Harlan County Lake usually has a limited amount of carryover storage. Lovewell Reservoir carryover storage is supplemented by fall diversions from the Republican River through Courtland Canal. There are competing needs for the limited available water so there is an urgent need to use the available water supplies as prudently and efficiently as possible. Chapter 2 discusses these competing needs further.

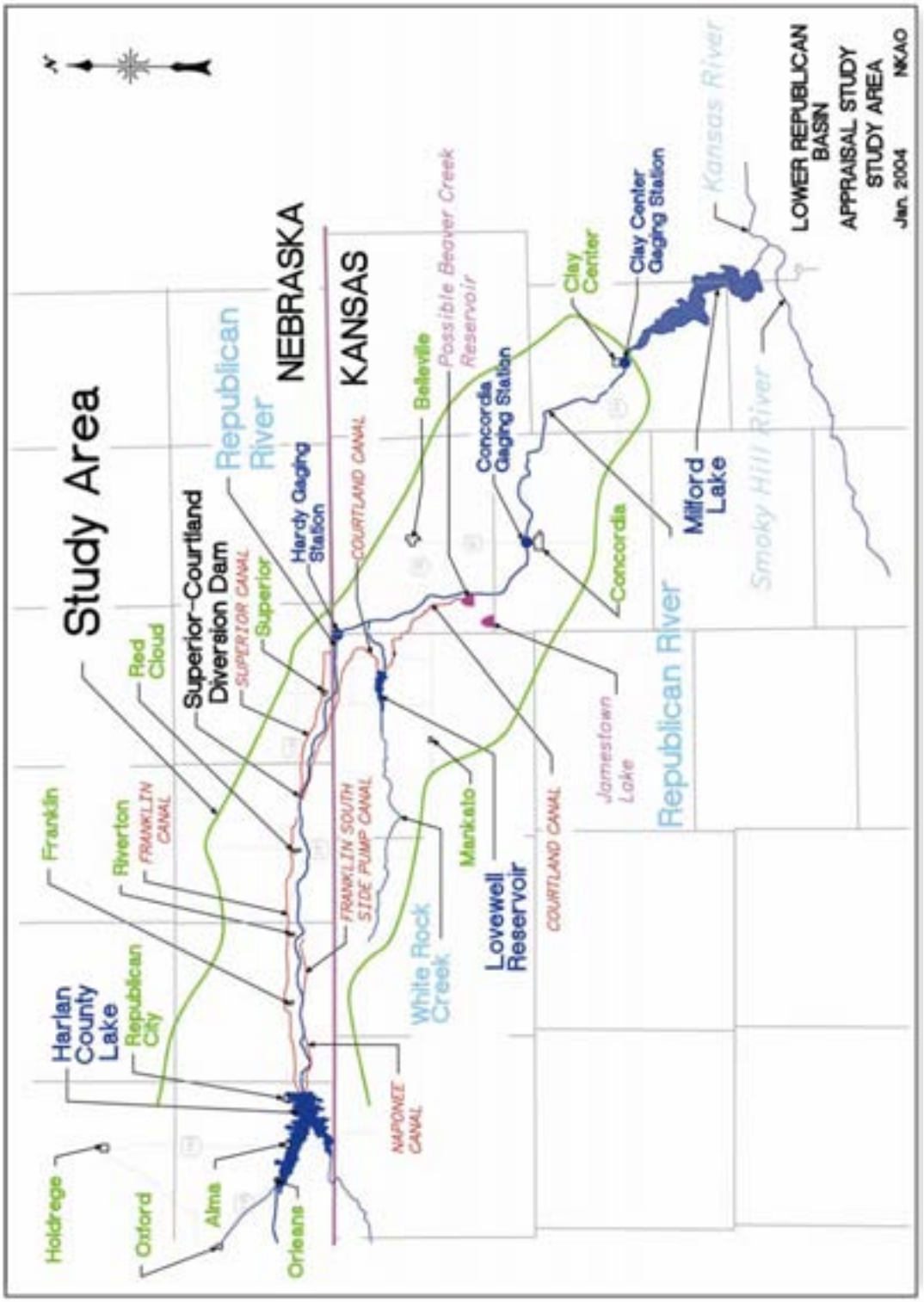

FIGURE 1. STUDY AREA.

1.5 Prior Studies, Reports, and Existing Water Projects

The Bostwick Division was authorized for construction by the Flood Control Act of 1944, Public Law (P.L.) 534, as part of the Missouri River Basin Project of the P-SMBP. The plan for the Bostwick Division was outlined in Senate Document No. 191, revised in Senate Document No. 247, as a coordinated plan of Reclamation and the Corps.

The study area has had considerable project investigations and development of water resource facilities over the last 60-plus years. Only the studies and reports that have a significant importance to the Bostwick Division and the Basin are highlighted:

- Bostwick Division, Nebraska-Kansas, Volume 1, Parts 1, 2, 3, and 4, Definite Plan Report (DPR), Bureau of Reclamation, Region 7, Denver, Colorado, June 1953.

- Bostwick Division, Nebraska-Kansas, Volume 1, Supplement, General Plan of Development, Definite Plan Report (DPR), Bureau of Reclamation, Region 7, Denver, Colorado, April 1956.

- Republican River Basin, Water Management Study, Special Report, Bureau of Reclamation, February 1985.

- Republican River Basin Flows; Flows Adjusted to 1993 Level Basin Development, prepared by Lane, Norval, and Weghorst in the Flood Hydrology Group, Bureau of Reclamation, Technical Service Center, Denver, Colorado, October 1995.

- Resource Management Assessment, Republican River Basin, Water Service Contract Renewal, Bureau of Reclamation, Great Plains Region, July 1996.

- Repayment and Long-Term Water Service Contract Renewals for the Republican River Basin, Nebraska and Kansas, July 2000.

- Technical Assistance to States (TATS) Study, Lower Republican River, Kansas, Water Augmentation Analysis, Bureau of Reclamation, May 2002.

- Final Settlement Stipulation (FSS), Supreme Court of the United States, Kansas vs. Nebraska and Colorado, December 15, 2002.

- Value Study Report, Proposals for More Efficient Management of Lower Republican River Water Supplies, Bureau of Reclamation, Technical Service Center, Denver, Colorado, December 17, 2002.

- Volume Analysis and Revised Flood Frequency Analysis for Comprehensive Facility Review, Lovewell Dam, Bureau of Reclamation, Technical Service Center, Denver, Colorado, May 2003.

- Republican River Basin Report of Preliminary Findings, Nebraska Department of Natural Resources, May 20, 2003.

- Analysis Addressing Hydrologic/Hydraulic Issues, Lovewell Dam, Bureau of Reclamation, Technical Service Center, Denver, Colorado, September 2003.

1.6 Consultation and Meetings

Reclamation and representatives from each State served on a Value Engineering Study Team that analyzed various alternatives to better utilize water supplies in the Lower Republican. During the preparation of the Value Study Report and prior to the commencement of this Study, a number of briefing meetings were conducted with the Republican River Lawsuit Settlement Negotiations Team. During the meetings, the Republican River Compact Commissioners recommended specific proposals that should be considered for further study. Chapter 2 discusses the descriptions of these proposals.

The consultation for this Study consisted of providing the States two written Status Reports and holding conference calls with the States and Reclamation representatives. State water and natural resource entities were invited and participated.

Reclamation hosted meetings in Superior and Kearney, Nebraska and Mankato, Kansas to discuss the Study. Attendees included personnel from Reclamation, both Bostwick Irrigation Districts, and state water and natural resource representatives from Kansas and Nebraska.

A brief report of Study activities was also provided to the attendees at the Annual Republican River Compact Workshop meeting held on August 21, 2003 and the Compact meeting on August 22, 2003 at Alma, Nebraska.

The State of Colorado indicated they would likely not be involved in any future feasibility study since Colorado is not directly involved with the existing features in the lower reaches of the Republican River (below Harlan County Dam). Colorado representatives did not attend the meetings held in Superior, Kearney, or Mankato, however, they were in attendance at later meetings and were a part of the Value Engineering Study Team.

Chapter 2 – Problems and Needs

There are many competing needs for the limited available water supplies in the study area. The two project irrigation districts usually receive less than the full amount of water needed for a full irrigation water supply. Kansas has established Minimum Desirable Streamflow (MDS) requirements, described later in this chapter, at two locations on the Republican River: Concordia and Clay Center. The instream flow requirements for these two locations have a priority date of April 12, 1984, established by the Kansas Legislature. (Note: Water users that have a priority date after April 12, 1984 are closed when the flows are less than the established MDS levels.)

2.1 Republican River Compact

The Compact allocates waters from the Basin, above Hardy, Nebraska to the States. The entire water supply originating below Hardy is allocated to Kansas. The Compact's Engineering Committee annually calculates the Basins water supply available for allocation and the Beneficial Consumptive Use (BCU) in the Basin. These calculations determine each States' allocation and total BCU. BCU is defined in the Compact as "That use by which the water supply of the Basin is consumed through the activities of man, and shall include water consumed by evaporation from any reservoir, canal, ditch or irrigated area." Water diverted at Superior-Courtland Diversion Dam is considered Compact water and would be included in the water supply and BCU calculations.

2.2 Republican River Compact Litigation and Settlement

In May 1998, the State of Kansas filed a Motion for Leave to file a Bill of Complaint with the U.S. Supreme Court (the Court) alleging the States of Nebraska and Colorado were violating the Compact. The Court referred the matter to a Special Master in November, 1999.

Following hearings, rulings of the Special Master, and a significant portion of discovery, the States began discussing the possibility of settlement negotiations. After several negotiation sessions the Special Master, at the request of the States, agreed to postpone the progression of the case until December 15, 2002, in order to allow the States to engage in settlement negotiations. The U.S. Department of Justice, Reclamation, and the U.S. Army Corp of Engineers (Corps) also participated. These negotiations culminated in a settlement package that was subsequently approved and entered into by the Governor and Attorney General of each State.

On April 15, 2003, the Special Master formally recommended the approval of the Final Settlement Stipulation (FSS) to the Court. On May 19, 2003, the Court approved the FSS. On October 20, 2003, the Court, based on the final report of the Special Master, took notice of this action, bringing a formal end to the litigation between the States.

On August 22, 2003, the Republican River Compact Administration (RRCA) formally adopted the Settlement's accounting procedures, including the groundwater model.

2.3 Settlement Provisions

Provisions excerpted from the FSS that pertain directly to this Study include:

> IV. Compact Accounting E. *"The States agree to pursue in good faith, and in collaboration with the United States, system improvements in the Basin, including measures to improve the ability to utilize the water supply below Hardy, Nebraska on the main stem."*
>
> V.A.4. *"Kansas and Nebraska, in collaboration with the United States, agree to take actions to minimize bypass flows at Superior-Courtland Diversion Dam."*

During the settlement negotiations, Reclamation published a Value Study Report, "Proposals for More Efficient Management of Lower Republican River Water Supplies," concerning management of the Lower Republican River water supplies. The report recommended that priorities be given to the following individual proposals, or proposal combinations, when conducting further study and analysis:

- Proposal B Courtland Canal Automation, Reshape Canal Prism, Winter Operation
- Proposal C1 Increase Lovewell Capacity – 16,000 acre-feet (ac-ft)
- Proposal C2 Increase Lovewell Capacity – 35,000 ac-ft
- Proposal G Off-stream Storage – Kansas Tributaries, Beaver Creek

Proposals B, C1, and C2 were analyzed and further developed as alternatives in the operations model. Due to budget and time constraints, potential for improved use of the water supply below Hardy on the mainstream was not analyzed. Other proposals involving tributaries to the mainstream were considered and analyzed.

Due to the limitations of the operations model, only a qualitative analysis of Proposal G was performed at this stage of the study.

2.4 Problems and Opportunities

2.4.1 Existing Conditions

The Basin reach downstream of Harlan County Dam is subject to occasional flooding, periods of excess precipitation, and occasional droughts. The existing project facilities for the Bostwick Division in Nebraska and Kansas are around 50 years old with typical ongoing maintenance and operational problems associated with aging facilities.

There are two irrigation districts that operate and maintain the irrigation system: the Bostwick Irrigation District in Nebraska and the KBID. These two districts began delivering water in the early 1950's. Current service is available to 22,935 acres in Nebraska and 42,500 acres in Kansas. Storage water is provided to the Bostwick Division from the Corps of Engineer's (Corps) Harlan County Lake and Reclamation's Lovewell Reservoir (1957). Due to changing hydrologic conditions in the entire Basin, these two districts frequently experience water supply shortages. For example, according to Reclamation's Resource Management Assessment (RMA) (Reclamation 1996) of the Basin, the mean annual historic (1931-1993) flow into Harlan County Lake was 247,000 ac-ft and the 1993 development level for the same period was 124,000 ac-ft. The 1993 development level projects what the flows would be if all of the 1993 level of development had occurred at the beginning of the study period and remained at that level throughout the study period.

In the Basin in Nebraska there are surface water rights totaling about 100 cubic feet per second (cfs) in the reach below Harlan County Dam and above the Superior-Courtland Diversion Dam. Most of these rights are junior to the Bostwick Division's rights. Below the Diversion Dam and above the Nebraska-Kansas State line there are surface water rights totaling about 25 cfs, with most of these rights also junior to the Bostwick Division rights. Nebraska has recently taken action to adjudicate water rights in this area and some rights may be cancelled in the future.

There are a considerable number of groundwater irrigation wells in Nebraska below Harlan County Dam. As of late 2003 there were 1,668 active irrigation wells in the Lower Republican Natural Resources District (LRNRD) below Harlan County Dam. There were 1,066 in Franklin County, 483 in Webster County, and 119 in Nuckolls County.

Except in certain circumstances the States adopted a prohibition on the construction of new wells in the Basin above the Superior-Courtland Diversion

Dam as part of the settlement provisions. In December 2002, in compliance with the FSS, the LRNRD approved a three year moratorium on new wells pumping more than 50-gallons-per-minute in the Nebraska part of the Basin. The LRNRD is also phasing in a well metering requirement for existing wells to track water usage.

Kansas surface water rights total about 210 cfs, including about 17 cfs vested rights, in the reach below the Nebraska-Kansas State line and above Clay Center. A vested right continues the beneficial use of water that began prior to June 28, 1945.

There are about 385 registered irrigation wells in the portion of the Basin from the stateline to Clay Center. Much of the bottom lands of the river valley are irrigated by wells pumping from the alluvial aquifer. Kansas considers the Basin to be fully appropriated. All water rights issued after 1984 are subject to administration when MDS standards are not met.

The Kansas Water Office (KWO) requests administrative action when a violation in MDS flows occurs. The Chief Engineer checks for unauthorized use, compliance with existing permits, and, if necessary, initiates administration of junior water rights. In 2000, flows dropped below the MDS resulting in the suspension of approximately 150 junior right groundwater irrigators. When they are allowed to pump, these irrigators use an estimated 10,000 ac-ft of water per year. These rights are in aquifers previously determined by the State of Kansas to be hydraulically connected to the river. This action did not impact the operations of the Bostwick Division since water rights associated with irrigation of project lands are senior to the water right priority date for MDS. Kansas has been administering MDS at Concordia and Clay Center since the summer of 2002 to the present time (August, 2004).

2.4.2 Expected Future Conditions

The conditions used for the hydrology baseline conditions, Chapter 3.3, are considered to be the expected future conditions of the Basin from Harlan County Dam to Clay Center. Actions will likely be required by the States to come into compliance with the Compact, however, there have been no understandings reached for the actions the States may take to control their consumptive uses if the Compact requirements are not met. Additionally, the new contracts between the Bostwick Irrigation Districts and Reclamation (signed in 2000) mandated distribution system and on-farm delivery system efficiency improvements. The Bostwick Irrigation Districts committed to implement improvements that would achieve on-farm efficiency improvements of 5 percent and delivery system efficiency improvements between 2 percent and 8 percent (each contract contains a specific number) in the 10-year period beginning in 2001. In the event these improvements are not obtained by any district by 2010, that district and

Reclamation will agree to additional water conservation measures to be implemented over the next 5 years (by 2015).

