DRAFT

Plan of Study

For

Frenchman Valley Appraisal Study

Nebraska-Kansas Area Office

Great Plains Region

U.S. Bureau of Reclamation

February 5, 2007

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Purpose

~~This study will develop and evaluate alternative water management scenarios which may assist partners/stakeholders in future planning.~~ The purpose of this appraisal study is to determine if there is a need for further Federal involvement in participating in a cost-share Feasibility Study.

Objectives

The water and related land resource problems and opportunities identified in this study will be stated as specific planning objectives and will provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the study area conditions. The following preliminary planning objectives will be updated during the study:

Optimize the economic and environmental benefits of the water resources in the study area

- Optimize economic benefits to the study area of irrigation, including surface and groundwater irrigation
- Optimize economic benefits of Enders Reservoir for recreation, fish and wildlife
- Evaluate environmental benefits/values to the study area of recreation, fish and wildlife, and water quality
- Evaluate economic benefit of flood control provided by Enders Dam
- Provide alternative water management scenarios to aide partners/stakeholders in future planning
- Minimize adverse environmental impacts

Authority

The Frenchman Valley Appraisal Study is authorized under Federal Reclamation Laws (Act of June 17, 1902, 32 Stat. 388, and acts amendatory thereof and supplementary thereto). The Frenchman Valley Basin is a subbasin of the Republican River Basin, which is governed by the 1942 Republican River Compact Agreement (RRCA), entered by the States of Colorado, Kansas, and Nebraska.

Study Partners

The partners for this study include: Bureau of Reclamation (Reclamation), Nebraska Department of Natural Resources (NDNR), Frenchman Valley Irrigation District (FVID), Hitchcock & Red Willow Irrigation Districts (H&RW ID), Riverside Irrigation District (RID), Middle Republican Natural Resources District (MRNRD), Upper Republican Natural Resources District (URNRD), Nebraska Game & Parks Commission (NGPC).

Description of the Study Area and Background

The study area (Figure 1) is approximately 9,465 square miles including the entire Frenchman Creek drainage basin, including the areas of the groundwater aquifer that have an influence on the drainage basin, and the FVID, H&RWID, and RID. The area is bounded on the south by the Republican River and on the east by Red Willow Creek. Frenchman and Red Willow Creeks drain into the Republican River to the west and east of McCook, NE respectively. The boundary also follows the Platte River in the north, and the extent of the High Plains Aquifer in the west, corresponding with the RRCA Groundwater model domain.

History

The FVID was organized in 1911, and the H&RWID in 1955. Construction of Enders Dam and Reservoir started in January 1947 and was completed in 1951. Storage of water began in October 1950, with releases beginning in 1951 and the reservoir pool filling by January 1952. Water was first delivered to the FVID and H&RWID in May 1958 and April 1961, respectively.

In May of 1998, the State of Kansas filed a motion with the U. S. Supreme Court alleging violations of the RRCA. The motion claimed that Nebraska allowed the proliferation and use of groundwater wells (Figure 2) hydraulically connected to the Republican River and its tributaries and failed to protect surface flows from other unauthorized appropriations.

On January 19, 1999, the U.S. Supreme Court granted Kansas' motion for leave to file. The States of Kansas and Nebraska were joined by the United States as "amicus curiae" in providing a briefing to the Supreme Court on January 19, 1999, which accepted the lawsuit to be known as Kansas v. Nebraska and Colorado, No. 126 Original.

In December, 2001 the Special Master assigned to the case agreed to postpone the progression of the case in order to allow the three Compact States, Colorado, Kansas, and Nebraska, to engage in settlement negotiations. These negotiations culminated in a settlement package that was approved by the Governors and Attorneys General of all three states in December, 2002.

The States agreed to resolve the pending litigation regarding the Republican River Compact by means of a Final Settlement Stipulation and a Proposed Consent Judgment. This included more efficient management of the Republican River to help extend water supplies and meet interstate compact needs as addressed in the Compact Settlement. The Supreme Court approved the Final Settlement Stipulation on May 19, 2003.

Hydrogeology/Geology

The study area (Figure 1) is underlain by the High Plains aquifer (Weeks et. al., 1988), which consists of parts of the Brule Formation, the Arikaree Group, the Ogallala Group, and Quaternary deposits. The Ogallala Group consists principally of unconsolidated to

semi-consolidated alluvial and eolian sands, gravels, silts, and clays. Unconfined water table conditions are predominant throughout the aquifer. However, localized cemented beds can create artesian or confined aquifer conditions in some locations.