It is anticipated the consumptive uses will stay at current levels or be reduced to attain compliance with the Compact and the FSS. The 1993 level of development for streamflow conditions was used to set the baseline condition for this Study with no significant changes in the operations of the Bostwick Division.

2.4.3 Opportunities

There are opportunities to improve the efficient use and overall management of the Basin's water resources. This can be done by increasing the water supplies available for Bostwick Division lands, providing additional flexibility for the States to comply with the FSS provisions associated with the Compact, or by supplying water for supplementing flows to meet downstream needs, particularly during times of shortage.

The Bostwick Irrigation Districts frequently experience water delivery shortages. There are opportunities to provide Bostwick Division lands with improved water deliveries to reduce the frequency and severity of the shortages.

If adequate water is available there may also be opportunities in the Basin to provide Kansas with supplemental water flows to meet the downstream needs, including supply to offset depletions of water right holders junior to MDS. Use of a storage facility at Beaver Creek, Jamestown, or other locations could provide additional fish and wildlife benefits, supplement flows to meet MDS, and improve the use of the water supply below Hardy.

2.4.4 Problems Warranting Federal Participation

Reclamation and the Corps have been involved in the Basin for over 60 years. Federal water supply contracts with the Bostwick Irrigation Districts were renewed in 2000. The Bostwick Division in Nebraska and Kansas use most of the water storage space in Harlan County Lake and Lovewell Reservoir. Both districts have experienced significant water delivery shortages and anticipate that shortages will continue. Available water supplies for the Basin have decreased over the years and the perception that Nebraska and Colorado use more than their Compact water allocation contributed to Kansas's decision to file a complaint against Nebraska and Colorado in the Court (May 26, 1998). Presently some water supplies in the Lower Basin are not being fully utilized, and with some improvements in the existing systems and possibly some additional storage, the system could be managed to alleviate some of the water shortage problems.

The Bostwick Irrigation Districts have Federal repayment obligations on their projects. The Federal government, although not a named defendant in the litigation among the States, was a participant in the negotiated FSS and agreed to collaborate with the States to pursue system improvements to make more efficient use of the water.

2.4.5 Planning Objectives and Planning Constraints

Input on planning objectives and planning constraints was sought from the involved States and interested parties such as the Bostwick Irrigation Districts, Natural Resource Districts (NRD) in the Basin, the Lower Republican Water Users, the Kansas Department of Wildlife and Parks, the Kansas Water Office (KWO), Kansas Division of Water Resources, and Nebraska Department of Natural Resources.

2.4.5.1 Planning Objectives

Input from interested parties resulted in Reclamation identifying the following planning objectives for the Study with the overriding objective to determine the Federal interest to conduct a feasibility study:

- Minimize bypass at Superior-Courtland Diversion Dam.
- Provide augmentation storage water for MDS.
- Develop cost effective solutions.
- Provide additional water supply to Bostwick Division lands (additional inches of water).
- Provide additional recreation benefits.
- Recognize possible environmental and cultural impacts.

The primary planning objective for developing alternatives is to conform to the FSS as agreed upon by the States and approved by the Court.

2.4.5.2 Planning Constraints

Constraints on the development of these plans include the following:

- Republican River Compact
- State Water Rights
- Harlan County Consensus Plan
- Physical limitations of existing facilities, including Courtland Canal, Lovewell Reservoir, and other storage facilities
- Environmental and cultural consideration

Chapter 3 – Alternative Plans

3.1 Management Methods

Several management methods were developed to enhance the use of the water supply in the section of the Basin below Harlan County Dam. Combinations of these management methods were developed into the alternatives presented in this chapter.

A number of the alternatives being considered involve the enhancement and rehabilitation of existing Reclamation-owned facilities. The work on these existing facilities may or may not require additional construction authority to implement. These alternatives were included in this Study to ensure that all of the possible methods would be considered and compared to determine the most economical and viable alternative.

3.1.1 Winterize Superior-Courtland Diversion Dam and Courtland Canal

The river flow at Superior-Courtland Diversion Dam currently cannot be diverted into Lovewell Reservoir during the winter months due to periods of icing. Winterizing[1] the Diversion Dam and Courtland Canal would allow canal diversions whenever water is needed and available. This could potentially increase the water in Lovewell Reservoir or some other storage structure near the canal. This improvement would result in Lovewell Reservoir filling earlier in the spring and would provide additional time for maintenance of the diversion dam and conveyance system.

3.1.2 Automate Superior-Courtland Diversion Dam and Courtland Canal

Fluctuations in the flows of the Republican River at the diversion dam occur because of storm runoff, weather changes, and operational changes. These flow fluctuations make it difficult to eliminate or minimize bypass flows at the Diversion Dam. Some of these fluctuations could be diverted by automating the gates at the Diversion Dam and the check structures and by placing a more reliable flow measurement structure on the canal to minimize bypass flows. This would result in a decrease in the river flow below the Diversion Dam when the capacity of Courtland Canal allows for more of the flow of the river at the Diversion Dam to be diverted. To address the stipulation detailed in the FSS to minimize the bypass flows at Diversion Dam, the implementation of an alternative involving this method would need to be addressed.

[1] "Winterizing" involves the placement of bubblers at the check stations on Courtland Canal and at the Superior–Courtland Diversion Dam to de-ice structures during the winter.

3.1.3 Renovate Courtland Canal (Restore the Courtland Canal to Design Capacity)

This measure would restore the Courtland Canal to its design capacity of 751 cfs between the Diversion Dam and Lovewell Reservoir. The current capacity is estimated to be approximately 580 cfs due to sloughing of the canal banks in some sections and the replacement of road bridges with in-line pipe structures that will not handle the canal design capacity at several points. These smaller in-line structures were installed by Jewell County as a cost savings measure when county road bridges were replaced. The pipe structures would be removed and replaced by structures which do not restrict flow. The canal would also be reshaped to provide for the additional capacity.

3.1.4 Provide for Increased Conservation Storage in Lovewell Reservoir

The existing Lovewell Reservoir has an active conservation capacity of 24,022 ac-ft (Figure 2). Proposals include raising this conservation storage by 16,000 ac-ft (Figure 3) or 35,000 ac-ft (Figure 4). Increases in conservation capacity would require raising the conservation pool from Elevation 1582.6 to Elevation 1587.3 (16,000 ac-ft) or Elevation 1592.0 (35,000 ac-ft). These proposals involve modifications to the existing dam and appurtenant structures allowing an increase in the active conservation capacity and the total reservoir capacity, while maintaining the existing flood control and surcharge capacities. Proposals that converted a

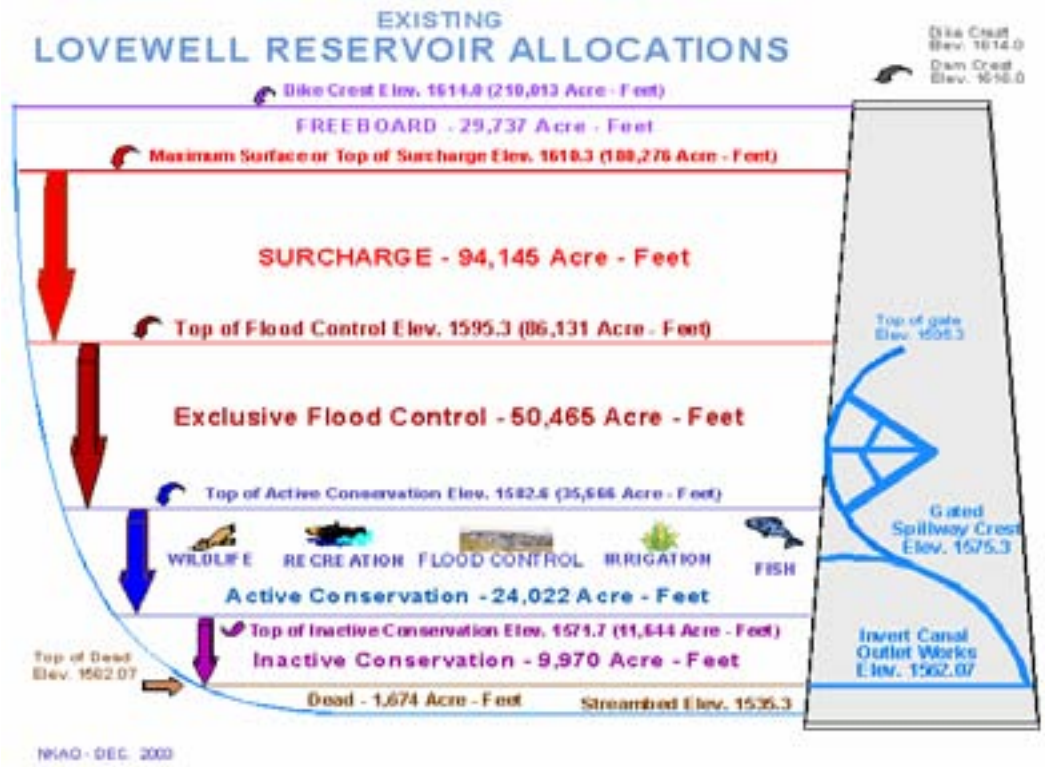

FIGURE 2. LOVEWELL RESERVOIR EXISTING ALLOCATIONS.

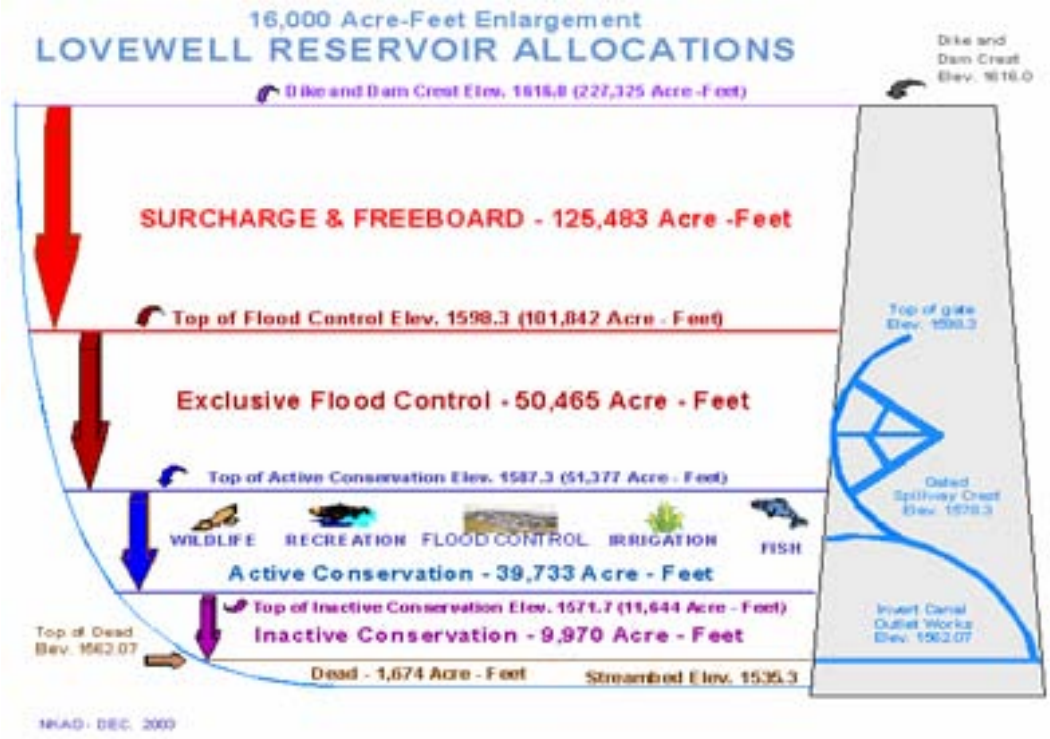

FIGURE 3. LOVEWELL RESERVOIR ALLOCATIONS FOR 16,000 AC-FT ENLARGEMENT.

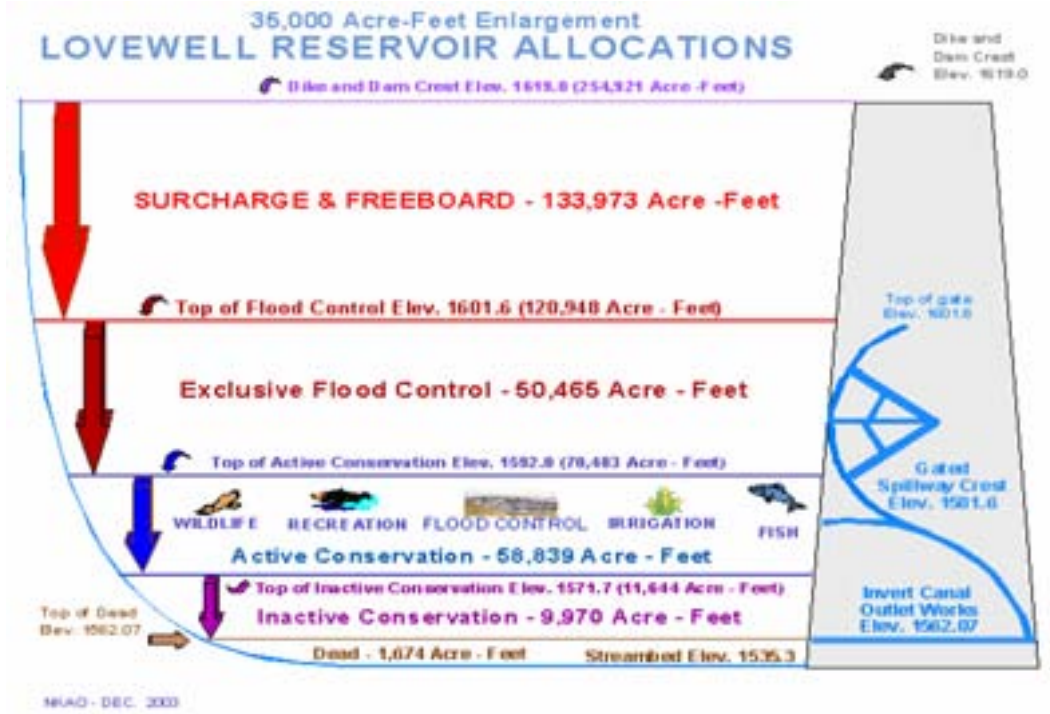

FIGURE 4. LOVEWELL RESERVOIR ALLOCATIONS FOR 35,000 AC-FT ENLARGEMENT.

portion of the flood control storage to conservation storage without modifications to the dam were considered but rejected due to the increased flood risks.

3.2 River System Operation Model

A modified version of the OPSTUDY computer model used for Reclamation's Contract Renewal Study in the Basin was used for the evaluation of the water supply for the alternatives presented in this Study. The computer model simulated the streamflow and reservoir conditions for the entire Basin. The original model used monthly hydrologic data between 1931 thru 1993. For this Study, the model was updated to include historic hydrologic data thru 2000.

Irrigation benefits for increased water supply for the Bostwick Division were determined at the appraisal level of detail. If more detailed studies to evaluate other potential benefits, such as MDS, are desired at a later date the model may need to be modified to evaluate these options for use of the water supply.

Since this Study concentrates on improving the use of the water supply below Harlan County Lake, efforts to improve the original model centered on that same area of the Basin (Figure 5). The model was modified to incorporate Harlan County Lake Consensus Plan (Consensus Plan) criteria which resulted from the contract renewal process. The details of the Consensus Plan and additional details concerning the model are included in Appendix A.

The operations model includes:

- Consensus Plan for Operation of Harlan County Lake
- Reservoir inflows and reach gain calculations
- Reservoir evaporation rates
- Monthly crop irrigation requirements.

3.3 Description of Baseline and Alternatives

The baseline condition, considered the future without or no action condition, included the simulation of the streamflows and reservoir operations of the Basin. The streamflow conditions were described above and the delivery efficiency associated with the contract renewals for the irrigation districts was included in the baseline run. The following alternatives were developed using various combinations of the management methods discussed previously. Table 1 indicates the parameters that were changed that were in the alternative model runs.

The nine alternatives are briefly described below. The evaluations of these alternatives are included in Section 3.4.

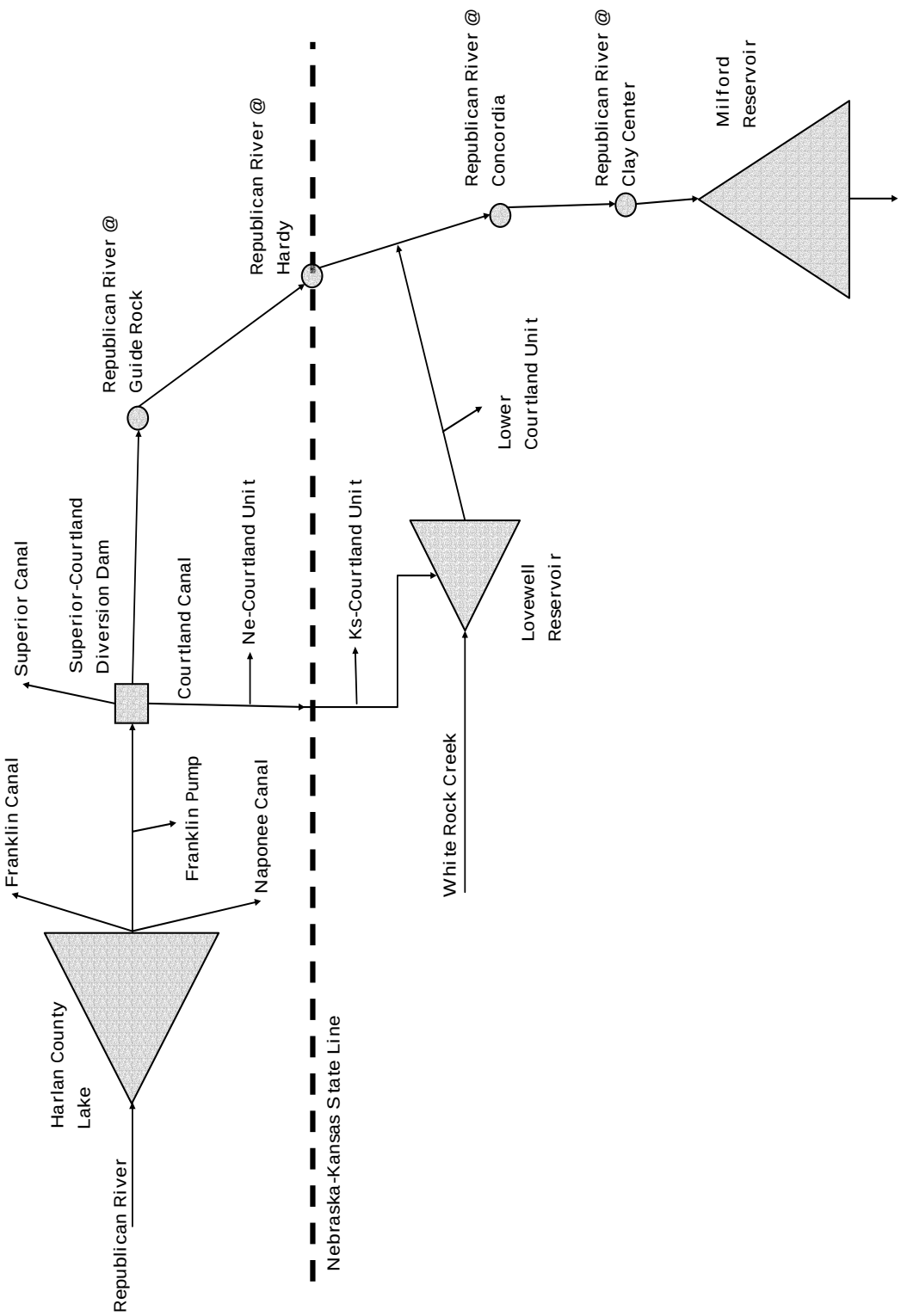

FIGURE 5. SCHEMATIC DIAGRAM OF LOWER REPUBLIC RIVER BASIN.

TABLE 1. SUMMARY OF MODEL RUNS

Courtland Canal Capacity (cfs)	580	751	580	751	580	751	580	751	580	751
Bypass at Div. Dam (cfs)										
Irrigation Season	40	40	0	0	0	0	0	0	40	40
Rest of Year	10	10	0	0	0	0	0	0	10	10
Lovewell TOC[1] (1000 ac-ft)	35.7	35.7	35.7	35.7	51.7	51.7	70.7	70.7	51.7	51.7
Lovewell BOC[2] (1000 ac-ft	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
Winter Diversions (Ice)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Increased Storage Use	NA	NA	NA	NA	Irr.[3]	Irr.	Irr.	Irr.	Irr.	Irr.

A. Courtland Canal to Design Capacity, Winterize

B. Automate, Winterize

C. Automate, Winterize, Courtland Canal to Design Capacity

D. Automate, Winterize, Raise Lovewell 16,000 ac-ft

E. Automate, Winterize, Raise Lovewell 16,000 ac-ft, Courtland Canal to Design Capacity

F. Automate, Winterize, Raise Lovewell 35,000 ac-ft

G. Automate, Winterize, Raise Lovewell 35,000 ac-ft, Courtland Canal to Design Capacity

H. Raise Lovewell 16,000 ac-ft

I. Raise Lovewell 16,000 ac-ft, Courtland Canal to Design capacity

[1] TOC = Top of conservation pool (Enlargement values vary some from values in Figures 3 and 4.

[2] BOC = Bottom of conservation pool.

[3] Irr. = Irrigation.

3.3.1 Alternative A – Courtland Canal to Design Capacity, Winterize

Alternative A would provide for winterizing Superior-Courtland Diversion Dam and Courtland Canal to allow for operations whenever water is available and needed for irrigation or storage in Lovewell Reservoir. This alternative would also return Courtland Canal to design capacity, allowing the capture of higher peak runoff events and increasing operational flexibility of Lovewell Reservoir storage.

3.3.2 Alternative B – Automate, Winterize Courtland Canal

Alternative B provides for automating and winterizing the Superior-Courtland Diversion Dam and Courtland Canal. Implementing this alternative would allow the capturing of the smaller bypass flows from the Diversion Dam that are within current reduced canal capacity, thereby minimizing the bypass at the Diversion Dam. It also provides for the diversion of water whenever water is available and needed for irrigation or storage in Lovewell Reservoir.

3.3.3 Alternative C – Automate, Winterize, Courtland Canal to Design Capacity

Alternative C is a combination of Alternatives A and B, including all the provisions of these alternatives.

3.3.4 Alternative D – Automate, Winterize Courtland Canal; Raise Lovewell 16,000 ac-ft

Alternative D includes the provisions of Alternative B and adds additional conservation storage of 16,000 ac-ft in Lovewell Reservoir for storage of available flows.

3.3.5 Alternative E – Automate, Winterize, Courtland Canal to Design Capacity; Raise Lovewell 16,000 ac-ft

Alternative E includes all of the provisions of Alternative C and adds the additional conservation storage of 16,000 ac-ft in Lovewell Reservoir for storage of available flows.

3.3.6 Alternative F – Automate, Winterize Courtland Canal; Raise Lovewell 35,000 AF

Alternative F includes the provisions of Alternative B and adds additional conservation storage of 35,000 ac-ft in Lovewell Reservoir for storage of available flows.

3.3.7 Alternative G – Automate, Winterize, Courtland Canal to Design Capacity; Raise Lovewell 35,000 ac-ft

Alternative G includes the provisions of Alternative C and adds additional conservation storage of 35,000 ac-ft in Lovewell Reservoir for storage of available flows.

3.3.8 Alternative H – Raise Lovewell 16,000 ac-ft

Alternative H continues the current operations and provides additional conservation storage of 16,000 ac-ft in Lovewell Reservoir for storage of available flows.

3.3.9 Alternative I – Courtland Canal to Design Capacity; Raise Lovewell 16,000 ac-ft

Alternative I would return Courtland Canal to design capacity and provides additional conservation storage of 16,000 ac-ft in Lovewell Reservoir for storage of available flows.

3.3.10 Other Storage Alternatives

Additional storage facilities that would need to be supplied by water delivered through the Courtland Canal system include a reservoir on Beaver Creek and the Jamestown Wildlife Management Area. Extension of the existing canal system would be required in order to deliver water to these storage facilities. Delivery of water to these facilities was not analyzed in this appraisal study because significant

revisions to the OPSTUDY model would be required. These alternatives could be examined further if a feasibility study is undertaken. Alternatives that include delivering additional water to Lovewell Reservoir could be modified to deliver the additional water to other storage facilities if other benefits such as supplementing flows to meet MDS were desired. Use of a storage facility such as Beaver Creek or Jamestown could also provide additional fish and wildlife benefits and could improve the utilization of the water supply below Hardy.

3.4 Evaluation of Alternatives

3.4.1 Hydrologic Evaluations

3.4.1.1 Changes of Water Supply into Lovewell Reservoir

Table 2 shows the flows into Lovewell Reservoir for each model run:

TABLE 2. AVERAGE DISCHARGE FROM COURTLAND CANAL INTO LOVEWELL (KAF – 1,000 AC-FT)

		Alternatives								
	Baseline	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Annual	25.2	32.8	30.3	35.5	35.1	39.1	39.7	42.5	29.4	32.9
Non-Irrigation Season	11.2	13.8	15.6	15.0	21.6	20.6	26.7	25.1	16.1	15.3
Irrigation Season	14.0	19.0	14.8	20.5	13.4	18.6	12.9	17.5	13.3	17.6
Dec thru Feb	0.0	4.8	5.4	5.2	7.2	7.0	7.5	7.4	0.0	0.0

Additional water available for storage in Lovewell Reservoir can be calculated by comparing the value for each alternative to the baseline value. As shown in Table 2 the increase in average water supply for the non-irrigation season varies from 2,600 ac-ft to 15,500 ac-ft and the annual variance is 4,200 ac-ft to 17,300 ac-ft, (e.g., 17,300 = 42,500 – 25,200). The December through February row indicates the additional water available by changes that provide for operations during times that icing is likely to occur.

3.4.1.2 Minimum Desirable Streamflows Analysis

As stated in Chapter 2, Kansas has established MDS requirements in the Basin. The MDS specifies the minimum streamflows to meet water quality and quantity needs of aquatic life and senior water rights downstream. Water users who received a water right after the effective date of MDS requirements have water rights subject to administration during periods when MDS flows are not met. When the water supply is insufficient for all users, water right holders with junior rights may be restricted or shut off. The present irrigation rights associated with the Bostwick Division are senior to the MDS priority date of April 12, 1984. Using the flow data

from the alternative analyses, the Republican River at Clay Center flows were examined to determine the effects of the alternative on the MDS at that location. Although the MDS is a daily flow requirement, monthly flows were analyzed to display overall effects of the alternatives on the baseline streamflow at this gage. The period analyzed for MDS effects was 1981-2000 (20 years).

When evaluating the alternatives for Bostwick Division irrigation benefits only, each alternative results in an increase in the number of times the MDS is violated and an increase in the total volume of additional water needed to meet the MDS. Baseline data for this period indicated that the MDS was violated 1,386 times with a variation of 1,488 to 2,073 times for the alternatives. The annual average volume needed for compliance in the baseline was 9,633 ac-ft with a variation of 9,107 ac-ft to 15,377 ac-ft for the alternatives. Additional information can be found in the tables summarizing the results of this analysis in Appendix A.

3.4.1.3 Farm Delivery Changes

For the irrigation benefit analysis estimation included in Section 3.4.3, Table 3 shows the average farm deliveries to the Bostwick Division that were used as an input to the analysis:

TABLE 3. AVERAGE ANNUAL FARM DELIVERIES TO BOSTWICK DISTRICTS (INCHES)

		Alternatives								
	Baseline	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Bostwick	11.5	11.7	12	12.2	13	13.1	13.7	13.8	12.4	12.4

All alternatives show an increase in farm delivery compared to the baseline. The average annual farm delivery requirement for this area is about 24 inches.

3.4.2 Alternative Design and Cost Estimates

Design assumptions and cost of the alternatives are discussed below. The cost estimates are summarized in Table 6 and presented in detail in Appendices B and C.

3.4.2.1 Canal Components

3.4.2.1.1 Canal Flow

The canal flow for the various alternatives was set either at 580 cfs (the current canal capacity) or 751 cfs (the original design canal capacity). The current reduced canal capacity of 580 cfs is due to the degradation of the original canal prism and restrictions at several locations.

3.4.2.1.2 Canal Rehabilitation

The Courtland Canal was originally designed with a combination of earth and concrete lined canal sections. The original design required the construction of a trapezoidal canal prism. Over time, the existing canal prism has become rounded,

and presently, the existing canal prism exhibits geometry somewhat less than trapezoidal. Sections of concrete lining have deteriorated which has resulted in reduced canal capacity. Additionally, the maximum flow rate of the Courtland Canal has degraded to a flow rate of 580 cfs (the Courtland Canal has been in service approximately 50 years). Canal rehabilitation would address the degradation of the existing canal prism through reshaping and return the flow rate to the original design flow rate of 751 cfs for Courtland Canal.

The Courtland Canal prism reshaping for earth-lined sections was based on using a maximum velocity of not more than 2.0 feet per second (fps) due to the embankment material's tractive forces encountered (for silts and silt loams conveying clear water, the maximum permissible velocity is 2.0 fps). The original design for full flow resulted in a velocity of approximately 2.4 fps and the material used to construct the earth-lined portions of the canal prism is identified as silts with some fine sands. As noted above, these higher-than-desirable flow velocities resulted in the erosion of the canal prism that has been observed. The rehabilitated canal prism would be sized to accommodate a 2.0 fps velocity for a flow rate of 751 cfs with a slope of approximately 0.00011. The length of the Courtland Canal subjected to canal prism reshaping was estimated at 29.6 miles (from Superior – Courtland Diversion Dam to Lovewell).

The original design of Courtland Canal included limited sections of non-reinforced concrete lined-canal. Over the years, these concrete lined sections have deteriorated beyond the point of repair. The Courtland canal rehabilitation would involve the removal of the existing concrete-lined sections. The rehabilitated canal prism would be sized to accommodate an estimated 2.9 fps velocity for a flow rate of approximately 751 cfs with a slope of 0.00008. Approximately, 15,000-ft of existing concrete-lined canal would be removed and replaced with 60 mils thick geomembrane on the canal prism invert and side slopes. Additionally, 8-inches of gravel cover over the membrane would be placed in the invert of the canal prism. The geomembrane would be exposed on the canal prism side slopes.

Currently there are six county road crossings using modified railroad tanker cars that are undersized and restrict canal flows. The crossings are to be replaced with road bridges that will accommodate the original design flow of 751 cfs.

Canal excavation, backfill and compacted backfill quantities were computed based on estimated canal cross sections. Quantities for canal earthwork, including common excavation, backfill and compacted backfill, were based on a typical canal section.

3.4.2.1.3 Modifications for Winter Operations

A bubbler system is proposed for each of the radial gates at the 11 check structures on Courtland Canal and canal headworks at the Diversion Dam in order to provide for

winter operations. The bubbler system would prevent the buildup of ice at the gates, thereby maintaining necessary flow control in the canal during the winter season. The cost estimate also includes furnishing and installing single phase 5 kilovolts (kV) power line with wood poles based on a 1.0 mile pull. The power would also be used for the Remote Terminal Unit (RTU) and radial gate motor operators.