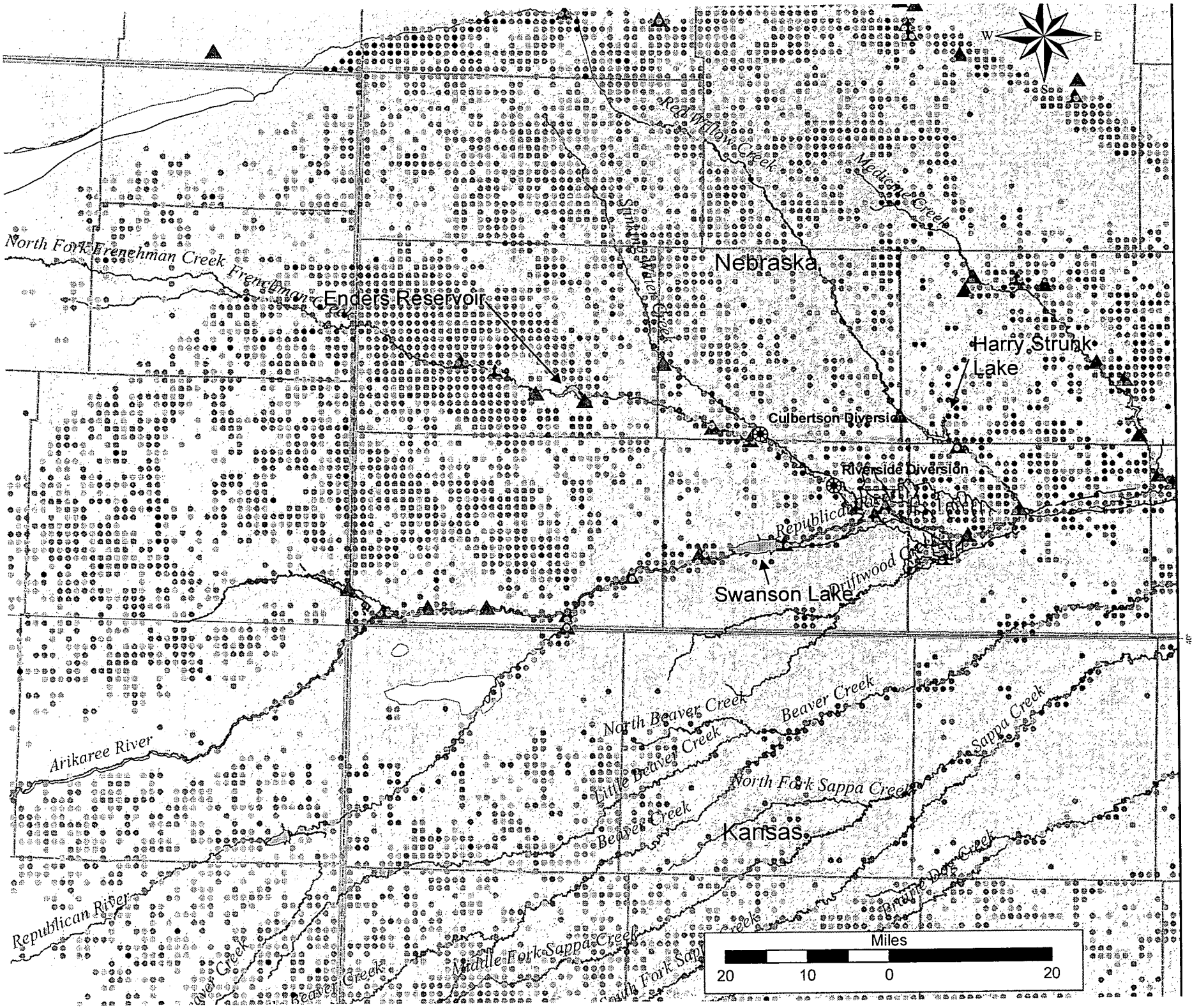
The study area lies within the Great Plains physiographic province (Fenneman, 1931), characterized by upland, terrace and river valley terrains. Terraces, comprising approximately seventy percent of the area (USDI, 1970), include fluvial sediments and loess. Uplands are mantled with loess that is deep and well drained, and the river valleys are dominated by fluvial sediments. Land use in the study area is largely agricultural or recreational.

The depositional history of the High Plains Aquifer is complex, containing fluvial and eolian sediments reflecting past tectonic and climatic controls. Tectogenetic events west of Nebraska had major impacts on the depositional and erosional history of the study area, though no significant structural deformation occurred locally within this hydrostratigraphic unit. More recently, continental and alpine glaciations have contributed greatly to the stratigraphic history of Nebraska (Cannia et. al., 2006). The saturated thickness of the High Plains aquifer ranges from zero in Colorado where it pinches out to approximately 1,000 feet in west-central Nebraska. Ground water flow is generally from west to east reflecting the land surface and aquifer geometry.

Water Resources

The Frenchman Creek drainage basin above Enders Reservoir is 950 square miles, though the area contributing inflows directly into Enders Reservoir is only ~790 square miles. A majority of the inflow into Enders Reservoir are derived from groundwater discharge into Frenchman Creek. Enders Reservoir provides off-season storage for the FVID and H&RWID. Water stored in Enders Reservoir, along with flows from the Frenchman and Stinking Water Creeks, provides water for the Culbertson Canal and the Culbertson Extension Canal systems, which serve 9,600 acres in the FVID and 11,490 acres in the H&RWID. The conservation pool in Enders Reservoir begins at elevation 3082.4 feet and extends to elevation 3112.3 feet (Figure 3) and totals 34,512 acre-feet (Reclamation, 1977). The last time Enders Reservoir reached the top of conservation level was in 1968.

The Frenchman-Cambridge Division, a project of the Reclamation's Pick Sloan Missouri Basin Project, encompasses the Frenchman-Cambridge Irrigation District, along with the FVID and the H&RWID. Facilities to serve these three irrigation districts include four storage dams and reservoirs, four diversion dams, and distribution systems. Project water is distributed for 54,680 acres of irrigable land in Chase, Hitchcock, Hayes, and Red Willow Counties. The Frenchman-Cambridge Division contains the Frenchman Unit, the Meeker Driftwood Unit, the Red Willow Unit, and the Cambridge Unit. The Frenchman Unit includes Enders Dam and Reservoir, Culbertson Diversion Dam, Culbertson Canal, Culbertson Extension Canal, and a system of laterals.


W
E
S
Red Willow Creek
Medicine Creek
North Fork Frenchman Creek
Frenchman
Enders Reservoir
Nebraska
Sand Hollow Creek
Harry Strunk Lake
Culbertson Diversion
Riverside Diversion
Republican
Driftwood Creek
Swanson Lake
North Beaver Creek
Beaver Creek
Arikaree River
Little Beaver Creek
Sappa Creek
North Fork Sappa Creek
Beaver Creek
Kansas
Prairie Dog Creek
Republican River
Middle Fork Sappa Creek
Miles
20
10
0
20

Ground water in the area generally flows eastward, discharging into the Republican River and major tributaries, including Frenchman Creek. The High Plains aquifer has been extensively developed throughout the study area (Figure 2). Irrigation wells are the primary groundwater users, with lesser amounts for municipal, industrial, domestic, and stock watering purposes. In 2005, a total of 4,945 wells were registered with NDNR (3807 upland wells and 1143 quick response wells) in the study area, with heavy concentrations within 12 miles of Frenchman Creek above Enders Reservoir. The upland wells serve approximately 500,000 acres and the quick response wells serve approximately 100,000 acres. In contrast, the portion of Colorado in the study area contains 2751 wells which serve approximately 350,000 acres.

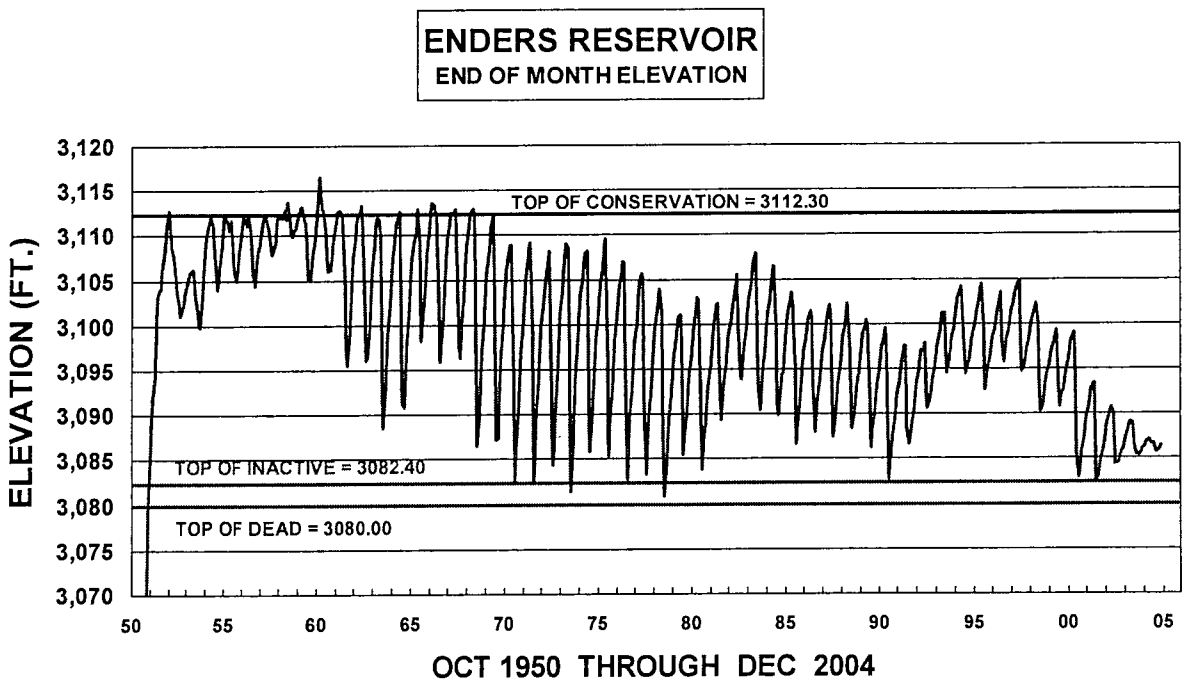


Figure 3. Historic reservoir elevation (updated graphs to be provided by BOR).

Ground water pumping for irrigation of croplands in the Republican River Basin was limited prior to World War II but progressed rapidly in the 1960's and 1970's. Since the 1950's, flow into Enders has been showing a progressive decline, with no indication of leveling off (Figure 4). This decline in inflows to the reservoir cannot be attributed to precipitation, which has remained relatively constant (Figure 5). The cause of decline appears to be the result of well development and conservation practices above Enders Reservoir.

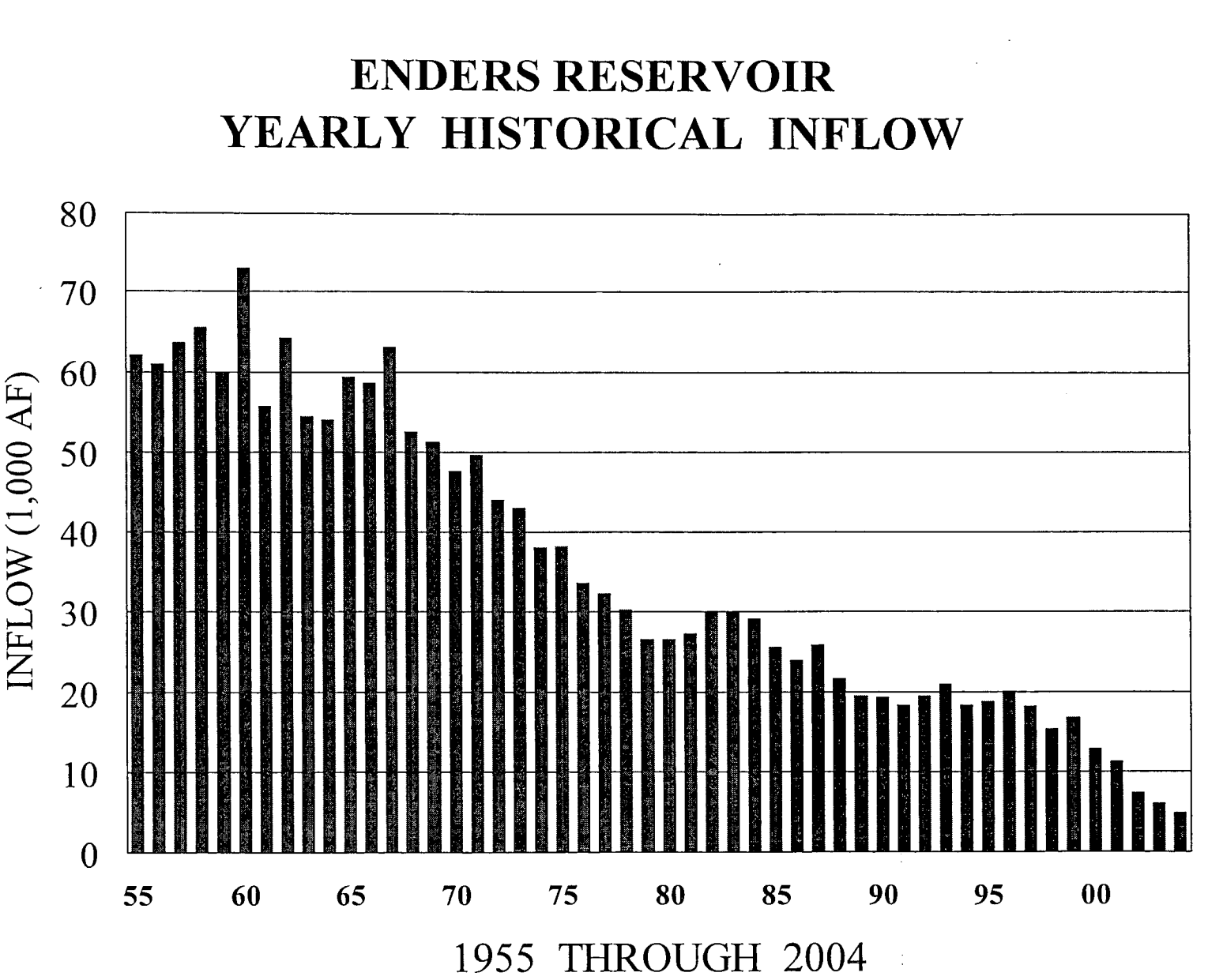


Figure 4. Historic inflows into Enders Reservoir (updated graphs to be provided by BOR).