3.4.2.1.4 Canal Automation

The automation component consisted of automation of the radial gates at 11 check structures and the canal headworks at the Diversion Dam. A local control mode would be used, based on upstream and downstream water depths to control the radial gate.

A RTU would provide the control at the individual radial gate. The RTU would consist of a PC-based controller which would receive input from gate position and water depth sensors. The RTU would provide local control of the radial gate based on control algorithms and control software.

Power would be provided to the RTU. The radial gates would be provided with a motor operator to allow the RTU to automatically raise or lower the gate position.

Stilling wells would be installed at the 11 check structures for monitoring the depth upstream and downstream of the radial gate[2]. A pressure transducer would be placed in each stilling well for water depth measurement. The pressure transducer would transmit water depth data back to the RTU.

3.4.2.2 Components to Increase Storage Capacity in Lovewell Reservoir

Lovewell Dam impounds water from White Rock Creek and from diversions of the Republican River made available by the Superior-Courtland Diversion Dam through the Courtland Canal. Based on Lovewell Reservoir Area and Capacity Tables dated June 1995, the existing Lovewell Reservoir has an active conservation capacity of 24,022 ac-ft at the top of active conservation Elevation 1582.6, and an additional 50,460 ac-ft of flood control space between reservoir Elevation 1582.6 and Elevation 1595.3. A surcharge space of 94,146 ac-ft is available between the top of flood control pool and the maximum water surface elevation of 1610.3 feet.

Lovewell Dam, completed in 1957, is a zoned earthfill embankment with a structural height of 93 feet and total crest length of 8,500 feet. The main portion of the dam across the valley floor and creek channel, station 2+33 to station 56+69, has a crest width of 30 feet and crest elevation of 1616 feet. A dike section extending along the left abutment, starting at station 61+50, has a crest width of 20 feet and crest elevation of 1614 feet. Between stations 56+69 and 61+50, the crest transitions from Elevation 1616 to Elevation 1614. Near the left

[2] Typically, stilling wells should be located at least 50 to 100 ft upstream and 100 to 200 ft downstream from check structures.

end of the dike section there is an existing railroad grade utilized primarily to transport agricultural commodities.

The spillway, located on the right abutment, is a gated-chute type structure with a stilling basin and short outlet channel. The spillway has two bays, each 25 feet wide, with an ogee crest at Elevation 1575.3. Flows are controlled by two 25- by 20-foot radial gates. The spillway discharge capacity is 35,000 ft^3/s at the design maximum water surface Elevation 1610.3, and 14,600 ft^3/s at the top of flood control pool Elevation 1595.3.

The outlet works, adjacent to and south of the spillway on the right abutment, provide releases into the Lower Courtland Canal. The outlet works consist of a trash-racked inlet, an emergency gate, a radial regulating gate, a stilling basin, a radial wasteway gate, two canal radial regulating gates, and a ramp flume. The design capacity of the outlet works is 635 cfs at reservoir Elevation 1571.7.

Existing State Highway 14 crosses the Lovewell Reservoir approximately 5 miles above the dam axis. The highway is a paved 28-foot-wide roadway with a 371-foot-long bridge with approaches across White Rock Creek. The top of the road is at approximate Elevation 1603. The State of Kansas has provided a flood easement to the United States up to Elevation 1595.3.

There are 62 privately owned cabins located in an area west of the State Park on the north side of Lovewell Reservoir. All of the cabins have been constructed above the top of active conservation pool (Elevation 1582.6). Most of these cabins are located above the top of the highest proposed increased conservation pool (Elevation 1592.0). The cabin owners lease their lots from the Kansas Division of Wildlife and Parks. A single lane boat ramp and about 12 boat docks are maintained by the cabin owners but are designated for public use. Those alternatives which increase the conservation storage in Lovewell Reservoir may impact some of the private cabins. The exact number of cabins to be affected is unknown at this time. Updated topographic maps will be needed to analyze potential impacts if additional studies take place in the future

The recreation facilities at Lovewell include a marina, leased cabins, approximately 56 trailors, numerous campsites, boat ramps, boat docks, fuel storage and distribution, picnic shelters, shower and restroom facilities, and parking lots. Specifics of the recreation facilities as related to this Study are discussed in Appendix C.

For this Study, two alternatives were considered to provide additional active conservation storage capacity in Lovewell Reservoir: 1) increasing Lovewell capacity by 16,000 ac-ft, and, 2) increasing Lovewell capacity by 35,000 ac-ft. These alternatives involve modifications to the existing dam and appurtenant structures to allow an increase in the active conservation capacity and the total

reservoir capacity, while maintaining the existing flood control and surcharge capacities. Increasing the reservoir conservation storage would allow storage of excess Republican River flows delivered to the reservoir through the Courtland Canal and also excess White Rock Creek flows. Increasing conservation storage capacity at Lovewell Reservoir may be considered a viable option for storing any excess flows as long as the required modifications to Lovewell Dam and appurtenant structures, and the resulting changes in operation of the facilities, do not increase risks to the public. Proposals that converted a portion of the flood control storage to conservation storage without modifications to the dam were considered but rejected due to the increased flood risks. Evaluation of the potential risks to the public considering the existing and modified structures and operations are summarized in Section 3.4.2.2.3 below.

3.4.2.2.1 Increase Lovewell Capacity – 16,000 ac-ft

Raising the crest elevation of the left abutment dike section from Elevation 1614 feet to the main dam crest Elevation of 1616 feet would provide an increase in total reservoir capacity of about 16,000 ac-ft. The additional 16,000 ac-ft of reservoir storage would be allocated to active conservation capacity by raising the top of active conservation pool from Elevation 1582.6 to Elevation 1587.3. To maintain the existing flood control capacity, the top of flood control pool would be raised from Elevation 1595.3 to Elevation 1598.3. The original reservoir surcharge capacity would remain at about 94,000 ac-ft with the dike section crest elevation raised to the main dam crest Elevation 1616.0 and the freeboard volume would change to reflect the capacity changes.

The appraisal level design and cost estimates for increasing the reservoir capacity by 16,000 ac-ft include raising the existing dike crest elevation to match the dam crest Elevation 1616, extending the left end of the dike about 400 feet at the new crest elevation, and raising the existing spillway ogee crest by about 3 feet. Raising the dike crest elevation requires excavating unsuitable material from the existing dike and foundation for the dike extension on the left end, placing and compacting embankment fill, and furnishing and placing riprap, bedding, and gravel surfacing. Raising the spillway crest requires excavation of existing crest structure concrete to obtain a suitable bonding surface, and placing new concrete to provide an ogee crest at Elevation 1578.3. Modifications to the outlet works are not required. Relocation of an existing railroad near the left end of the dike and the State Highway 14 roadway and bridge at the upper end of the reservoir appear to be unnecessary.

3.4.2.2.2 Increase Lovewell Capacity – 35,000 ac-ft

Raising the crest elevation of the existing dam and dike section to Elevation 1619 would increase the total reservoir capacity about 35,000 ac-ft. The additional 35,000 ac-ft of storage would be allocated to active conservation capacity by raising the top of active conservation pool from Elevation 1582.6 to Elevation 1592.0. To maintain the existing flood control capacity, the top of the flood control pool would be raised from Elevation 1595.3 to Elevation 1601.6. The

original reservoir surcharge capacity would remain at about 94,000 ac-ft with the dam and dike crest elevations raised to Elevation 1619 and the freeboard volume would change to reflect the capacity changes.

The appraisal level design and cost estimates for increasing the reservoir capacity by 35,000 ac-ft include raising the dam crest elevation by 3 feet, raising the dike section crest by 5 feet, and extending the left end of the dike about 1,000 feet at the new crest elevation. The existing spillway ogee crest would be raised about 6 feet. In addition, the spillway gates would have to be modified to accommodate the potential loading from higher reservoir water surfaces.

Raising the crest of the dam and dike sections will require excavation of unsuitable materials from the existing crests and the foundation for the dike extension, placing and compacting embankment fill, and furnishing and placing riprap, bedding, and gravel surfacing. Soil-cement or geo-grid reinforced fill would be used to allow a relatively steep downstream slope for the raised section, minimizing the amount of earthfill required for the dam raise.

Raising the spillway crest requires excavation of existing crest structure concrete to obtain a suitable bonding surface, and placing new concrete to provide an ogee crest at Elevation 1581.6. In addition, the existing spillway gates and hoisting equipment would have to be removed, modified, and reinstalled to accommodate the higher maximum reservoir water surface elevation. A relocation of an existing railroad line near the left end of the dike section will be necessary. In addition there will likely be a need to raise or protect the existing Highway 14 roadway crossing at the upper end of the reservoir. Costs for addressing impacts to the railroad and highway were not specifically identified. It was assumed that these costs would be covered under 'unlisted items' in the cost estimate. Modifications to the outlet works are not required.

3.4.2.2.3 Lovewell Dam Safety Issues

Enlargement of Lovewell Dam and Reservoir would be accomplished consistent with Reclamation's Guidelines for Achieving Public Protection in Dam Safety Decision Making, dated June 15, 2003. Reclamation policy would require a Dam Safety Decision approving the enlargement. The Dam Safety Decision document would be supported by an analysis of dam safety risks for the modified structure. Previous dam safety studies for Lovewell Dam for hydrologic events show that the dam overtops by up to 5 feet for 19 hours during the Probable Maximum Flood (PMF). The most recent PMF, developed in 1986, consists of a general storm event with a peak inflow of 301,300 ft^3/s and a 6.2-day volume of 382,600 ac-ft. Flood routings using the Standing Operating Procedures operation criteria show that the dike crest at Elevation 1614 feet would overtop at 63 percent of the PMF. During the 1997 Comprehensive Facility Review (CFR) for Lovewell Dam, a screening level risk assessment was completed which concluded that hydrologic risks could not be adequately determined due to inadequate flood frequency information. The CFR recommended a flood frequency analysis, flood

routings, and revised inundation mapping to refine the results of the screening level assessment.

A "Volume Analysis and Revised Flood Frequency Analysis for Lovewell Dam" was completed in May 2003[3], and "Analyses Addressing Hydrologic/Hydraulic Issues for Lovewell Dam," which included flood routings for the proposed modifications to increase the capacity of Lovewell Reservoir, was completed in September 2003[4]. Routings for a 10,000-year flood show about 9 feet of freeboard and spillway discharges less than the design maximum of 35,000 ft^3/s for the existing dam and for the dam with either of the proposed modifications to increase storage capacity. In a hydrologic risk framework, these results show an annual failure probability significantly less than 0.0001 for the existing dam and for either of the proposed modifications to increase reservoir storage. Estimates of the annualized loss of life due to hydraulic loading also indicate diminishing justification to reduce risk for the existing dam. Analyses completed to date indicate the proposed modification would result in very minor changes in hydrologic risks for the facility.

The 1997 CFR screening level risk assessment estimated the annual probability of failure and annual risk of loss of life for piping/internal erosion and landslides on the right abutment as very low, indicating diminishing justification to take action to reduce risk for these potential failure modes. The proposed modifications to increase reservoir capacity are expected to have little impact on the estimated piping/internal erosion or landslide failure risks because of the relatively small increases in the normal reservoir operating levels.

The proposed modifications are expected to have very little impact upon dam safety risks for Lovewell Dam. Additional dam safety issue analysis would be required when a preferred alternative is selected for modifications. Appropriate risk reduction actions, if any, would be incorporated into the final design. It is expected additional risk reduction measures would be minor relative to the overall scope of the proposed modifications.

3.4.2.3 Other Storage Alternatives

Three other storage alternatives in the Kansas portion of the study area were evaluated by the Value Study Report referenced in Section 1.5. These alternatives were investigated for supplying water for meeting only downstream MDS-related

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[3] "Volume Analysis and Revised Flood Frequency Analysis for Comprehensive Facility Review, Lovewell Dam, Pick-Sloan Missouri Basin Project, Kansas, Great Plans Region," Bureau of Reclamation, Flood Hydrology Group, Technical Service Center, Denver, Colorado, May 2003.

[4] "Analyses Addressing Hydrologic/Hydraulic Issues, Lovewell Dam, Pick-Sloan Missouri Basin Program, Kansas, Great Plains Region," *Technical Memorandum No. LOV-8130-TM-2003-1*, Bureau of Reclamation, Technical Service Center, Denver, Colorado, September 2003.

needs in Kansas, which could include private irrigators who are junior to the MDS. These alternatives included[5]:

- Alternative J – Off-stream storage created by enlarging the South Dam of the Jamestown Waterfowl Management Area

- Alternative K – Off-stream storage created by enlarging the North Dam of the Jamestown Waterfowl Management Area

- Alternative L – Off-stream storage created by constructing a new dam structure on Beaver Creek in Section 12, Township 6 South, Range 4 West

Since the operation of these types of storage options was not modeled by the hydrology model OPSTUDY at this time, no further analysis was performed for these alternatives. For the purposes of this Study, the cost-estimates from the Value Study Report are considered comparable to the cost-estimates included for Alternatives A through I outlined in this report. The findings of the Value Study Report are outlined below.

At the time of this Appraisal Study, it is undetermined as to whether Reclamation, the State of Kansas, or some other entity would own and operate any of the above facilities should they be constructed. If it is determined that Reclamation will own and operate the facilities, the dams would be subject to regulation under Reclamation's Dam Safety Program.

3.4.2.3.1 Alternatives J and K. Off-stream Storage – Jamestown Waterfowl Management Area

The State Lake-Jamestown Waterfowl Management Area, also known as Sportsman Lake, is located approximately 7 miles south of Courtland, Kansas. The existing lake is created by two small structures, a "south dam" and a "north dam." Both sections of the lake are relatively shallow, with a total estimated storage of 2,000-3,000 ac-ft.

Alternative J – South Dam Enlargement
By raising the existing dam about 10 feet, it is estimated that an additional 20,000 ac-ft of storage could be provided. An appraisal level estimate was prepared for a dam with a crest elevation at 1400 feet. The maximum dam height is estimated to be 20 feet. The design assumed a 20-foot-wide dam crest that was 8,000-foot long. The upstream slope was assumed to be 3:1 and the downstream slope 2:1.

The 20,000 ac-ft of water could potentially be delivered through the Courtland West Canal. The Courtland West Canal has a capacity of at least 80 cfs until a point in the middle of Section 33, Township 4 South and Range 5 West. From

[5] In the Value Study Report, Alternatives J, K, and L were designated as Proposal F1, F2, and G, respectively.

that point a 4-mile-long pipeline would drop the water to Marsh Creek just above where it flows into Jamestown Reservoir. An 80 cfs continuous flow would deliver the 20,000 ac-ft in 126 days, which would be expected to be allowed within the irrigation off-season. This would affect the Operation and Maintenance (O&M) with a longer operating season.

Alternative K – North Dam Enlargement
By raising the existing north dam about 10 feet, it is estimated that an additional 10,300 ac-ft of storage could be provided. An appraisal level estimate was prepared for a dam with a crest elevation at 1400 feet. The maximum dam height is estimated to be 10 feet. The design assumed a 20-foot-wide dam crest that was 2,400-foot long. The upstream slope was assumed to be 3:1 and the downstream slope 2:1.

The 10,300 ac-ft of water could potentially be delivered through the Courtland West Canal. The Courtland West Canal has a capacity of at least 80 cfs until a point in the middle of Section 33, Township 4 South and Range 5 West. From that point a 4-mile-long pipeline would drop the water to Marsh Creek just above where it flows into Jamestown Reservoir. A 40 cfs continuous flow would deliver the 10,300 ac-ft in 126 days, which would be expected to be allowed within the irrigation off-season. This would affect the O&M with a longer operating season.

3.4.2.3.2 Alternative L. Off-stream Storage – Kansas Tributaries, Beaver Creek

The Value Study Report identified a site on Beaver Creek as a potential storage site in Kansas. The site is located in Section 12, Township 6 South, Range 4 West, and would hold an estimated 8,500 ac-ft. The dam structure associated with this size impoundment would be approximately 40-foot high with a 2400-foot crest length.

The site has a drainage area of approximately 36 square miles. No streamflow data are available for Beaver Creek at this location, but a preliminary estimate using hydrologic data for White Rock Creek would indicate inflow to the Beaver Creek site would be approximately 3,200 ac-ft per year. Water could also be delivered to the reservoir by the Courtland Canal. The Courtland Canal passes the reservoir site about ½-mile to the east.

3.4.2.4 Recreation Mitigation

Costs for relocating recreational facilities that could be affected by those alternatives which include raising Lovewell Dam were derived from aerial photography and estimates and assumptions summarized below and in Appendix C. The estimates of inundated areas on the aerial photos were based on elevations that did not precisely match the estimated elevations of the two dam

raise options[6]. These estimates were developed using the best available information at this time. The cost of relocating or extending the recreational facilities affected by the high raise of the conservation pool in Lovewell Reservoir (Alternatives F and G) to Elevation 1592 is probably overestimated, since the aerial photo delineation took in a larger area than would actually be affected. Conversely, the cost of relocating or extending the recreational facilities affected by the low raise of the conservation pool in Lovewell Reservoir (Alternatives D, E, H and I) to Elevation 1587.3 is probably underestimated since the aerial photo delineation took in a smaller area than would actually be affected.

The National Park Service's "Cost Estimating Guideline with Class C Cost Data" was used to determine unit costs for the various recreation facilities. Quantities were estimated from the aerial photographs but should be considered to be gross estimations as the discernable detail on the aerial photos was limited. This cost data guideline was used because it has been shown that Reclamation costs are similar to those borne by the Park Service. Class C cost estimates are referred to as "conceptual" or "order-of-magnitude" estimates. Class C cost estimates are usually used for:

- Appraisal studies
- Selection from among alternative designs
- Development of project scope and program

Additionally, a Class C estimate is a conceptual cost estimate based on square footage cost of similar construction. Class C cost estimates are usually prepared without a defined scope of work. A location factor is assigned to account for regional variations such as geographic accessibility, work force availability, cost of building materials, etc. For the purposes of this Study, a location factor of minus eight was used[7]. This is the location factor assigned by the Park Service for the National Tall Grass Prairie Preserve, the closest Park Service managed area to Lovewell Reservoir.

For each option, two component costs were estimated: the costs associated with facilities in Lovewell State Park and the costs associated with Lovewell State Wildlife Area. The detailed cost estimates, including the design assumptions, for the recreational facilities are included in Appendix C. The estimated costs are summarized in Table 4 below. These costs do not include the costs of mobilization, unlisted items, contingencies and non-contract costs.

[6] The aerial photos delineated elevation 1595' to represent the high raise (Alternative F and G) and elevation 1583 to represent the low raise (Alternatives D, E, H and I). However, the actual elevation levels are projected to be 1592 and 1587.3 respectively.

[7] This translates into an 8 percent reduction in the estimated cost of the facilities.

TABLE 4. ESTIMATED COSTS SUMMARY FOR THE RECREATIONAL FACILITIES

Option	State Park Costs	State Wildlife Area Costs	Total Costs
Low Raise (to 1587.3')	$130,000	$36,000	$166,000
High Raise (to 1592.0')	$1,900,000	$250,000	$2,150,000

3.4.2.5 Cost Estimates

This section discusses estimated field and non-contract costs and summarizes costs for the nine alternatives.

3.4.2.5.1 Contract Cost Estimates

Construction contract cost estimates are included in Appendix B. Construction contract costs referred to as field cost in the Appendix include 5 percent for mobilization, 20 percent for unlisted items, and 25 percent for contingencies. Definitions for these items follow:

Mobilization. Percentage allowance, for: movement of personnel, equipment, supplies, and incidentals to the project site; establishment of offices, buildings, plants and other facilities; premiums for project bonds and insurance;

Unlisted Items. Percentage allowance for additional items of work which will appear in the final design required for a fully finished feature.

Contingencies. Percentage allowance to cover minor differences between actual and estimated quantities, unforeseeable difficulties at the site, possible minor changes in plans, and other uncertainties.

3.4.2.5.2 Non-contract Cost Estimate

Non-contract activities are usually based on a percentage of construction costs. The costs are shown in Table 5.

TABLE 5. NON-CONTRACT COSTS

Activity	Percent of Contract Costs
Planning	5.0
Investigations	3.5
Design and Specifications	3.0
Contract Administration	6.0
Water Rights	0.5
Environmental Permits[8]	5.0
Right-of-Way (ROW)	2.0
TOTAL	25

[8] The environmental permitting multiplier includes the cost for activities such as environmental mitigation and cultural resource mitigation.

The total project cost for each of the alternatives is shown in Table 6. The costs of Alternatives J, K, and L were derived by increasing the costs identified for those alternatives in the Value Study Report by 5 percent to account for cost of inflation.

TABLE 6. TOTAL PROJECT COST FOR EACH OF THE ALTERNATIVES

Alternative	Feature	Pay Item Cost	Field Cost[1]	Total Project Cost[2] (8/2002)	Total Project Cost[2] (11/2003)
A	Reshape Courtland Canal	$1,359,553			
	Removal of Existing Concrete Lining	$1,402,155			
	Geomembrane Lining	$2,459,485			
	Bubblers	$272,000			
	County Bridges	$994,000			
	Total	$6,487,193	$10,000,000	$12,500,000	$13,000,000
B	Automate Gates	$308,000			
	Stilling Wells	$362,250			
	Bubblers	$272,000			
	Total	$942,250	$1,500,000	$1,900,000	$2,000,000
C	Automate Gates	$308,000			
	Stilling Wells	$362,250			
	Bubblers	$272,000			
	County Bridges	$994,000			
	Reshape Courtland Canal	$1,359,553			
	Removal of Existing Concrete Lining	$1,402,155			
	Geomembrane Lining	$2,459,485			
	Total	$7,157,443	$11,500,000	$14,500,000	$15,000,000
D	Automate Gates	$308,000			
	Stilling Wells	$362,250			
	Bubblers	$272,000			
	Raise Lovewell 16,000 AF	$624,100			
	Recreation Mitigation	$166,000			
	Total	$1,732,350	$2,700,000	$3,400,000	$3,600,000

[1] Field Cost includes mobilization, unlisted and contingency costs.
[2] Total Project Cost includes non-contract costs of 25 percent.

TABLE 6. TOTAL PROJECT COST FOR EACH OF THE ALTERNATIVES

Alternative	Feature	Pay Item Cost	Field Cost[1]	Total Project Cost[2] (8/2002)	Total Project Cost[2] (11/2003)
E	Automate Gates	$308,000			
	Stilling Wells	$362,250			
	Bubblers	$272,000			
	County Bridges	$994,000			
	Reshape Courtland Canal	$1,359,553			
	Removal of Existing Concrete Lining	$1,402,155			
	Geomembrane Lining	$2,459,485			
	Raise Lovewell 16,000 AF	$624,100			
	Recreation Mitigation	$166,000			
	Total	$7,947,543	$12,500,000	$15,500,000	$16,500,000
F	Automate Gates	$308,000			
	Stilling Wells	$362,250			
	Bubblers	$272,000			
	Raise Lovewell 35,000 AF	$2,698,100			
	Recreation Mitigation	$2,150,000			
	Total	$5,790,350	$9,100,000	$11,500,000	$12,000,000
G	Automate Gates	$308,000			
	Stilling Wells	$362,250			
	Bubblers	$272,000			
	County Bridges	$994,000			
	Reshape Courtland Canal	$1,359,553			
	Removal of Existing Concrete Lining	$1,402,155			
	Geomembrane Lining	$2,459,485			
	Raise Lovewell 35,000 AF	$2,698,100			
	Recreation Mitigation	$2,150,000			
	Total	$12,005,543	$19,000,000	$24,000,000	$25,000,000
H	Raise Lovewell 16,000 AF	$624,100			
	Recreation Mitigation	$166,000			
	Total	$790,100	$1,250,000	$1,550,000	$1,650,000

[1] Field Cost includes mobilization, unlisted and contingency costs.
[2] Total Project Cost includes non-contract costs of 25 percent.

TABLE 6. TOTAL PROJECT COST FOR EACH OF THE ALTERNATIVES

Alternative	Feature	Pay Item Cost	Field Cost[1]	Total Project Cost[2] (8/2002)	Total Project Cost[2] (11/2003)
I	County Bridges	$994,000			
	Reshape Courtland Canal	$1,359,553			
	Removal of Existing Concrete Lining	$1,402,155			
	Geomembrane Lining	$2,459,485			
	Raise Lovewell 16,000 AF	$624,100			
	Recreation Mitigation	$166,000			
	Total	$7,005,293	$11,000,000	$14,000,000	$14,500,000
J	Jamestown Enlargement – South				$14,490,000
K	Jamestown Enlargement – North				$6,720,000
L	Beaver Creek				$12,600,000

[1] Field Cost includes mobilization, unlisted and contingency costs.
[2] Total Project Cost includes non-contract costs of 25 percent.

3.4.2.5.3 Annual Operation, Maintenance and Replacement (OM&R) Costs

No quantitative analysis of the OM&R was performed for this Study. Future more detailed studies would include the estimated costs for OM&R for each of the potential alternatives. Generally, it is expected that those alternatives involving existing facilities would have a smaller increase in annual OM&R costs as compared to those alternatives involving new project facilities. However, for those alternatives involving systems automation, it is recognized that trained electronics personnel would be necessary. The following table summarizes qualitatively the expected changes in OM&R costs for each of the alternatives:

TABLE 7. SUMMARY OF ALTERNATIVES–OM&R IMPACTS

Alternative	Implementation Costs	OM&R Costs	Comments/Observations
A	$13,000,000	2	Longer operation period.
B	$2,000,000	2	Automation requires trained staff. Longer operation period.
C	$15,000,000	2	Automation requires trained staff. Longer operation period.
D	$3,600,000	2	Automation requires trained staff. Longer operation period.
E	$16,500,000	2	Automation requires trained staff. Longer operation period.
F	$12,000,000	1	Automation requires trained staff. Longer operation period.
G	$25,000,000	1	Automation requires trained staff. Longer operation period.
H	$1,650,000	3	Only minor changes in O&M procedures on an existing facility.
I	$14,500,000	2	Longer operation period.
J	$14,490,000	2	Major modifications of existing facility.
K	$6,720,000	2	Major modifications of existing facility.
L	$12,600,000	1	New facility.

1-Major Increase in OM&R; 2-Moderate Increase in OM&R; 3-No Change in OM&R

3.4.3 Economic Benefit Evaluation

This economic portion of the Study estimates the economic benefits accruing from the changes to operations associated with each alternative. These benefits will then be compared to project costs. Annual O&M costs are usually not part of an appraisal-level study but would be included in a feasibility study.

The hydrology analyses described above modeled operation of the system under each alternative scenario with the intent to maximize irrigation benefits. Additional hydrological analyses to model system operation to emphasize other potential resource needs, such as MDS, were not performed at this level of study. As a result, only irrigation benefits have been quantitatively estimated. Allocation of water to provide MDS benefits could reduce the water available for irrigation, resulting in a reduction of irrigation benefits and a potential increase in MDS related benefits. The extent to which such increased MDS benefits might offset the lost irrigation benefits is unknown at this time.

Potential irrigation benefits or MDS benefits of a Beaver Creek Dam and Reservoir or an increase in the size of Jamestown Reservoir were not estimated. The hydrology model was not revised to incorporate these additional facilities.

The alternatives which include increasing the size of Lovewell Reservoir would have the potential to increase the recreational use of facilities at the Reservoir. While these potential benefit increases were not quantitatively estimated at this level of study, they are qualitatively assessed below. Increasing the storage in Lovewell Reservoir and/or increasing canal capacity would also allow storage to remain in Harlan County Lake for longer periods of time. This could potentially increase recreational use of facilities at Harlan County Lake.

3.4.3.1 Irrigation Benefit Estimation

Irrigation benefits were estimated by isolating the incremental net farm income from the relatively small changes in the irrigation water supply associated with the alternatives. To determine the incremental income, the net farm income in a "without project" baseline condition was compared to a "with project" baseline condition. For small changes in the water supply, the best indicator of benefits comes from predicted changes in yields. For the purposes of this Study, the change in yield of only the most dominant crop for the area, corn, was evaluated. A spreadsheet model developed by the University of Nebraska was used to estimate the yields for the varying levels of water supply[9].

This benefit analysis of the potential irrigation benefits was conducted to conform with National Economic Development (NED) standards as published in "The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (Principles and Guidelines). Therefore, normalized prices published by the USDA Economic Research Service (U.S. Department of Agriculture, ERS) were used to determine the change in gross revenues. Gross revenues on a per acre basis were calculated by multiplying yield changes per acre by price per bushel.

Variable costs of production, resulting from the projected change in the amount of irrigation water applied, were taken from farm budgets prepared by the University of Nebraska[10]. The only cost which was expected to change with yield was the harvesting cost[11]. This same assumption applies to the cultural practices such as plowing, disking, and cultivating and the management skills of the farmer.

The annual irrigation benefits were transformed into a present worth value by taking the annual benefit into the future 100 years and then discounting it back to the present. The fiscal year 2003 federal discount rate of 5.875 percent was used in this report.

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[9] Further information on the modeling and the benefit analysis is provided in Appendix D.

[10] For further discussion of the methodology utilized, please refer to Appendix D of this report.

[11] Other production costs are assumed to not change. For example, the same amount of fertilizer will be applied to corn that produces 140 bushels as will be applied to 144-bushel corn.

3.4.3.1.1 Irrigation Benefits of Corn Production

The range of current corn yields was derived from data included in previously completed economic studies and from the Nebraska Agricultural Statistics. Average district-level irrigated yields for 1991-95 are shown in Table 1 of Appendix D.

The simple average of irrigated yields for the two irrigation districts came to 153.4 bushels. This average irrigated yield was considered the yield being obtained by farmers in recent years with the available water supply.

The yield estimation model was modified to account for the range of water supplies estimated by the hydrology models. The estimated yield for the Baseline Alternative came to 154.5 bushels of corn per acre. This is 0.9 bushels higher than the reported average for the two districts. Overall, water supplies ranged from a low of 11.5 acre-inches to a high of 13.8 acre-inches. Estimated yields ranged from a low of 154.5 bushels per acre to a high of 161.1 bushels. The yields estimated by the model are shown in Table 8.

TABLE 8. ESTIMATED YIELDS FOR THE SELECTED WATER SUPPLY RANGE

Alternative Name	Inches of Water to Farm	Corn Yield (bu)
Baseline	**11.5**	**154.5**
A	11.7	155.2
B	12.0	156.2
C	12.2	156.8
D	13.0	159.2
E	13.1	159.4
F	13.7	160.9
G	13.8	161.1
H	12.4	157.4
I	12.4	157.4

bu = bushels

Based on the above estimated yields, gross revenues under each alternative were calculated using the Economic Research Service (ERS) normalized price of $2.25/bushel. Total variable costs of production (custom work, seed, fertilizer, chemicals) came to $135.54 per acre excluding custom costs of harvest[12]. After subtracting all the costs of production, the estimated net revenues for corn production under each alternative were computed. Gross revenues from the analysis ranged from a low of $347.55 per acre to $362.58 per acre. Net revenues per acre, after subtracting out all costs of production, ranged from $191.93 to $206.09. The net revenues obtained from each alternative had higher net revenues

[12] Custom harvest costs that changed under the selected alternatives came from a transportation charge of $0.13 per bushel.

than the Baseline Alternative. Alternatives F and G had the largest changes in net revenue. Gross and net revenues per alternative are shown in Table 3 of Appendix D. Appendix D provides details on all the above calculations.