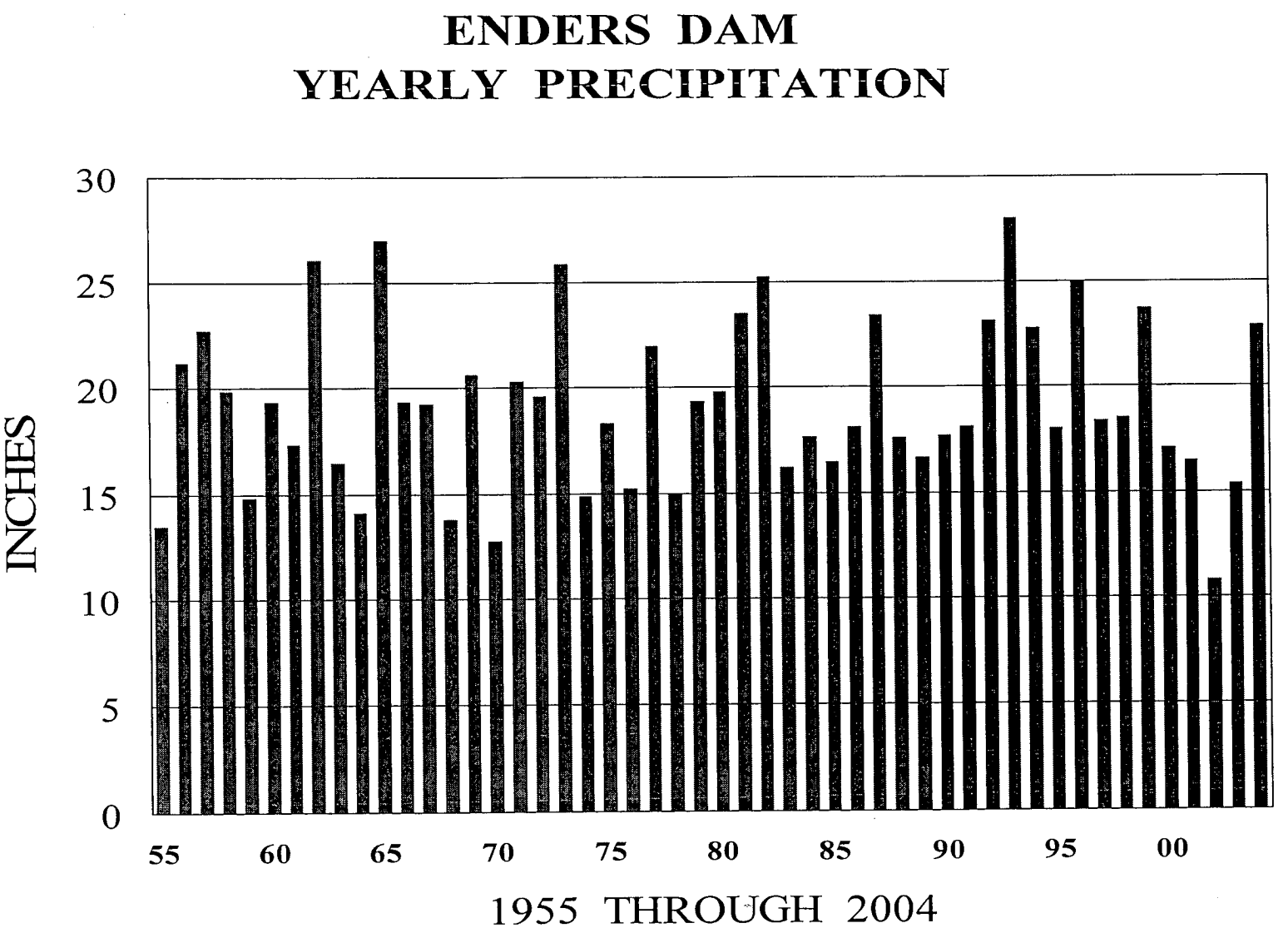


Figure 5. Historic precipitation at Enders Dam (updated graphs to be provided by BOR).

Previous Investigations and Reports

Numerous investigations have been completed in the study area to address the surface water depletions occurring in the upper Republican River Basin. A 1963 USGS study addressed the geology and irrigation patterns in the Frenchman basin above Palisade, NE (Cardwell and Jenkins, 1963). This included an analysis of the extent to which future pumping of ground water for irrigation might deplete streamflow in the Frenchman River and in Stinking Water Creek.

Another report was prepared to provide geohydrologic data to the Southwest Nebraska ground water Conservation District, for use as a base in assessing impacts of future ground water withdrawals in the district (Leonard and Huntoon, 1974).

The U.S. Department of the Interior (1977) evaluated the water supply problems facing the Frenchman Unit of the Frenchman-Cambridge Division, which includes the FVID and H&RWID. The report concluded, "The primary problem facing the Frenchman Unit is the continuous decline of the water supply from Enders Reservoir. The results of the 1977 appraisal study indicate that intensive private irrigation well development upstream has caused depletion of the base flow of the Frenchman River."

As part of the process of renewing the water service contracts for the irrigation districts in the Republican River Basin, Reclamation (1996) examined surface water supply (historic and present) and ground water supply within the Basin. The report indicated that reservoir inflows have declined significantly since pre-development. The causes of declining inflows appeared to be surface water diversions, irrigation well pumpage, conservation practices, and upstream reservoir development.

A complete list of the reports available for use in this study can be found in Appendix A.

Problems

1. Water demands exceed available water supplies – Current water demands in the study area exceed water availability. All water needs cannot be fully met.

2. Declining Streamflows Above and Below Enders Reservoir – The surface water supply is depleted. Ground water development and conservation measures above Enders Reservoir have resulted in the subsequent depletion of the surface flows of the Frenchman River, reducing both the natural flow and storage water supplies available to the irrigators in the Frenchman Unit.. The Frenchman Valley and H&RW Irrigation Districts are dependent on Enders Reservoir to provide supplemental irrigation water. Declining streamflows affect the following:

    - Irrigation Districts - Irrigation Districts may not be able to continue without supplemental storage water from Enders

- Federal Investment - If the irrigation districts cannot continue, future payments to the federal government and O&M of project facilities by the Districts will be jeopardized.
- Groundwater Recharge - Under existing project operations, there is a recharge benefit to the project area. Stopping district operations may harm groundwater users in the project area and possibly those outside the area.
- Recreation - Declining inflows lead to lower reservoir levels resulting in decreased recreation, fish and wildlife benefits at Enders Reservoir. If recreation benefits continue to diminish, the Nebraska Game and Parks Commission may have difficulty in justifying future investments in recreation facilities.

3. Compact Compliance – Nebraska's consumptive use is limited to Nebraska's allocation as specified by the Republican River Compact.
4. Declining groundwater levels – withdrawals from the groundwater aquifer exceed groundwater recharge.
5. Water quality – One of the identified benefits to the Frenchman Cambridge Division with a full water supply included maintaining water quality. Reduced streamflows and reduced water supplies of the Frenchman Unit have resulted in negative effects on water quality for municipalities in the area.

Opportunities

Opportunities will be reviewed in an attempt to balance competing water demands with available water supplies. All reasonable solutions will be considered. Study partners will have opportunities to provide input on all alternatives.

Modeling efforts will be needed for various scenarios, including the No Action alternative. Existing groundwater models will be enhanced/modified in order to determine future water supplies. The groundwater modeling results will/may need to be incorporated into a surface water model or reservoir operations model.

Modeling outputs for various scenarios will be presented to stakeholders to further evaluate and develop alternatives.

There may be opportunities to:

- Continue existing operations ~~as is~~ with Enders storage and natural flows being utilized for direct surface water diversions for irrigation benefits for the Frenchman Unit.
- Utilize Enders storage and/or the natural flows to provide groundwater recharge benefits for groundwater irrigators in the area below Enders and/or areas served by the Culbertson and Culbertson Extension canals.
- Utilize Enders Reservoir for recreation, fish and wildlife benefits.
- Utilize Enders storage and/or natural flows for the State of Nebraska's compliance with the Republican River Compact.

- Increase restrictions on groundwater irrigation and/or provide additional incentive programs in order to improve streamflows in the Frenchman Creek, both above and below Enders Reservoir.
- Increase restrictions on groundwater irrigation and/or provide additional incentive programs in order to reduce consumptive use for Compact compliance.
- Implement any combination of the above opportunities.

Existing Constraints

Study alternatives will be developed within the existing constraints with the possible exception of specific changes that would potentially require additional legislation or other actions in order to change the constraints.

The following existing constraints will be considered in developing alternatives to address the problems include:

- Amount of water physically available – location, timing
- Final Settlement Stipulation and Proposed Consent Judgment
- Republican River Compact, including meeting sub-basin allocations
- State water laws and regulations
- Integrated Management Plans for the Upper and Middle Republican Natural Resource Districts
- Republican River Water Conservation District regulations in Colorado
- Frenchman Unit authorization - The Frenchman Unit of the Frenchman-Cambridge Division was authorized by the Flood Control Act of December 22, 1944 as amended.
- The Frenchman Unit Project is operated in accordance with Federal Reclamation laws and regulations.
- Frenchman Valley and H&RW Irrigation District water service contracts with the United States.

Methodologies employed in this investigation will be consistent with those recorded in Accounting Procedures and Reporting Requirements (RRCA, 2002). Management practices and groundwater withdrawals will be conducted in accordance with the principals and objectives delineated in the respective Natural Resource Districts' Integrated Management Plans (MRNRD, 2005, LRNRD, 2005 and URNRD, 2005) and the Nebraska Ground Water Management and Protection Act (2004).

Input on planning objectives and constraints will be solicited from the study partners and others.

Planning constraints, for which alternatives will be developed to address the problems, include conformation to the Final Settlement Stipulation and Proposed Consent Judgment, to the Republican River Compact and to State and NRD regulations.

Scope of Work

The scope of work for this study is proposed to consist of three phases, a preliminary groundwater modeling phase, a secondary groundwater modeling phase, and a future planning phase. Detailed tasks to be completed in the first phase are presented below. Tasks for the later phases will be developed utilizing results from the first phase of study by a multi-disciplinary planning team organized by the Study partners, consisting of experienced individuals representing major functional disciplines. Milestones marking the completion of each phase will provide opportunities to share information as it becomes available and to redirect project resources as needed to more fully satisfy the study goals.

The NDNR will take the lead in development of Phase I of this Appraisal Study, which will include modeling services and data gathering and analysis. Phase II responsibilities will be shared between NDNR and Reclamation. Phase II will quantify desired model refinements and define additional groundwater modeling scenarios. The Upper and Middle Republican NRDs, NGPC, Reclamation, and the NDNR will be responsible for Phase III, which will include future water distribution, planning, and development of model scenarios which will examine the viability of several potential future uses of Enders Reservoir storage and natural flows.

The RRCA groundwater model will be utilized in Phase I to define the scope and extent of the problem. A limited set of rainfall and water use scenarios, as determined by the planning committee, will be modeled. Phase II will begin with a milestone meeting to assess Phase I model results and to determine the course of study for Phase II. This may involve the development of a refined, sub-regional model of the study area and/or the selection of additional precipitation and irrigation scenarios to be performed using the RRCA model. Phase II will conclude with a milestone meeting, a Reclamation determination of the "future without" condition (if so desired by the Reclamation), and the planning of further modeling scenarios for Phase III. Resource optimization studies will be conducted during Phase III utilizing the RRCA model and/or any new model developed during Phase II.

Phase I

Model scenarios will be developed in Phase I to facilitate examination of the regional water budget, baseflow gains or losses to/from Frenchman Creek, and inflow to Enders Reservoir using the RRCA model. The inflow to Enders Reservoir under the various model scenarios will be compared to alternate target irrigation demands for the FVID and H&RWID. Table 1 shows the inflows required for Enders to provide a range of irrigation levels under two target reservoir levels (See Appendix C for detailed results by irrigation district).

The purpose of the Phase I scenarios is to estimate the time necessary to meet the districts' irrigation requirements and maintain NGPC reservoir levels under a range of precipitation and groundwater pumping. Precipitation scenarios will be calculated

through statistical analysis of historic data. For example, scenario runs could include precipitation at the 10th percentile, representing a continued drought cycle, the 50th percentile to represent average precipitation, and the 90th percentile, representing a continued wet cycle. Minimum and a maximum target irrigation levels and reservoir target elevations will be determined by the planning committee for each precipitation scenario. Groundwater pumping scenarios will also be chosen by the committee. Each pumping scenario will then be combined with a precipitation scenario to create unique model runs. The model will then be run forward in time to determine the approximate number of years required for reservoir inflows to return to levels sufficient to maintain reservoir elevations and provide irrigation water for the irrigation districts (i.e., time required to meet minimum and maximum target irrigation levels).