Based on the estimated net revenues, or benefits, per acre, the total annual net benefits were computed by multiplying the per acre benefit by the 65,435 acres[13] expected to receive benefits. The estimated baseline total annual benefits were $12,559,172[14]. Assuming this amount of benefits accrue each year over the next 100 years and is then discounted back to today's dollars using a discount rate of 5.875 percent, the net present value is $213,064,200.

This calculation was performed for each alternative, and the incremental change caused by the alternative was calculated by taking the difference between the net present value of the baseline and the alternative. Table 9 shows the total benefits for the baseline and other alternatives and the incremental net present value of irrigation benefits for each alternative.

TABLE 9. INCREMENTAL IRRIGATION BENEFITS FOR EACH ALTERNATIVE

Alternative	Baseline Benefits for All Acres	Alternative Benefit for All Acres	Incremental Net Present Value Relative to the Baseline
Baseline	**$ 213,064,200**		
A		$ 214,703,193	$ 1,638,993
B		$ 217,056,592	$ 3,992,391
C		$ 218,566,319	$ 5,502,118
D		$ 224,094,585	$ 11,030,384
E		$ 224,727,338	$ 11,663,138
F		$ 228,246,335	$ 15,182,134
G		$ 228,779,179	$ 15,714,979
H		$ 220,020,541	$ 6,956,341
I		$ 220,020,541	$ 6,956,341

Alternative G had the biggest water supply increase and the greatest benefits, followed by Alternative F.

3.4.3.2 Evaluation of Recreation Benefits

Based on existing research, recreation use of a reservoir often increases as water levels rise. As long as most recreation facilities are still accessible, higher water levels are typically preferred given the increased surface acreage and improved aesthetics (i.e. reduced mud, flats, and "bath tub" rings). For Alternatives D-I, which include the two options for raising the conservation pool in Lovewell

[13] Of this total, 22,935 acres are located in Nebraska and 42,500 acres are in Kansas.

[14] Net income of $191.93 times 65,435 acres.

Reservoir, it is therefore possible that recreational use of the reservoir might increase if the existing recreational facilities expected to be inundated by higher water levels were replaced or extended. However, quantification of these benefits would require a level of data collection and analysis that is beyond the scope of an appraisal study, and as a result, the evaluation of these potential benefits is treated qualitatively in this report.

The recreation analysis at Lovewell Reservoir looked at the projected monthly availability of recreation facilities for each alternative as compared to the baseline alternative. Two iterations of analysis were performed:

- First Iteration: An analysis that did not take into consideration possible relocation or extension of the facilities

- Second Iteration: An analysis that assumes inundation of facilities is mitigated by relocation or extension of the facilities.

The results of the second iteration analysis under average water conditions are presented below. Complete results for both the first and second iteration analyses are presented for average, wet, and dry water conditions in Appendix E.
For dam raising alternatives D-I, most of the potential recreation benefits (relative to the baseline) would not be realized unless the investment was made to relocate/extend the recreational facilities which would be affected by higher water levels. The cost associated with this mitigation (discussed in Section 3.4.2.4 above) has been included in the alternative specific cost estimates. These facility relocation/extension costs assume the facilities would be replaced in-kind. For the purposes of this Study, it was assumed that in-kind replacement of boat ramps, which allowed for the use of the ramps at the higher water levels, would continue to provide service down to the lowest water levels currently being served. For some facilities, this may not be possible due to the topography in the area, and in these cases the benefits at lower water levels may not be fully realized.

3.4.3.2.1 Methodology

Recreation facilities were separated into water-based and water-influenced facilities. Water-based facilities reflect those that depend on access to the water, including facilities such as boat ramps, marinas, and swimming beaches. At Lovewell Reservoir, there are six boat ramps (concessions area (2), marina, cabin area, Oak Hill, and Highway 14), one marina, and one swimming beach. Water-influenced facilities include campgrounds, picnic areas, trailer sites, and cabins. While use of these land-based but water-influenced facilities may be affected by water level fluctuation due to changing reservoir aesthetics, the thrust of the analysis is on the evaluation of possible flooding effects due to lost access.

To provide data for both the first and second iteration facility availability analyses, information was needed for both high end and low end usability thresholds where each of the facilities become unavailable. For example, boat ramps are only usable across the range of water levels which maintain access to the ramp. Water levels below the low end or above the high end of the ramp would result in the ramp being unusable. This high-and low-end concept was used for the water-based facilities. Under the second iteration analysis presented below, for alternatives that involve raising Lovewell Dam (i.e., Alternatives D through I), it is assumed that potentially inundated recreational facilities would be relocated or extended. As a result, only the low end thresholds would be relevant to this analysis since the current high end thresholds would no longer be a constraint.

Since the water-influenced facilities are land-based, low-end usability thresholds are not applicable (i.e., low water levels do not preclude use). Given the assumption that these facilities would be moved to higher ground if necessary, they should be available for all months and alternatives under the second iteration analysis. Therefore, these facilities are not discussed in the remainder of this section. Table E-1 in Appendix E shows the availability thresholds used in the second iteration analysis.

Projected end of month (EOM) water levels at Lovewell Reservoir, measured in terms of feet above mean sea level (msl), were obtained from the hydrology model. Three different hydrologic conditions were evaluated for each alternative – average, dry, and wet. Average conditions were based on average EOM water levels for each month. Dry conditions were based on the water level representing the 10th percentile of projected water levels for each month (i.e., water levels are expected to be higher than the dry condition level 90 percent of the time). Wet conditions were based on the water level representing the 90th percentile of projected water levels for each month (i.e., water levels are expected to be higher than the wet condition level only 10 percent of the time).

The monthly water levels for each alternative under average, dry, and wet conditions were compared to the facility usability thresholds to estimate monthly facility availability. Since monthly water levels reflect a single day at the end of each month, the analysis provides a general indicator of possible impacts and does not account for changes in daily water levels within each month. Water level data was obtained for all months, but the information is only presented for the months of May through September when recreation activity is highest. Facility availability for each alternative is also compared to the baseline alternative to identify differences.

3.4.3.2.2 Results

The facility availability results for all three hydrologic conditions are displayed in Appendix E. The results for the average hydrologic conditions are discussed below.

Baseline. Based on the high and low end facility availability thresholds and the EOM water levels for the baseline alternative, none of the six boat ramps are projected to be available on average during the months of July through September. In addition, the high water ramps (Oak Hill and Highway 14) are projected to be unavailable on average during May and June. The Lovewell marina is projected to be unavailable on average during July through September and Lovewell beach is projected to be unavailable on average in August. The unavailability of these facilities is due to low water levels.

Alternative A. Courtland Canal to Design Capacity, Winterize. Based on average hydrologic conditions, facility availability for this alternative is the same as the baseline.

Alternative B. Automate, Winterize Courtland Canal. Based on average hydrologic conditions, facility availability for this alternative is the same as the baseline.

Alternative C. Automate, Winterize, Courtland Canal to Design Capacity. Based on average hydrologic conditions, facility availability for this alternative is the same as the baseline.

Alternative D. Automate, Winterize Courtland Canal; Raise Lovewell 16,000 ac-ft.

Compared to the baseline, additional facility availability is expected to occur on average as follows: Oak Hill and Highway 14 ramps in May and June; marina in July; and the beach in August.

Alternative E. Automate, Winterize, Courtland Canal to Design Capacity; Raise Lovewell 16,000 ac-ft. This alternative follows essentially the same pattern of facility availability as Alternative D. The only difference lies in the additional availability of the concessions area ramps in July. This also reflects an additional gain in facility availability compared to the baseline alternative. Total gain in facility availability compared to the baseline is as follows: concessions ramps in July; Oak Hill and Highway 14 ramps in May and June; marina in July; and the beach in August.

Alternative F. Automate, Winterize Courtland Canal; Raise Lovewell 35,000 ac-ft.

In addition to the gains made from the baseline by Alternative E, Alternative F also provides that the marina and cabin area boat ramps are available in August. The total gain in facility availability compared to the baseline is as follows: concessions, marina, and cabin area ramps in July; Oak Hill and Highway 14 ramps in May and June; marina in July; and the beach in August.

Alternative G. Automate, Winterize, Courtland Canal to Design Capacity; Raise Lovewell 35,000 ac-ft. This alternative provides the same gains made as Alternative F.

Alternative H. Raise Lovewell 16,000 ac-ft. Of the alternatives which involve raising Lovewell Dam, this alternative provides for the fewest gains relative to the baseline. Relative to the baseline, the alternative provides the additional availability of only the Oak Hill and Highway 14 boat ramps during the months of May and June.

Alternative I. Courtland Canal to Design Capacity; Raise Lovewell 16,000 ac-ft. This alternative would provide the same gains over the baseline as those identified for Alternative D, namely the Oak Hill and Highway 14 ramps in May and June, the marina in July, and the beach in August.

3.4.3.3 Benefit-Cost Analysis

A benefit-cost ratio analysis provides a discounted measure of a project worth and is calculated by dividing the discounted worth of the benefit stream by the discounted worth of the cost stream. A discounted present worth of benefits was found by projecting annual benefits 100 years into the future and then discounting them back to the present using a discount rate of 5.875 percent.

A similar process would be followed for the implementation costs for each alternative if the implementation costs were borne over a period of years. However, for this analysis, the implementation costs are assumed to all accrue in year one of construction, and as a result, no interest during construction was identified for any of the alternatives. Therefore, the stated cost is the net present value of that cost and the benefit values can be compared directly to the cost values shown in Table 10.

When the benefit-cost ratio analysis is used, the selection criterion is to accept all the independent projects with a benefit-cost ratio of 1.0 or greater. Ranking of the alternatives from "best" to "worst" according their benefit-cost ratios should not be done as this may lead to erroneous assumptions about the "best" alternative to select. Instead, the benefit-cost ratios should only be used to provide a "go or no-go" type of decision that can be consistently applied across the alternatives being studied.

Total implementation costs for each alternative were estimated and ranged from $1,650,000 for Alternative H to $25,000,000 for Alternative G. The estimated implementation costs are shown in Table 10 along with the estimated benefits[15].

As can be seen, benefits do not exceed costs for all of the alternatives. The alternatives where benefits exceed costs include Alternatives B, D, F, and H.

[15] As noted previously, the benefits for Alternatives J, K, and L were not estimated as the OPSTUDY model could not model the operation of these facilities.

Alternative B has benefits that exceed costs by $1,992,391. Benefits for Alternatives D, F, and H exceed their implementation costs by $7,430,384, $3,182,134, and $5,306,341, respectively.

The benefits and costs of the proposed alternatives can also be presented as a ratio. Ratios are advantageous in that the "accept" or "reject" decision is easily made. The criterion used in this analysis for accepting an alternative is if the benefit-cost ratio is equal to or greater than 1.0. Alternatives having benefit-cost ratios of less than 1.0 are normally rejected. While some of the alternatives have benefit-cost ratios less than unity, they could be revisited in the early stages of a feasibility study. The benefit-cost ratio is not used for ranking the alternatives. Benefit-cost ratios for the alternatives are shown in Table 11.

TABLE 10. ESTIMATED BENEFITS AND COSTS OF IMPLEMENTATION FOR EACH ALTERNATIVE

Alternative	Estimated Agricultural Benefits	Implementation Cost
A	$1,638,993	$13,000,000
B	$3,992,391	$ 2,000,000
C	$5,502,118	$15,000,000
D	$11,030,384	$3,600,000
E	$11,663,138	$16,500,000
F	$15,182,134	$12,000,000
G	$15,714,979	$25,000,000
H	$6,956,341	$1,650,000
I	$6,956,341	$14,500,000

TABLE 11. BENEFIT-COST RATIOS FOR EACH ALTERNATIVE

Alternative	Benefit-Cost Ratio
A	0.13
B	2.00
C	0.37
D	3.06
E	0.71
F	1.27
G	0.63
H	4.22
I	0.48

3.4.4 Environmental Evaluations

There are environmental resource impacts associated with each alternative. The effects of these impacts can be cumulative if alternatives are combined. The following is a brief summary of the environmental issues that may be associated with the various alternatives. Other potential impacts will be identified during the National Environmental Policy Act (NEPA) scoping process if any alternatives are to be studied further at the feasibility level.

Increased diversions and storage would most likely have a negative impact on Republican River riparian habitat, fisheries and recreation opportunities (fishing) below the diversion point. Additional diversions could result in degraded riparian habitat, reduced fish habitat, impacts on fish health, fish kills, and degraded fishing experience in river reaches below the diversion point.

Lovewell Reservoir is within the Central Flyway and has been an important resource for migratory birds, particularly migrating waterfowl. Reservoir expansion could have short-term negative effects on migratory waterfowl due to construction disturbance, but would most likely have a long-term beneficial effect because of the expanded water surface.

It is likely that the Fish and Wildlife Coordination Act (FWCA) of 1946 would apply if enlargements are proposed at Lovewell Reservoir. The FWCA amendments enacted in 1958 require consultation with the U.S. Fish and Wildlife Service (Service) and the fish and wildlife agencies of States where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified by any agency under a Federal permit or license. Consultation is to be undertaken for the purpose of preventing loss of and damage to wildlife resources." The amendments authorize the transfer of funds to the Service to conduct related investigations. State Agencies in both Nebraska and Kansas may have to be consulted.

The Service was consulted during the preparation of the Basin environmental impact statement for contract renewal. Based on the information contained in the June 2000 Final Environmental Impact Statement, Republican River Basin Repayment and Long-Term Service Contract Renewals, the Service identified the following threatened and endangered species to occur within the Basin (which includes Lovewell Reservoir): bald eagle, Eskimo curlew, interior least tern, piping plover, and whooping crane. Initially it is not believed that implementation of any of the alternatives would significantly adversely affect any of the previously listed species. The Service will be contacted for an updated list of threatened, endangered, proposed, candidate species, and species of concern that may be present within or migrate through the proposed project area. The NEPA compliance document would include an analysis to determine if there are any impacts to identified species.

As previously mentioned, possible permits that may be required include National Pollutant Discharge Elimination System (NPDES) from Nebraska and Kansas and a 404 permit from the Corps. Each of these permits may contain specific environmental stipulations to reduce or compensate for resource-related impacts associated with the activity.

Water quality trends in the Basin have been altered by the major lakes and reservoirs located in the Basin. Diminished streamflow has lowered water quality; with high-quality low flows being depleted, the filling of reservoirs has become more dependent upon high flows of lower quality, causing their quality to further deteriorate. Agricultural practices and agricultural runoff have contributed to the increase in fecal coliform, turbidity, suspended solids, and nitrates throughout the basin.

Surface water within the Basin is turbid and contains a moderate concentration of dissolved minerals. Streams have good oxygen concentrations to support warm-water aquatic life. They carry a fairly high level of nutrient materials, as evidenced by the high concentrations of nitrates and phosphates. Water quality analysis and results indicate that water quality in the Basin is generally good, with the exception of selenium.

Selenium is a naturally occurring trace element found within the Basin. Reclamation studies conducted in 1994 indicate that selenium is elevated at some sampling sites. While selenium levels can be influenced by the weathering of natural rock formations, the levels have probably been increased by human activities including irrigation, which has accelerated the natural leaching process. Although no specific studies have been conducted to determine if reproductive impairments are occurring, no obvious indications of impairment, such as missing age (size) classes of fish species or the disappearance of species have been reported.

It is unknown what role project water plays in the overall Basin selenium load. Reclamation initiated water quality studies in 1994 to evaluate selenium within the basin and the potential risks to aquatic resources. Forty six samples were collected from sites located from near Benkelman, Nebraska, to Norway, Kansas. Samples were collected from sites influenced by project, non-project, and a combination of project and non-project irrigation drain waters. While the data results indicate strong evidence of food-chain bioaccumulation of selenium in aquatic invertebrates and fish, no obvious indications of reproductive impairments have been reported.

3.4.4.1 Alternatives A, B, and C: Alternatives That Only Involve the Diversion Dam and Canal

- Removal of trees on the outside and inside canal prisms may require mitigation.