Surface Irrigation (inches)	Enders Elev - 3089.4 (acre feet)	Enders Elev - 3099.0 (acre feet)
0	*****	*****
1	*****	*****
2	*****	*****
3	*****	*****
4	*****	*****
5	*****	*****
6	*****	*****
7	*****	*****
8	*****	*****
9	*****	*****
10	*****	*****
11	*****	*****
12	*****	*****
13	*****	*****
14	*****	*****
15	*****	*****
16	*****	*****
17	*****	*****
18	*****	*****

Table 1. Enders releases required for various levels of irrigation of FV and H&RW Irrigation Districts. ***** Data to be developed by BOR.

These analyses and model runs provide a project framework that includes an absolute minimum timeframe (wet cycle + minimum irrigation scenario) for reservoir recovery, as well as the timeframe under scenarios chosen by the committee. These results will

for what? for recovery?

The goals of this study can be more realistically pursued after phase I

additionally provide a tentative outside limit for project completion that can be more effectively determined with information gathered through Phase I. ~~Resource planning can more effectively and realistically pursue the goals of this study through Phase I~~ determination of scope and scale of restoring Enders Reservoir.

Specific tasks involved in Phase I are as follows:

Task Ia. Stakeholder Meeting – February 15, 2007.

Task Ib. Planning meeting to determine modeling scenarios – February 2007. The planning committee will meet to discuss alternatives for modeling scenarios within Phase I. A specific list of scenarios to be modeled will be decided upon at this time. The NDNR will coordinate with the study partners to schedule this meeting.

Lead Individuals: James Schneider, NDNR and Jack Wergin, Reclamation
Team Members: Jill Manring, Mark Phillips, Marv Swanda, Reclamation and Doug Hallum, Jesse Bradley, Paul Koester, NDNR
Product: Final list of model scenarios.
Due Date: Feb 28, 2007.

Task Ic. Preparing model parameters – March 2007. The groundwater modeling group will collect data to determine input parameters for modeling scenarios determined in Task Ia.

Lead Individual: James Schneider, NDNR Paul Koester
Team Members: Jack Wergin, Jill Manring, Mark Phillips, Reclamation and Doug Hallum, Jesse Bradley, Paul Koester, NDNR
Product: Specific input parameters for model scenarios..
Due Date: Mar. 15, 2007.

Task Id. Running modeling scenarios – April 2007. NDNR groundwater modeler Paul Koester will run the model scenarios using the RRCA groundwater model. Results of the model runs will be compiled. Specifically, the predicted baseflow into the upper reaches of Frenchman Creek and Enders Reservoir will be extracted from the model output and summarized.

Lead Individual: Paul Koester, NDNR
Team Members: Mark Phillips, Jill Manring, Jack Wergin, Reclamation and James Schneider, Doug Hallum, Jesse Bradley, NDNR
Product: Inflows to Enders Reservoir for each model scenario.
Due Date: Apr. 15, 2007.

Task Ie. Completion of a report summarizing Phase I results – May 2007. The NDNR modeling group will interpret results of the modeling scenarios and prepare a report summarizing the results. This report will also contain specific recommendations for future work under Phases II and III based on the results of the Phase I model scenarios.

Lead Individual: James Schneider, NDNR

Team Members: Mark Phillips, Jill Manring, Jack Wergin, Reclamation and Doug Hallum, Jesse Bradley, Paul Koester, NDNR
Product: Phase I Final Report.
Due Date: May. 15, 2007.

Task If. Milestone Meeting – May 2007. The planning committee will meet to discuss the results of the Phase I modeling scenarios and recommendations for Phase II. The NDNR will coordinate with the study partners to schedule this meeting. The Phase I report will be distributed by NDNR prior to this meeting to allow time for review by the study partners.

Lead Individual: James Schneider, NDNR and Jack Wergin, Reclamation
Team Members: Jill Manring, Mark Phillips, Marv Swanda, Reclamation and Doug Hallum, Jesse Bradley, Paul Koester, NDNR
Product: Working plan for Phase II.
Due Date: May 31, 2007.

Phase II

Phase II will begin with a milestone meeting (March, 2007) to assess the results of Phase I, to quantify desired model refinements and to define additional groundwater modeling scenarios. Desired precipitation and irrigation scenarios will be defined ~~for model development~~ to enable the Reclamation determination of the "future without" condition. Possible scenarios include reductions in ground water pumping related to programs currently in place (Appendix D), continuing ground water withdrawals at current levels, incremental pumping reductions to quantify timeline sensitivity, and increasing ground water withdrawals according to historical trends.

Phase II scenario development and selection will be directed by Reclamation. Reclamation will estimate a "future without" condition, which is Reclamation's best estimate of what will happen over the next 40 years with no additional federal involvement. The "future without" will be the baseline to which all other alternatives are compared, to determine if there is a federal interest in proceeding with a feasibility study.

Phase III

Future water distribution and planning will be the focus of Phase III. Model scenarios will examine the viability of several potential future uses of Enders Reservoir storage and natural flows, including the use of the reservoir and/or canals for the purpose of enhancing groundwater recharge, operating only the FV or the HR&W irrigation district, operating both irrigation districts, and any scenarios yet to be developed. The milestone meeting to transition from Phase II to Phase III will be in March, 2008.

Economic effects of various scenarios will be determined in Phase III.

Economic benefits of flood control provided by Enders Dam will be quantified to ~~serve as a tool to~~ aid decision making. Choices relating to lake level and recharge benefits

through use of Ender Reservoir will also be evaluated. Options regarding utilization of the surface water distribution infrastructure related to Enders Reservoir will be evaluated to balance associated costs and benefits. Phase III study results will be shared among resource managers to aid in decision making and optimization of water uses within the study area.

Study Costs and Cost Sharing Agreement

Study costs will be shared by the parties involved in the study. Costs may be shared through monetary contributions, or in-kind services.

A Memorandum of Agreement between the Nebraska Department of Natural Resources and Reclamation will be developed to identify each agency's roles and responsibilities in this Appraisal Study.