- If any dredged material is removed from the canal, a spoil site(s) will need to be identified.

- If canal lining is installed, there may be a need to identify location(s) of deer escape structures.

- It may be necessary to apply for a NPDES permit from the appropriate State Agency responsible for environmental quality.

3.4.4.2 Alternatives D, E, H, and I: Alternatives That Also Involve Raising Lovewell 16,000 Ac-Ft.

- The impacts associated with automating and winterizing the Courtland Canal would be similar to those listed above.

- Raising the operating pool elevation at Lovewell Reservoir could result in potential impacts to private cabins due to increased shoreline erosion. The potential exists for increased shoreline erosion reservoir-wide if the operating pool elevation at Lovewell Reservoir is raised. This could result in potential impacts to: (1) private cabins, (2) existing recreational facilities, (3) reservoir fisheries, and (4) mature established trees. Mitigation might be required.

- Shoreline erosion results in increased sedimentation and potential water quality problems.

- Benefits to recreation and fisheries may occur if the conservation pool in Lovewell Reservoir is raised.

3.4.4.3 Alternatives F and G: Alternatives That Also Involve Raising Lovewell 35,000 Ac-Ft.

- The impacts associated with these alternatives are somewhat similar to Alternatives D and E; however, because the operating pool would be increased an additional 19,000 ac-ft, impacts may be significantly greater. For example, higher operating pool elevations under Alternatives F and G might affect a greater number of homes in the private cabin area. To determine the extent of reservoir impacts, it will be necessary to delineate the new water surface elevations.

3.4.5 Socioeconomics

Socioeconomics describes an area in terms of social and cultural values and issues. This includes population numbers, income, and agricultural resources. The counties included in this overview include Franklin, Harlan, Nuckolls, and Webster Counties in Nebraska and Republic and Jewell Counties in Kansas. The information presented here is a partial listing of the data contained in the document entitled "Resource Management Assessment, Republican River Basin, Water Service Contract Renewal"[16] and can be seen in its entirety in that publication.

3.4.5.1 Overview

The socioeconomic structure in the Basin is characterized as a rural, agriculture-based lifestyle. The area is sparsely populated. Business and commerce centers are smaller towns with a high percentage of trade and service businesses being locally owned.

Farming and ranching is a way of life and is the primary economic force in the region. Recreation and tourism has influenced farming and ranching, however. Influences from recreation and tourism include the agricultural sector making changes in reservoir operations and irrigation water deliveries to minimize perceived negative impacts to recreation.

3.4.5.2 Agricultural Production and Value

The agricultural industry has traditionally dominated the economic base and land use in the Basin, a trend that continues today. However, the number of farms has been declining over time, from a high of 7,816 farms averaging about 320 acres in size in 1949 to 3,223 farms averaging 690 acres in 1992. The annual value of agricultural production for the two irrigation districts (Bostwick Irrigation District in Nebraska and Kansas Bostwick Irrigation District No. 2) increased from $12,513,503 in 1978 to $14,258,274 in 1992. The annual value of crop production for the five counties in the study area was about $420.4 million in 1992. Thus, the value of crop production from the two irrigation districts accounts for about 3.4 percent of the total value of production in the counties in 1992. These averages were obtained from the 1992 Census of Agriculture. On a per acre basis, the value of crop production averaged $238.78 (in 1978) across the two irrigation districts and $331.99 per acre in 1992.

3.4.6 Cultural Resources Evaluations

The primary cultural resource requirements applicable to the proposed project are Section 106 of the National Historic Preservation Act and 36 CFR Part 800, the regulations which implement Section 106. These regulations specify a consultation process with the State Historic Preservation Officer, the public, interested parties and Indian Tribes. Through the consultation process,

[16] Resource Management Assessment, Republican River Basin: Water Service Contract Renewal, U.S. Department of Interior, Bureau of Reclamation, Great Plains Region, July 1996.

Reclamation would determine if the proposed project would have an adverse effect on any historic properties (cultural resources which are eligible for inclusion in the *National Register of Historic Places*). If Reclamation determines that there will be an adverse effect, it will enter into a memorandum of agreement with the consulting parties to address the adverse effect. The usual method of mitigating adverse effects to archaeological sites is through archaeological excavation of a portion of the site. Public education or interpretation is another possible method of mitigating an adverse effect.

3.4.6.1 Alternatives A, B, and C: Alternatives That Only Involve the Diversion Dam and Canal

The Superior-Courtland Diversion Dam and Courtland Canal are in themselves cultural resources; actions that would modify these structures would require Section 106 consultation. However, it is not known if consultations would result in a determination that the modifications constitute an adverse effect to the Diversion Dam or canal. Adverse effects to such structures are usually mitigated through thorough documentation, some form of interpretation for the public, or both.

3.4.6.2 Alternatives D, E, F, G, H, and I: Alternatives That Also Involve Raising Lovewell Reservoir

The proposals to increase storage capacities of Lovewell Reservoir may require considerable cultural resources investigations. Additional lands currently outside Federal property boundaries will be directly impacted resulting from increased pool elevations. There are approximately 15 "locations" currently outside Federal property boundaries that may be flooded with the proposed larger reservoir increase. Reclamation will likely obtain title to or easement on these parcels of land. Any lands becoming Federal property, either by fee title or easement, will require cultural resource surveys.

The higher reservoir operation elevations will impact existing riprap, roads, bridges, cabins and recreation facilities. Any construction activity related to these features will require cultural resource surveys.

All archeological sites eligible for inclusion on the *National Register of Historic Places (National Register)* will have to be mitigated prior to any federal undertaking which would impact these sites. Within current Federal property boundaries there are 55 known archeological sites located near the edge of the current normal pool elevation of 1,583 feet and/or extending to an elevation of about 1,600 feet. Of those 55 sites, eleven (11) sites are not eligible for the *National Register* and require no additional work. Sixteen (16) sites are located at the current normal pool elevation and require additional *National Register* testing to determine eligibility. Twenty-one (21) sites are located at the current normal pool elevation plus 5 feet and require additional *National Register* testing. Seven (7) sites are located 5 to 10 feet above current normal pool elevation and require additional *National Register* testing. Included in these numbers are seven (7)

archeological sites which have been identified to be part of an Archeological District or Multiple Property nomination form for the National Register. Additional sites are expected to be identified with the cultural resource activities associated with any future investigations.

The Kansas State Historic Preservation Office (SHPO) is viewing "normal" reservoir operations as Section 106 processes. Any modifications to the existing reservoir will have SHPO involvement. Tribal consultation will also be required on all undertakings.

There are three known Euro-American cemeteries at or near Lovewell Reservoir. One and possibly two may be impacted by raising the water level in Lovewell Reservoir. Monitoring, stabilization and possibly relocation of graves may be required.

Native American burials have been discovered at Lovewell Reservoir. Sixteen burials were excavated from one archaeological site in 1982 and at least five more burials have been discovered since then. It is quite likely that additional Native American burials will be encountered and that additional archaeological excavation and ground disturbance will reveal more Native American burials.

Some of the previously discovered burials have been found to be affiliated with the Pawnee, Wichita, and Arikara (Three Affiliated Tribes) while others have been affiliated with the Oneota tradition. The discovery or excavation of additional Native American human remains are of concern to those tribes, and may be of concern to other tribes which have a connection to the area. Not only would the Tribes be involved in the Section 106 consultations regarding raising Lovewell, they would also be parties to a comprehensive agreement developed pursuant to Native American Graves Protection and Repatriation Act (NAGPRA).

The abandoned town of Rubens, located on the western end of the current reservoir location, would have to be documented. State documents need to be reviewed and may reveal if there was a separate town cemetery located nearby.

3.4.6.3 Other Storage Alternatives

No information is available on cultural resources associated with any of the off-stream storage alternatives. It is reasonable to assume that some archaeological sites or other cultural resource sites are located in the vicinity of the off-stream storage alternatives, but no statements can be made regarding effects to cultural resources based on present information.

3.4.7 Legal and Institutional Evaluations

3.4.7.1 Legal

3.4.7.1.1 Water Rights

The current right to store water in Lovewell Reservoir is held by the KBID for use of irrigation of Bostwick Division lands. If a permanent right to store additional water in Lovewell is desired, an additional storage right may be necessary, depending on purpose and the amount of additional storage. If additional water is stored in a new or other existing storage facility(s), a new storage water right designating the purpose of the storage would be necessary. A natural flow right may also be required. The reach of the Republican River between Harlan County Dam and Hardy, Nebraska is closed to new surface water rights and groundwater well permits at this time.

The settlement stipulation provides for a priority date of February 26, 1948 for Kansas Bostwick Irrigation District diversions of natural flow at Superior-Courtland Diversion Dam. This priority date would not be in effect for other purposes. In the settlement stipulation, it is stated that each of the States has closed or substantially limited its portion of the Basin above Hardy, Nebraska to new surface water rights and groundwater well permits. Obstacles to obtaining additional storage rights at Lovewell Reservoir given current moratoriums and the established MDS would need to be discussed and coordinated with officials from both States.

Presently Kansas administers ground water and surface water use. Nebraska does not require water right permits for ground water use. In Nebraska, the local NRDs are responsible for the administration of ground water use and the Nebraska Department of Natural Resources is responsible for the administration of surface water use.

3.4.7.1.1.1 Nebraska Surface Water Rights below Harlan County Dam and above State line

- There are 4.25 cfs of water rights above the Superior-Courtland Diversion Dam that are senior to the Bostwick Unit's earliest direct flow right dated April 3, 1946.

- There are 94.04 cfs direct flow water rights in the Basin above the Superior-Courtland Diversion Dam and below Harlan County Dam that are junior to the Bostwick Unit's earliest direct flow right dated 4/3/46. This includes water rights on tributaries that discharge into the Republican River above the Diversion Dam. Included are: 9.12 cfs in Harlan County above the Franklin Pump Canal; 28.25 cfs in Franklin County above the Franklin Pump Canal; 28.17 cfs in Franklin County below the Franklin Pump Canal; 28.50 cfs in Webster County.

- There are 4.04 cfs water rights on the mainstream on the Republican River below the Superior-Courtland Diversion Dam and above the State line that are senior to the Bostwick Unit's earliest direct flow right dated 4/3/46. These are in Nuckolls County.

- There are 21.40 cfs direct flow water rights on the mainstream of the Republican River below the Superior-Courtland Diversion Dam and above the State line that are junior to the earliest direct flow right of the Bostwick Unit dated 4/3/46. 2.76 cfs of the total are in Webster County and the remaining 18.64 cfs are in Nuckolls County.

3.4.7.1.1.2 Kansas Water Rights, State line to Clay Center

- All water within the State of Kansas is dedicated to the people of the State, subject to the control and regulation of the State and may be appropriated for beneficial use. Water appropriation rights may be obtained for surface or groundwater. Water rights are administered through the Kansas Water Appropriation Act, which is based on the Doctrine of Prior Appropriation. The date of priority of a water right and not the purpose of use determines the right to divert and use water at any time when supply is not sufficient to satisfy all water rights. The protection of instream flow from encroachment by new appropriations has been addressed at 33 locations on 23 streams and rivers by the establishment of MDS which have a priority date of April 12, 1984. Two of the locations are on the Republican River, one at Concordia and the other at Clay Center. All water rights in Kansas are administered by the Kansas Department of Agriculture, Division of Water Resources.

- Vested Rights: A vested right continues the beneficial use of water prior to June 28, 1945. There are 5 vested rights in the Basin from the State line to Clay Center. The authorized quantity is 342.5 ac-ft, the authorized rate is 17.18 cfs, and the authorized total is 766 acres.

3.4.7.1.1.3 Bostwick Division Water Rights

Reclamation has the storage rights for water in Harlan County Lake and also the storage use rights for lands in Nebraska. KBID has the rights associated with Lovewell Reservoir.

In addition to the storage rights, the Districts have natural flows rights for the irrigation of project lands. All of the natural flow rights are senior to the MDS priority date. During the time of the year that irrigation water is needed, the flows in the Basin are usually less than the amount of the districts' natural flow rights for extended periods of time. Therefore the natural flows are supplemented by storage water.

- Bostwick Irrigation District in Nebraska: The Bostwick Division in Nebraska has numerous water rights from the State of Nebraska for direct diversion from the Republican River. The earliest right is for Superior Canal and it has a priority date of April 3, 1946. Water rights have been added and transfers have occurred to provide coverage for changes in irrigated lands.

- KBID: Current KBID water rights for Lovewell Reservoir.

  KBID currently has two water rights from the State of Kansas which involve the diversion of water into Lovewell Reservoir, subsequent storage of water in Lovewell Reservoir, and diversion of water from Lovewell Reservoir for irrigation purposes.
  First, KBID has the right to divert and use water from the Republican River in Nebraska. That right, Water Right, File No. 385, from the State of Kansas, authorizes KBID to divert a maximum of 102,521 ac-ft of water per calendar year at a rate not to exceed 700 cfs for irrigation. The right has a priority date of July 16, 1948. Water diverted under this water right can be stored in Lovewell Reservoir without regard to the storage limits imposed by Water Right, File No. 4673.

  Second, KBID holds Water Right, File No. 4673, from the State of Kansas which authorizes diversion of a maximum of 19,700 ac-ft of water per calendar year at a maximum rate of 635 cfs from White Rock Creek. This right has a priority date of October 7, 1955, and includes 41,690 ac-ft of authorized storage in Lovewell Reservoir for subsequent irrigation use. This authorized storage can occur above the inactive pool (shutoff limit imposed by KBID's contract with Reclamation).

  Any change of the type of beneficial use of this water from irrigation to some other type of use would require approval of an application for a change in type of use, but the water right would retain its same priority date.

3.4.7.1.1.4 New Water Rights in Kansas

Use of water for any type of use in excess of the quantities or rates set forth above will require the approval of a new application to appropriate water for beneficial use. Such a permit would hold a priority date as of the date the application is filed and as such it would be subject to administration to prevent impairment to water rights senior to that permit.

New appropriations from surface water of the Republican River are specifically governed by the Kansas Administrative Regulation (KAR) 5-3-11(d)(6) (III) which provides in part:

"A. Each application to appropriate surface water for direct diversion from the Lower Republican River Basin, and its tributaries within the Lower Republican River Basin, shall be approved if it does not impair existing water rights nor prejudicially and unreasonably affect the public interest. No new permits to appropriate water shall be issued for appropriations that will be primarily dependent on surface water return flows from the Bostwick irrigation district.

B. Every application to appropriate surface water for direct diversion which is approved by the chief engineer shall be subject to the following conditions:

The approval of application or water right for direct diversion of surface water shall not be exercised if:

1. *Exercising the approval of application or water right causes impairment of senior water rights or senior approvals of applications.*

2. *The Kansas Water Office has requested that junior water rights be administered to meet the minimum desirable stream flow rates at the gage at Clay Center on the Lower Republican River;*

3. *The proposed point of diversion is above the Concordia minimum desirable stream flow gage and the Kansas Water Office has requested that junior water rights be administered to meet the minimum desirable streamflows at Concordia; or*

4. *The Chief Engineer is enforcing the terms of paragraph 6(b) of the Milford Water Reservation Right, identified as File No. 22,197-AR-6.*

C. Applications to appropriate surface water from tributaries to the mainstream of the Lower Republican by means of dams may be approved only if the approval will not result in impairment of existing rights, nor prejudicially an unreasonably affect the public interest. Any dam permitted on an ephemeral stream shall meet the requirements of K.A.R. 5-40-1 et seq. and be equipped with a controlled outlet with a minimum diameter of four inches. Any dam permitted on an intermittent or perennial stream shall be equipped with a controlled outlet with a minimum diameter of four inches. The controlled outlet shall be placed to allow water to pass through the dam at or near streambed elevation."

In the event that it becomes necessary to obtain new appropriations for water being stored in Lovewell Reservoir or any other proposed structure, the above criteria in Paragraph A must be met in order for the application to be approved and the conditions consistent with the provisions of Paragraphs B and C would be placed on the approval of the application.

3.4.7.1.1.5 Milford Water Reservation Right

The Water Reservation Right to Divert and Store Water in Milford Lake under Authority of the State Water Plan Storage Act, KSA 82a-1301 et seq., has a priority date of April 3, 1974, and is denominated as File No. 22,197-AR-6. The authorized point of diversion is the SW 1/4 SE 1/4 S17, T11S, R5E in Geary County, Kansas.

The State of Kansas, through the KWO, is authorized to utilize 100 percent of the total storage space between Elevation 1080.0 above MSL and Elevation 1144.4 MSL, which was 372,300 ac-ft of storage space in 1994. The KWO is currently authorized to market the yield of Milford Lake through a 2 percent drought, which was calculated in 1996 to be 124,381 ac-ft per year. If the reservoir is at or below Elevation 1144.4 and at or above Elevation 1140.0, any flows in excess of 50 cfs not needed to satisfy prior downstream rights may be stored. If the reservoir is below Elevation 1140.0, it is deemed to be in a drought condition and all natural flows not needed to satisfy senior downstream rights may be stored under the Reservation Right. Water Reservation Rights are enforceable based on their priority dates against all water rights with a priority date junior to the water reservation right.

3.4.7.1.1.6 Summary

Storage of water under the KBID water rights can occur with the existing priority dates as long as the total volume from the Republican River does not exceed the 102,521 ac-ft diversion limit. This limit was not a constraint in the model runs for this appraisal study. White Rock Creek water can be stored for subsequent irrigation use up to a storage limit of 41,690 ac-ft with the existing priority date. Water for any other purpose would require either a change of the type of use in the current water rights held by KBID or a new water right. Any change of the type of use would require approval of an application for a change in type of use, but the water right would retain its same priority date. Any new water right would have a priority date junior to all existing rights. The Settlement document does not address water stored or diverted for other purposes.

3.4.7.1.2 Congressional Authority and Appropriation

Reclamation requires specific Congressional Authorization to conduct a feasibility study by Section 8 of the Act of July 9, 1965 (Public Law [P.L.] 89-72, 79 Stat. 213). Congressional authority may be required and appropriations would be necessary for any construction, including construction of additional storage in Lovewell Reservoir, and/or to substantially modify the operation of existing facilities beyond what was contemplated in the Definite Plan Report (DPR) of the

Bostwick Division. It is believed that Congressional Authority exists for those alternatives involving improving operational efficiencies such as system automation or O&M improvements on existing Reclamation facilities.

3.4.7.2 Institutional

3.4.7.2.1 General

The study area in this appraisal study is the reach of the Basin from Harlan County Dam in Nebraska to the upper reaches of Milford Lake in Kansas. Both of these features were built and operated by the Corps. There is one Federal Reclamation project in the area, the Bostwick Division of the P-SMBP built by Reclamation. Reclamation and the two Bostwick Irrigation Districts have authorized use of irrigation space in Harlan County Lake in accordance with the Consensus Plan developed by the Corps and Reclamation. There is one other storage reservoir, Lovewell Reservoir in Kansas, which provides irrigation storage for lands in Kansas and also provides some flood control space. Other institutions that have responsibilities and authority in the area are:

- Nebraska Department of Natural Resources
- Kansas Department of Agriculture
- Kansas Water Office and the Kansas Water Authority
- Lower Republican Natural Resources District in Nebraska
- Middle Republican Natural Resources District in Nebraska
- Various involved Counties in both States
- Lower Republican Basin Advisory Committee in Kansas

3.4.7.2.2 Republican River Compact

The Republican River Compact was ratified by the three States, and consented to by the Congress by the Act of May, 26, 1943, (P.L. 60, ch 104, 57 Stat. 86). The purposes of the Compact are to provide for the most efficient use of the waters of the Basin for multiple purposes; to provide for an equitable distribution of such waters; to remove all causes, present and future, which might lead to controversies; to promote interstate comity; to recognize that the most efficient utilization of the waters within the basin is for BCU; and to promote joint action by the States and the United States in the efficient use of water and the control of destructive floods.

3.4.7.2.3 Republican River Basin Lawsuit

There was a disagreement on the use of the water in the basin and in May 1998 the State of Kansas filed a complaint with the Court alleging that Nebraska violated the Compact. After 17 months of intense negotiations an out-of-court settlement was reached and which was approved by the Court in May 2003.

3.4.7.2.4 Final Settlement Stipulation (FSS)

The litigation resulted in the FSS with the following key stipulations:

- Counts all groundwater use that is determined to deplete stream flow as part of the States consumptive use.
- Waives and forever bars all past claims for damages.
- Gives the States the flexibility to use its allocation wherever it sees fit.
- Increases flexibility by measuring Compact compliance on a 5-year running average, as opposed to annually, except in dry years when compliance is measured on a two-or three-year running average basis.
- Provides that the States, in collaboration with the United States, will pursue system improvements to make more efficient use of the water that is available in the basin.
- Provides for a five-year study of the impact of small ponds and terraces on stream flow.

3.4.7.2.5 Repayment Contracts

Reclamation has repayment contracts with two entities, the Bostwick Irrigation District in Nebraska and the KBID. These contracts stipulate the payments the Districts must make to Reclamation to repay the irrigation costs of the existing structures assigned to them for repayment. Additional contractual arrangements with the Districts or other entities would need to be negotiated for the repayment of costs assignable to the Districts or other entities for increasing storage and/or canal improvements.

3.4.8 Summary of the Evaluation of Alternatives

Relative to the preceding sections, the key information to assist in determining if there are viable alternatives that justify further Federal participation in a feasibility study is arrayed in Table 12. This table includes an evaluation of each alternative relative to the study's planning objectives identified in Section 2.4.5. This evaluation was conducted under the assumption that the additional water made available by the alternatives would be allocated to irrigation benefits. It should be noted that this assumption was made only for the purposes of this Study and this evaluation. As previously discussed, the volume of additional water varies from

between 4,200 to 17,300 ac-ft per year. Different allocations of the additional supply, such as allocating exclusively to MDS or something in between, could be considered at the next level of study. Table 13 displays an evaluation of the alternatives relative to an allocation emphasizing MDS. However, the amount of data available associated with this type of allocation was limited and therefore is more subjective than the information contained in Table 12.

Table 12 does not include a column for the sixth objective identified in Section 2.4.5, "recognize possible environmental and cultural impacts" as the evaluation process did not identify differences which would result in a variation of scoring for the alternatives.

Table 13 includes an evaluation of each alternative relative to the benefits to MDS only. In Table 13, additional flows and/or storage for each alternative would be used in attempt to meet established MDS levels. The Bostwick Division would not receive additional water if all flows were used for MDS. There may be irrigation benefits realized by non-project/private irrigators by meeting established MDS levels, but these benefits were not computed in Table 13.

3.4.9 Uncertainties

A number of uncertainties have been identified through the course of the study which could not be fully quantified or evaluated in the appraisal phase study. These uncertainties should however be recognized and resolved to whatever extent possible at the next level of study. Some of these uncertainties include:

- It is expected that OM&R costs will likely change from the baseline, particularly for the alternatives involving automation to the canals. OM&R costs have not been quantified in this Study, Table 7 in Section 3.4.2 provides a qualitative summary of the OM&R changes.

- Recreation benefits resulting from enlarging Lovewell Reservoir have not been quantified. Benefits may be realized from both the larger surface area of the reservoir and from facilities remaining available for use over longer periods of time.

- For the alternatives involving enlarging Lovewell Reservoir, because of the many known cultural resources sites at the Reservoir, the impacts to cultural resources may exceed the cost estimated in the non-contract cost multiplier for Environmental Permitting as listed in Table 5 in Section 3.4.2.

- For alternatives involving enlarging Lovewell Reservoir the cost of acquiring rights-of-way may exceed the cost estimate of 2 percent of the construction costs as listed in Table 5.

TABLE 12. SUMMARY OF ALTERNATIVE EVALUATIONS—IRRIGATION BENEFITS ONLY

Alternative	Implementation Cost (Irrigation Only)	Objective 1	Objective 2		Ratio	Objective 4 (inches)	Conditions) (vs. Baseline)
A	$13,000,000	$1,640,000	-	NE	Smallest Increase	0.13	0.2	No Change
B	$2,000,000	$3,990,000	+	NE	Moderate Increase	2.00	0.5	No Change
C	$15,000,000	$5,500,000	+	NE	Moderate Increase	0.37	0.7	No Change
D	$3,600,000	$11,000,000	+	NE	Moderate Increase	3.06	1.5	Moderate Increase
E	$16,500,000	$11,700,000	+	NE	Largest Increase	0.71	1.6	Moderate Increase
F	$12,000,000	$15,200,000	+	NE	Largest Increase	1.27	2.2	Largest Increase
G	$25,000,000	$15,700,000	+	NE	Largest Increase	0.63	2.3	Largest Increase
H	$1,650,000	$6,960,000	-	NE	Smallest Increase	4.22	0.9	Smallest Increase
I	$14,500,000	$6,960,000	-	NE	Smallest Increase	0.48	0.9	Moderate Increase
J	$14,490,000	NE	NE	NE	Likely Decrease	NE	NE	NE
K	$6,720,000	NE	NE	NE	Likely Decrease	NE	NE	NE
L	$12,600,000	NE	NE	NE	Likely Decrease	NE	NE	NE

Objectives

Objective 1 – Minimize bypass at Superior-Courtland Diversion Dam
Objective 2 – Provide augmentation storage water for MDS
Objective 3 – Develop cost-effective solutions
Objective 4 - Provide additional water supply to Bostwick Division lands – (additional inches of water)
Objective 5 – Provide additional recreation benefits

+ = highly complies with objective
- = does not comply with objective
NE = Not Estimated or Evaluated

Alternatives

A – Courtland Canal to Design Capacity, Winterize
B – Automate, Winterize
C – Automate, Winterize, Courtland Canal to Design Capacity
D - Automate, Winterize, Raise Lovewell 16,000 ac-ft
E - Automate, Winterize, Raise Lovewell 16,000 ac-ft, Courtland Canal to Design Capacity
F – Automate, Winterize, Raise Lovewell 35,000 ac-ft.
G – Automate, Winterize, Raise Lovewell 35,000 ac-ft, Courtland Canal to Design Capacity
H - Raise Lovewell 16,000 ac-ft
I – Raise Lovewell 16,000 ac-ft, Courtland Canal to Design Capacity
J – Off-Stream Storage, Jamestown Waterfowl Management Area South Dam
K - Off-Stream Storage, Jamestown Waterfowl Management Area North Dam
L – Off-Stream Storage, Beaver Creek

TABLE 13.–SUMMARY OF ALTERNATIVE EVALUATIONS–MDS ENHANCEMENT ONLY

Alternative	Implementation Cost		Objective 1	Objective 2	(in MDS violations)		(vs. Baseline)	(Average Hydrologic Conditions) (vs. Baseline)
A	$13,000,000	NE	-	-	Small Decrease	NE	No Change	No Change
B	$2,000,000	NE	+	-	Small Decrease	NE	No Change	No Change
C	$15,000,000	NE	+	-	Small Decrease	NE	No Change	No Change
D	$3,600,000	NE	+	0	Moderate Decrease	NE	No Change	Moderate Increase
E	$16,500,000	NE	+	0	Moderate Decrease	NE	No Change	Moderate Increase
F	$12,000,000	NE	+	+	Largest Decrease	NE	No Change	Largest Increase
G	$25,000,000	NE	+	+	Largest Decrease	NE	No Change	Largest Increase
H	$1,650,000	NE	-	0	Moderate Decrease	NE	No Change	Smallest Increase
I	$14,500,000	NE	-	0	Moderate Decrease	NE	No Change	Moderate Increase
J	$14,490,000	NE	NE	+	Largest Decrease	NE	NE	NE
K	$6,720,000	NE	NE	+	Largest Decrease	NE	NE	NE
L	$12,600,000	NE	NE	+	Largest Decrease	NE	NE	NE

Objectives

Objective 1 – Minimize bypass at Superior-Courtland Diversion Dam
Objective 2 – Provide augmentation storage water for MDS
Objective 3 – Develop cost-effective solutions
Objective 4 - Provide additional water supply to Bostwick Division lands – (additional inches of water)
Objective 5 – Provide additional recreation benefits

+ = highly complies with objective
0 = complies with objective
- = does not comply with objective
NE = Not Estimated or Evaluated

Alternatives

A – Courtland Canal to Design Capacity, Winterize
B – Automate, Winterize
C – Automate, Winterize, Courtland Canal to Design Capacity
D - Automate, Winterize, Raise Lovewell 16,000 ac-ft
E - Automate, Winterize, Raise Lovewell 16,000 ac-ft, Courtland Canal to Design Capacity
F - Automate, Winterize, Raise Lovewell 35,000 ac-ft.
G – Automate, Winterize, Raise Lovewell 35,000 ac-ft, Courtland Canal to Design Capacity
H – Raise Lovewell 16,000 ac-ft
I – Raise Lovewell 16,000 ac-ft, Courtland Canal to Design Capacity
J – Off-Stream Storage, Jamestown Waterfowl Management Area South Dam
K- Off-Stream Storage, Jamestown Waterfowl Management Area North Dam
L – Off-Stream Storage, Beaver Creek

- Because of the limits associated with the existing water rights, there are uncertainties regarding the volumes of water available for storage.

- For alternatives that provide non-project benefits, several authority/legislative issues would need to be addressed, such as conveyance and storage of non-project water in Bostwick project facilities and the repayment of the implementation costs assigned to the Districts and/or the States.

Chapter 4 – Findings

4.1 Findings

Prolonged droughts and devastating floods prompted irrigation and flood control development with Federal involvement. The States realized that there needed to be legal recognition of how the waters of the Republican River would be utilized so they entered into a Compact that was consented to by the Congress by the Act of May 26, 1943 (P.L. 60, ch. 104, 57 Stat. 86). The Flood Control Act of 1944 authorized the construction of major water resource development in the basin as part of the Pick-Sloan Missouri Basin Program. The Corps finished the construction of Harlan County Dam in 1952 and Reclamation initiated construction of the Bostwick Division in 1948 with the first irrigation water delivered in 1952.

The irrigation districts have experienced significant water delivery shortages due to decreasing water supplies and it is anticipated that these shortages will continue to occur as well as shortages downstream in the Republican River Valley. In addition, streamflows will periodically be less than the MDS established flows in Kansas. Presently some water supplies in the Basin are not being fully utilized. With improvements in the existing systems and possibly with additional storage capability, the system could be managed to alleviate some of the water shortage problems and provide some streamflow augmentation in the lower reaches in Kansas. Nebraska and Kansas are interested in pursuing a feasibility study to further assess possible system improvements and both have indicated their willingness to cost-share the study.

4.1.1 Recommendation

Based upon the States' continued support for further study and the potential viability of some alternatives, there is justification for further Federal participation in a cost-shared feasibility study. It is recommended that a feasibility study be undertaken to investigate solutions.

4.2 Preliminary Plan of Study – Feasibility Study

The preliminary plan of study (POS) is provided as Appendix F. The POS for the feasibility study defines the planning approach, activities to be accomplished, schedule, and associated costs that the Federal Government and the local sponsor(s) will be supporting financially. The study cost estimate and detailed work schedule are included with the POS, but will not be fully developed and finalized until there is specific Congressional authorization for a feasibility study. The POS defines participating requirements between Reclamation and the local sponsor(s) as well as those who will be performing and reviewing the activities involved in the feasibility study.

Appendix A

Hydrology Report

Appendix B

Cost Estimate Worksheets

Appendix C

Recreation Mitigation Costs

Appendix D

Benefit Estimation

Appendix E

Recreation Analysis

Appendix F

Preliminary Plan of Study — Feasibility Study