APPENDIX A

List of Previous Investigations and Reports

Bentall, R.& Hamer, T., 1980, Stream-Aquifer Relationships in Nebraska: UNL Conservation and Survey Division and Nebraska Department of Water Resources, 102 pages, 171 illustrations.

Boohar, J.A., and Provaznik, Mary Kay, 1996, Peak flows for the period of record for current and discontinued streamflow stations in Nebraska: U.S. Geological Survey Open-File Report 96-101, 518 p.

Bradley, E., and Johnson, C.R., 1957, Geology and ground-water hydrology of the valleys of the Republican and Frenchman Rivers, Nebraska: U.S. Geological Survey Water-Supply Paper 1360-H, p. 589-713.

Cannia, James C., Woodward, Duane and Cast, Larry D., 2006, Cooperative Hydrology Study COHYST Hydrostratigraphic Units and Aquifer Characterization Report, February 24, 2006

Cardwell, W.D.E., and Jenkins, E.D., 1963, Ground-water geology and pump irrigation in Frenchman Creek basin above Palisade, Nebraska: U.S. Geological Survey Water-Supply Paper 1577, 472 p.

Carlson, M.P., 1993, Geology, Geologic Time and Nebraska: Conservation and Survey Division Educational Circular No. 10, August 1993, 60 pages.

Channel, C.B., 1901, Third Biennial Report of the State Engineer, Secretary of the State Board of Irrigation to the Governor of Nebraska 1899 and 1900: Hunter Woodruff Printing Co. Lincoln, Nebraska, 220 pages.

Chen, H.H. and Druliner, A.D., 1987, Agricultural chemical contamination of ground water in six areas of the High Plains aquifer, Nebraska, in National Water Summary 1986—Hydrologic events and ground- water quality: U.S. Geological Survey Water-Supply Paper 2325, p. 103-108.

Condra, G.E., 1907, Geology and water resources of the Republican River valley and adjacent areas, Nebraska, U.S. Geological Survey Water-Supply Paper 216.

Druliner, A.D., and McGrath, T.S., 1993, Predicting nitrate-nitrogen and atrazine contamination in the High Plains aquifer in Nebraska, in Morganwalp, D.W., and Aronson, D.A., eds. 1994, U.S. Geological Survey Toxic Substances Hydrology

Program—Proceedings of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4015.

Dugan, J.T., and Zelt, R.B., 2000, Simulation and analysis of soil-water conditions in the Great Plains and adjacent areas, central United States, 1951-80: U.S. Geological Survey Water-Supply Paper 2427, 81 p.

Dugan, J. T., 1984, Hydrologic characteristics of Nebraska soils: U.S. Geological Survey Water-Supply Paper 2222, 19 p., 12 pls.

Ellis, M.J., 1981, Hydrogeologic reconnaissance of the Republican River Basin in Nebraska: U.S. Geological Survey Open-File Report 81-531, 3 sheets.

Ellis, M.J., Engberg, R.A., Kastner, W.M., and Steele, E.K., Jr., 1985, Nebraska ground-water resources, in National Water Summary 1984-hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, p. 291-296.

Fenneman, N.M., 1931, Physiography of western United States: New York, Mcgraw-Hill, Inc., p. 11.

Hedman, E. R., Engel, Glenn B., 1989, Flow characteristics for selected streams in the Great Plains subregion of the central midwest regional aquifer system and selected adjacent areas--Kansas and Nebraska, and parts of Colorado, Iowa, Missouri, New Mexico, Oklahoma, South Dakota, Texas and Wyoming: Hydrologic Atlas 708.

Heimes, F.J., Luckey, R.R., and Stephens, D.M., 1986, Evaluation of sampling methods to estimate irrigation pumpage in Chase, Dundy, and Perkins Counties, Nebraska: U.S. Geological Survey Water- Resources Investigations Report 86-4092, 27 p.

Heimes, F.J., Ferrigno, C.F., Gutentag, E.D., Luckey, R.R., Stephens, D.M., and Weeks, J.B., 1987, Comparison of irrigation pumpage with change in ground-water storage in the High Plains aquifer in Chase, Dundy, and Perkins Counties, Nebraska, 1975-83: U.S. Geological Survey Water-Resources Investigations Report 87-4044, 34 p.

Helgesen, J.O., Leonard, R.B., and Wolf, R.J., 1993, Hydrology of the Great Plains Aquifer System in Nebraska, Colorado, Kansas, and Aduacent Areas: U.S. Geological Survey Professional Paper 1414-E, 80 pages, 10 plates (photocopy).

Hibbs, B.J., 1989, Investigation of a brine contaminated aquifer in southeastern Hitchcock County, Nebraska: emphasizing the conjunctive use of geophysical and geochemical methods of pollutant detection, Thesis (M.S.)--University of Nebraska--

Lincoln, 1989.

Johnson, M.R., Stanton, J.S., Cornwall, J.F., and Landon, M.K., 2002, Streamflow gain/loss in the Republican River Basin, Nebraska, July 1975: U.S. Geological Survey Open-File Report 02-080, ARC/INFO Export format, available at http://water.usgs.gov/pubs/of/ofr02-080/.

Johnson, M.R., Stanton, J.S., Cornwall, J.F., and Landon, M.K., 2002, Streamflow gain/loss in the Republican River Basin, Nebraska, May 1975: U.S. Geological Survey Open-File Report 02-079, ARC/INFO Export format, available at http://water.usgs.gov/pubs/of/ofr02-079/.

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APPENDIX B

Natural Flow Water Rights

Frenchman River – Natural Flow Water Rights

Frenchman Valley Irrigation District 05/16/1890 9160.4 ac	D-24R	130.86 cfs
H & RW Irrigation District 04/03/1946 1415.0 ac	A-3869AR	16.64 cfs
H & RW Irrigation District 04/16/1954 9576.0 ac	A-6214R	136.80 cfs
H & RW Irrigation District 03/04/1959 157.0 ac	A-9697R	2.24 cfs
Frenchman Valley Irrigation District 03/17/1960 132.0 ac	A-9802R	1.89 cfs
H & RW Irrigation District 04/03/1946 683.0 ac	A-13016R	9.76 cfs
H & RW Irrigation District 06/04/1976 60.0 ac	A-14249R	.86 cfs
H & RW Irrigation District 07/10/1980 24.0 ac	A-15678R	.34 cfs
Riverside Irrigation Company, Inc. 12/19/1893 51.1 ac	D-10AR	.73 cfs
Riverside Irrigation Company, Inc. 07/28/1894 291.0 ac	D-18	4.16 cfs
Riverside Irrigation Company, Inc. 07/03/1922 190.0 ac	A-1674	2.71 cfs
Riverside Irrigation Company, Inc. 07/31/1941 140.0 ac	A-3477R	2.00 cfs

Frenchman River – Storage Water Right

Bureau of Reclamation 05/01/1946	A-3899	44,079 AF

Storage Use Water Rights

Enders, Strunk, Harlan County, and Swanson Reservoirs
Bureau of Reclamation A-6225HR
04/16/1954
Covers flow rights A-3869AR

Bureau of Reclamation A-6225HR
04/16/1954
Covers flow rights A-6214R

Enders, Strunk, Harlan County, Swanson, and Hugh Butler Lake Reservoirs
Bureau of Reclamation A-9782
12/16/1959
Covers flow rights D-24-30, A-6214, A-9697, A-9802
Bureau of Reclamation A-15839
04/18/1981
Covers flow rights A-13016R, A-14249R, A-15678R

Total Natural Flow Rights

Frenchman Valley Irrigation District	132.75 cfs	9,292.4 acres
H & RW Irrigation District	164.40 cfs	11,915 acre
Riverside Irrigation Company	9.60 cfs	672.1 acres

Irrigation Requirement Spreadsheet

AL Irrigation Requirement (acre feet)			Frenchman Valley Irrigation Requirement			H&RW Irrigation Requirement		
es H&RW	Enders Elev - 3089.4	Enders Elev - 3099.0	Releases FVID	Enders Elev - 3089.4	Enders Elev - 3099.0	Releases H&RW	Enders Elev - 3089.4	Enders Elev - 3099.0
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***** Data to be developed by BOR

APPENDIX D

Considerations for Enders Model
And
"Future Without" Conditions

URNRD IMP: http://www.urnrd.org/

Reduce groundwater pumping by 5% basin wide (1998-2002). Reduction quantities for each NRD will be determined by NDNR. Increase reductions of groundwater pumping in water short years as directed by NDNR.

1998-2002 pumping:
- URNRD – 531763
- MRNRD – 309479
- LRNRD – 242289

1998-2002 depletions (Republican Basin Total)
- URNRD – 74161
- MRNRD – 52168
- LRNRD - 43954

MRNRD IMP: http://www.mrnrd.org/

Reduce groundwater pumping by 5% basin wide (1998-2002). Reduction quantities for each NRD will be determined by NDNR. Increase reductions of groundwater pumping in water short years as directed by NDNR.

1998-2002 pumping:
- URNRD – 531763
- MRNRD – 309479
- LRNRD – 242289

1998-2002 depletions (Republican Basin Total)
- URNRD – 74161
- MRNRD – 52168
- LRNRD – 43954

RRWCD http://www.republicanriver.com/home.asp, http://www.water.state.co.us/

reduce agricultural water use by 5%. Starting by targeting 35000 acre-feet of irrigation water on 30000 irrigated and 5000 non-irrigated acres annually. Mechanisms for goal achievement will be CRP, CREP and EQIP programs.

CREP: Allocated acres targeted for reduction by county

Kit Carson – 9505 (31.7%)[not in study area], Logan – 293 (1.0%), Phillips – 3870 (12.9%), Sedgwick – 1314 (4.4%), Yuma – 15018 (50.1%)

EQIP: Two programs; permanent and temporary (3-15 year) retirement. No quantifiable numbers of acres, but budgets show increased emphasis on permanent retirement of acres. Email request in to RRWCD to quantify acreages enrolled in EQIP.

2005-2006 change in funding:

Permannent: 129k -232k (80% increase)

Temporary: 85k-93k (8.2% increase)

CREP (Republican/Platte River Valleys – NE): Reduce irrigated acres in Platte and Republican Valleys by 125000AF. Permanently retire 8% of irrigated cropland. Conserve 100000AF of water within reservoirs. Increase flow in rivers by 50000AF.

Water use per irrigated acre:

2004 – 14.85 acre inches

2005 – 8.78 acre inches

EQIP (Nationwide): Reduction of 15.3 million irrigated acres(1996).

Permanent retirement:

MRNRD - ~1200acres (2005)

Republican – 2640acres

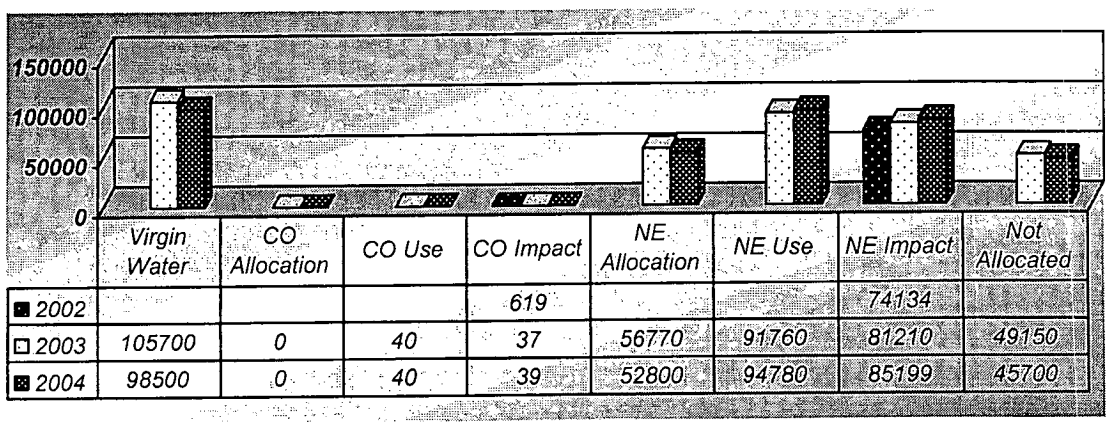
Permanent plus Temporary(4yr) retirement?:

URNRD – 527.9 (ground water)

MRNRD – 2781.12 (2524.02 ground water, 257.10 surface water)

RRCA (http://www.republicanrivercompact.org/):

Allocates water to the states(CO, KS, NE) per the legal framework of RRCA.



	Virgin Water	CO Allocation	CO Use	CO Impact	NE Allocation	NE Use	NE Impact	Not Allocated
2002				619			74134	
2003	105700	0	40	37	56770	91760	81210	49150
2004	98500	0	40	39	52800	94780	85199	45700